Critique of "A City on Mars" and Other Writings Opposing Space Settlement

By Dale Skran, Copyright 2024

Introduction

It is often said that great social movements pass through four stages: First they ignore you, then they laugh at you, then they fight you, and then you win.

For many decades, advocates of space settlement have been widely ignored, and sometimes laughed at. It is only in the present decade that the idea is being taken seriously enough that a number of authors are actively fighting against it. Ironically, these authors deserve a few claps of applause for bringing us into Stage 3, which in turn brings us closer to Stage 4 where we ultimately expand human civilization into space.

Part 1 (page 2), the bulk of this essay, is an extended response to the book, *A City on Mars* (2023) by Kelly and Zack Weinersmith. As a comprehensive critique of space settlement, this book poses special interest, especially considering that the authors attended the 2021 NSS Space Settlement Workshop and refer to content from this workshop in a number of places.

Part 2 (page 74) is a response to the book *Dark Skies* (2021), in which Daniel Deudney, an Associate Professor of political science at Johns Hopkins University, argues that space development and settlement is actually dangerous. Deudney starts from the assumption that space settlement will succeed, and in doing so lead to the fractionation of the human race into a diverse set of xenophobic new species that will fight an existential war to the death. This scenario, although not totally impossible, seems far less likely than the opposite notion that space settlement will restore time and distance to our lives, making the rapid destruction of all life in an interplanetary war less likely rather than more likely.

Part 3 (page 83) is a response to the article "Why We'll Never Live in Space" that appeared in *Scientific American* in October 2023. This dogmatic dictum is somewhat like writing an article 70,000 years ago on "Why Humans Will Never Live Outside of Africa." Ultimately humans will settle space for a simple reason: that's where most of the resources are.

Part 4 (page 86) is a response to a 1997 essay "The Case Against Space" by Gary Westfall, which argues against humans in space in general.

Endnotes are on pages 89-90.

Part 1: A City on Mars

I have already written a brief review of *A City on Mars* that appeared in Ad Astra 2024-2 under the title *No City on Mars?* However, there is so much – good and bad – in *A City on Mars* that a much more extended response is in order. The super-short review is that if you are already well-informed about space settlement, I recommend reading *A City on Mars*. But this is not a good book to introduce anyone to space settlement since the authors spill most of their ink trying to make a case against the idea.

Here I provide a chapter-by-chapter, section-by-section response to the entire book *A City on Mars*. To allow the reader to easily find the relevant part of *A City on Mars*, chapter names and section titles from *A City on Mars* are re-used in this paper unless stated otherwise. This paper is written in neither journal article nor book format, and may be most useful as a "tool box" from which ideas about space settlement may be extracted.

Discussion of Chapter 1: "A Preamble on Space Myths"

"Bad Arguments for Space Settlement"

"Argument 1: Space Will Save Humanity from Near-Term Calamity by Providing a New Home."

This argument is pretty much a "straw man" that the Weinersmiths easily incinerate. I am not aware of anyone beyond Elon Musk who seriously talks about "short" term "backup" settlements in space (and even Elon almost certainly doesn't believe his numbers – he just knows we need to go as fast as we can to maximize our chances). Those of us actively pushing for space settlement are well aware of the challenges involved, but we draw a different lesson from the magnitude of those challenges than the authors. Upon understanding that the challenges are large, they counsel that we wait until some magical time when global issues are resolved and we all get along somehow, and most importantly, someone has developed powerful technology to support space settlement. Others take the opposite approach, that in order to have even a remote chance of any kind of space settlement 100 years in the future, we need to push as hard as possible right now, because, see, space is hard!!! There is also the fact that waiting for technologies to develop themselves can be like waiting for Godot. Unless an immense challenge is taken on with intensity, it is far less likely that major new breakthroughs will be achieved in time. If for instance, one believes there is a 50-year window to tackle climate change, is the smart choice to wait 40 years before taking any action because our technology will be much more advanced then and the task far easier?

At the NSS we often distinguish between space settlement (the process of developing space resources and building communities in space) and a space settlement (an actual permanent community in space). It may well be that the construction of an independent true space settlement will not start for 100 years, but the process of space settlement is happening right now. The ISS is part of that process. StarShip/SuperHeavy is part of that process. VAST building a rotating space station[1] is part of that process. Artemis is part of that process. The construction of medium-term space settlements that are not autarkic are part of that process. Most importantly, if we do not establish the legal right to mine resources in space and use them to build things that can be bought and sold (including, eventually, space settlements), there is little chance anyone will ever develop space resources or build any space

settlements – ever. And this battle is being fought right now in the halls of Congress, in the UN, and via academic debate. If SpaceX cannot get permission to test and utilize StarShip/SuperHeavy, there is little chance that any future major space project will be allowed, such as space solar power, or returning metals mined in space to the Earth. The NSS is in the thick of this battle, and it will most likely be decided in the relatively near future, not 100s of years from now.

The Weinersmiths then attempt to demolish the "short window" argument. In this approach, the space settlement supporter suggests we need to move forward as fast as possible since the period of time our current culture will be space capable is limited. Sometimes nuclear war or disease are thought to be capable of ending the window, but it is just as likely that an atmosphere of "degrowth[2]" and "limits to growth[3]" might lead to a lack of cultural will to take on any major scientific or technological project that is not extremely "Earth centered." For a good example of this kind of thinking, I suggest climate activist Bill McKibbin's book *Enough*, in which past NSS leaders such as Eric Drexler appear as villains. My view is not that we know the window is short, but that we don't know how long the window actually might be. And since we don't know when the window will close, we should push as hard as possible for space settlement, with the hope that we have 100s of years, because we will need centuries to create a self-supporting spacefaring civilization. To illustrate this point, consider the following table:

Window size	**We push for space settlement**	**We settle space slowly**
Too short for settlement	Extinction	Extinction
Long enough to settle space if we push	Species survival	Extinction
Really long	Species survival	Species survival

My bet is the pushing space settlement maximizes the chances of species survival. But if the window is really short, we are all dead anyway. Keep in mind that sometime in the next minute Putin might decide that since he is dying of cancer (not saying this is true!), he wants to bring the world into darkness with him. One hour later we are all dead in the USA. Five years later nuclear winter has led to the extinction of the human race by starvation. Or suppose the Super Volcano under Yellowstone goes off next week, or we are wrong about Apophis just missing us in 2029. In these and many other scenarios the window is too short. Perhaps the most important point about the three examples given is that no amount of focusing on Earthly problems is going to make any difference.

One difficulty with the argument just made lies in varying perceptions of the likelihood of an extinction event for the human race. Many technological optimists tend to lean toward the type of disasters mentioned causing a period of collapse but not total extinction, followed by new golden ages that may yet result in space settlement. First, even the greatest optimist ought to be honest enough to admit that extinction is a real possibility. We can debate a long time on how likely it might be, but the probability is clearly not zero. Second, with the sort of massive collapse envisioned, although in the distant future a new civilization many indeed settle space, it will not be our civilization. It may be something we would consider a nightmare. Third, going through cycles of collapse has to be a risky approach. Yes, we may survive a cycle or two, but it seems like the odds of avoiding biological extinction drop over time. Finally, many of the "disasters" envisioned are not "extinction" in the biological sense, but the extinction of the possibility of space settlement.

This final point deserves elaboration. If a strong "degrowth" mentality takes hold, humanity might conceivably enjoy a long existence until done in by inevitable natural disaster, but all hope for space settlement will be, in fact, extinct. Alternatively, if uploading to or permanent connection with highly satisfying virtual worlds becomes the human condition, space settlement may never occur since we are all lost in an endless dream. One could go on hypothesizing scenarios in this fashion, but clearly the "extinction" of all hope for space settlement has a broader meaning than just the biological extinction of the human race.

The Weinersmiths make another point: "…the current age is simply not golden enough to deliver an independent Mars economy." This is far from obvious. Certainly, we cannot afford a space settlement built by NASA using the same technology that built the ISS. But as can readily be seen from the SpaceX Starlink project, once we move away from cost-plus monopoly contractors, and start focusing on making money in space, amazing things become possible. And we are just getting started. Space technology has been in stasis since the 1980s, and only with the advent of SpaceX has there been any significant progress in lowering costs. We are at the start of an upward curve of technology development that if allowed to continue for another 50 years, will make it as easy to reach space as to fly to Australia. And we have done virtually no research on large-scale space construction since the time of O'Neill. The focus of NASA has been on bespoke exploration at enormous expense, not on lowering the cost of doing things in space.

Of course, mere rhetoric will not convince the skeptics. We need to develop space resources and capabilities to the point that the construction of space settlements will not be viewed as being especially difficult. This suggests that our focus over the next ten years (the near term) and the subsequent 50 years (the medium term) should be expanding the space-based economy to the maximum extent possible, starting with Low Earth Orbit. We need to establish an economically self-sustaining LEO economy over the next ten years and a self-sustaining cislunar economy during the following 50 years, so that then we can build the first non-autarkic free space settlements, that will lead 100s of years later to a truly self-sustaining spacefaring civilization spread over the entire inner solar system. Only then will our chances of species survival materially improve. But that journey starts today, with creating the legal and regulatory environment to allow space businesses to be profitable.

"Argument 2: Space Settlement Will Save Earth's Environment by Relocating Industry and Population Off-World."

The second argument is another "straw man" for the Weinersmiths to again incinerate. The "straw man" is the idea that serious space settlement proponents actually think that some significant part of the Earth's population will move to large numbers of orbiting space settlements in some short to medium time frame. The authors argue that moving people off-world in large numbers is absurd (220,000 per day is said to be needed to move a single day's population growth off-world). Setting aside the fact that as the world develops economically, population growth is slowing everywhere and on a downward spiral in countries like Japan and South Korea[4], such that this number is almost certainly would not be needed, it should be noted that every day about 500,000 passengers are in the air on a global scale. Viewed in this context, sending 220,000 people to space per day is far from impossible or even unreasonable.

Although Jeff Bezos may not make this clear in his speeches, it is heavy industry that would move off-world first, not the population. Large scale emigration to space may never occur, or only occur in the distant future. As space resources (and other new technology) make everyone on the Earth far richer

than they are today, demographic facts suggest population growth on the Earth will continue to slow, and eventually population there will drop. As this occurs, there will be gradually increasing movement of people toward space settlements, combined with a steady natural growth of the space born population. Perhaps 500 years in the future, there might be a few billion left on the Earth, but with a much greater number living in space.

The authors then go after the idea that we will be able to move heavy industry off the Earth. They focus on an example – cement production – chosen to make the idea seem ridiculous. We also are not going to import sand from Mars or oxygen from the Moon, equally silly ideas. The whole "garden Earth" idea only works in the scenario I described above – everyone getting richer, the population dropping, and many people emigrating to space. In this scenario the global cement needs will drop by a factor of 10x or more, as will their environmental impact. As an aside, research to lower the substantial carbon impact of cement production on the Earth is highly desirable, since the Weinersmiths are correct that we are not moving this industry into space.

The Weinersmiths focus on the difficulty of producing cement on the Moon for export to the Earth, and worry about the temperature swings making industrial operations difficult. This is misguided since we are not going to manufacture cement on the Moon except for local use. The Moon is a great source of materials for building cislunar free space settlements, however. Mining and manufacturing do need to be re-invented for the Moon, but scientists and engineers have been working hard for decades, waiting for the day when a ride to the Moon was affordable. That day is coming soon. An excellent book on lunar development is *The Moon: Resources, Future Development and Settlement* which provides extensive information on mining and processing lunar materials[5].

The other space resources that settlement advocates have in mind will be found in the asteroid belt, where temperature swings are easy to control with sunshades. Additionally, if we move mining into space, we would over time move much manufacturing into space, with the result that only certain intermediate or final products are brought back to the Earth. One real benefit from space mining lies in not needing to engage in environmentally destructive mining and manufacturing on the Earth.

Finally, it must be emphasized that space mining will only occur if it is less expensive – when viewed in toto – than mining the Earth. Sometimes space mining critics point out that if we bring large amounts of platinum back to the Earth the price will drop. This is true, but if platinum was inexpensive, we would use it for many things we do not use it for now, much as we use a lot of aluminum now compared to when only kings and queens could afford aluminum tableware. What matters is can we sell the platinum on the Earth for more than the cost of mining and transporting it – wherever it is mined. It is worth noting that supermarkets are an immense industry, but they operate on about a 3% profit margin.

The Weinersmiths raise the excellent point that space mining advocates are often cavalier about how the metals get back to the Earth. The first part of the problem lies in moving the metals from where they are mined to the vicinity of the Earth. An obvious direction is to do refining and mining at the source, so that only pure, valuable materials are sent to the Earth. In practice, most of the material may be used to construct space habitats near the mine site, but the rare Earths and so are might be targeted for return to the Earth. Sending refined metal back to the Earth will not be based on giant container ships with atomic drives, or the like. Instead, the "vehicle" will be the mass to be transported, and the propulsion some form of mass driver or thermal water rocket, powered by solar energy and abundant, cheap, locally obtained fuel. The engines and avionics in this system will be fully reused, while the vehicle body

makes use of aerobraking to land on the Earth the Earth. A typical solution is to build a foamed titanium lifting body (or steel, or iron – whatever is easy and cheap and environmentally safe during re-entry), install an avionics package, and fill the interior with the good stuff. Land on water to minimize risk – and the foamed lifting body will float until it can be towed into port. But there is an issue here – we need to be looking right now at creating laws and regulations to allow the large-scale return of manufactured products from space. Recently a satellite containing space-manufactured potentially life-saving drugs was not being allowed to return to the Earth by government agencies because of issues that have not been made public[6]. If we cannot do this routinely and on a large scale, humanity will miss out on many of the possible benefits of space development and settlement.

Another issue exists with the large-scale return of materials from space, the potential pollution of the atmosphere via the formation of various oxides as the metallic bodies re-enter. Research in these impacts is in the early stages, and it may be the case that the pollution generated makes the return of materials mined in space prohibitive. It is also possible that via the addition of appropriate ablative coatings, such as silica glass, these problems may be minimized. Without additional research, it is impossible to say for sure that the Weinersmiths are incorrect in their skeptical attitude toward asteroid mining replacing mining on the Earth. What can be said is that it is premature to dismiss the notion of returning materials mined in space to the Earth.

As the Weinersmiths point out, the ease of generating solar electricity in space is foundational to space development. They focus on the challenges in beaming power back to the Earth, but the "power" could be returned to the Earth in other ways, such as by doing energy intensive manufacturing in space, with the result that we do not need the power on the Earth itself. One modern idea that O'Neill did not consider is to move server farms in space, where power is cheap and you can dump heat into space with a black piece of metal. If this was done on a large scale, the carbon impact of data services on the Earth would drop greatly even if power is not beamed back to the Earth. There are almost certainly other ways we can use power in space to do things in space that benefit people on the Earth.

The authors arguments against space solar power focus on the supposed cost of panel maintenance in space. They envision that "They'll have to be repaired and cared for either by astronauts or an army of advanced robots. Solar panels in Australia can be cleaned by a teenager with a squeegee." The astronaut idea is just not going to happen – too expensive and risky. It will be either tele-operated devices or autonomous robots. Why we need "an army" is unclear. Modern SPS designs are totally modular, so "repair" will boil down to replacing a module. Each module will have built-in status reports, and when total module damage gets to some level, a robot will walk across the structure and replace the defunct module. Modules will have a lot of redundancy, so they will not have to be replaced very often. There is no weather – no sandstorms or hurricanes in space. I'm betting the maintenance will be less in space. In principle, an SPS with this kind of maintenance might have something approximating an indefinite life.

An often-asserted argument against any industrial activity in space, whether it be space solar power, orbital data farms, or something else, is that such installations are especially vulnerable to the use of a nuclear weapon in space. This line of argument assumes that the orbital structures have not been designed to withstand a strong EMP attack, although surely they are useless if they cannot survive regular assaults from solar chronal mass ejections. Of course, no matter how they are designed or armored, with enough nuclear weapons they can be destroyed. However, this is equally true with

regard to any installation on the Earth, so it does not seem like a strong argument to avoid space development.

The Weinersmith's appear to have been influenced by the anti-SPS thinking of Casey Handmeer. I've written a point-by-point rebuttal of Handmeer's main SPS blog post[7], but I do agree that beaming solar power to the ground is not a sure thing. It's just tragic that we are spending close to zero government research dollars on a known-to-work energy generation system and billions on more far-out approaches. Even the Weinersmiths agree solar power is great in space for work in space. Finally, as I point out above, we don't need to beam the power to the ground to build a better future for everyone using space resources.

*"**Argument 3: Space Resources Will Make Us All Rich**."*

Here the Weinersmiths may (may!) have hit paydirt! Indeed, space advocates often argue glibly that space resources will make us all rich. Sadly, there may be vast benefits to humanity from space resources, but with the result that most people will still not feel rich. A big reason is that "rich" is a relative thing. People only "feel rich" when they have a lot more than those around them. Thus, if 100 years from now, every single human being has the equivalent wealth of a millionaire today, they almost certainly won't feel rich because there will be trillionaires in the asteroid belt, with the result that they still feel poor. In much the same way, the average American is rich beyond the dreams of even kings in ancient times, but certainly does not "feel rich" because people like Bezos and Musk have 100s of billions.

The Weinersmiths mention that aluminum, which once graced the tables of kings and queens with flatware, is now dirt cheap and used everywhere, yet we don't feel rich. Once the asteroid mines are going strong, gold and platinum may be as cheap as aluminum today, and we still won't feel rich. Objectively, we are much better off now than in the Middle Ages, and if we bring the benefits of space to humanity, we may be objectively far "richer" 100 years from now than we are today. But the Weinersmiths are surely correct – nobody will "feel richer" than they do today.

It is also true that space has improved our lives in countless ways that don't make us "feel rich." For example, we can now telephone anyone in any developed country almost for free, but this doesn't make us "feel rich" any more than owning a metal axe made someone "feel rich" in the 1700s. The same sort of argument applies to weather prediction, location services, and more. We are objectively far better off, but we just don't "feel rich" when everyone we know has equal access to the same valuable services.

The Weinersmiths mention this point later, but I will address it here. A common argument against space mining is that this or that valuable material is only present in low concentrations, making the cost of mining that material in space prohibitively expensive. Setting aside the reality that our understanding of the resources of space remains quite limited, the main usage of space resources will be in space, mostly to build rotating habitats and other infrastructure, as well as to obtain rocket fuel and water. A byproduct of these activities will be enough gold, platinum, cobalt, etc. to supply the Earth's needs many times over, and not at high cost. A further common error is to attempt to move a labor and water intensive refining process to space, and then declare space mining to be economically infeasible. In reality, space mining may use, for example, high-efficiency, low-energy biological techniques that are

totally different than those used on the Earth, and that are highly effective at concentrating rare minerals.

The authors also make the point that most of the "value add" in a product consists of ideas and technology, not the raw materials. This is beyond dispute, so is it possible that the vast material resources of space will have virtually no impact on humanity? If looked at from the perspective of "will my TV be a lot cheaper" the answer is almost certainly space will have little impact on our lives – beyond making them healthier and happier due to the reduction in the environmental impact of mining and electric power production on the Earth's biosphere. However, in the longer-term space resources will enable the large-scale manufacturing of living space in free-space habitats as envisioned by O'Neill, something that on the Earth is essentially a fixed quantity. If land is wealth, then space development and settlement have the potential to make everyone much richer than they are today.

"***Argument 4: Space Settlement Will End, or at Least Mitigate, War***."

Here things fall on the Weinersmith's side, but the authors end on a troubling note. First, the authors seek to puncture the idea that creating vast amounts of land on orbiting space settlements will end war by pointing out that people fight over particular land, not land in general. They have a point here, which is easily grasped by asking whether the existence of 1,000 O'Neill cylinders in cis-lunar space would end the current wars in the Ukraine or Gaza. I humbly suggest the answer is that it would not.

However, the Weinersmiths then dive into the confused end of the pool, arguing that we are "building land" when we build a house or skyscraper. Oddly, I don't know of anyone who thinks that way. A space habitat is not a house even if it is a "built structure' – it is a place to build homes or skyscrapers. I can build as big a home as I like on the Earth, but such activity will never create the potential advantages a space habitat has – distance from potential enemies, isolation, mobility, independence, access to vast stocks of new resources, potential to create customized environments, the ability to expand land area as needed, etc. Equally, buying an empty plot of land in North Dakota as the Weinersmiths suggest will not have any of these advantages either. I will deal with these ideas in more detail later in this paper but part of the reason the Weinersmiths are negative on space settlements is that they appear to not appreciate the potentialities that others see in them, or perhaps they simply do not value these advantages very much.

Secondly, the Weinersmiths demolish the idea that if we are all rich, we won't fight. Although wars over resources do occur, they occur for lots of other reasons as well, so the vast resources of space making us rich will not end war. Also, as I pointed out in the section on Argument 3, we won't "feel rich" even if objectively we are much better off than we are today.

The third point that authors seek to knock off is the idea that wars in space will be less likely to occur since "unhappy citizens" can leave to another space settlement. The Weinersmiths point out that moving from settlement to settlement will not be that easy, as finding a welcoming home may be difficult or impossible due to resource limitations at some particular settlement. This point is the most true when we think of isolated orbital space settlements. Yet will there really be a lot of isolated orbital space settlements? Futurist and NSS President Issac Arthur envisions clusters of settlements physically near to each other, perhaps sharing in some project or political organization. This vision is shared by others, including some working with the British Interplanetary Society[8]. In this case, going from one settlement to another might be as simple as putting on space suit and using a reaction gun to make the

short trip to your new home. It is also true that although some settlements might be crowded, others might be eager for new faces and more hands. Regardless of how all this works out though, the Weinersmiths have a point that Argument 4 does not appear particularly strong.

One viable option might be disgruntled individuals banding together to build a new space settlement, which seems absurd to the authors due to the assumed great expense involved. A more likely scenario is disgruntled individuals joining up with a group or company building a new space settlement to provide labor in return for a new home. But it is hard to see this as preventing war.

The Weinersmiths end by referring to space as "an escape from political realities one group finds uncomfortable," quoting a Dr. Kilgore that this is a form of celestial "white flight." The authors' lack of sympathy for "escaping political realities" that are "uncomfortable" contributes to their negative views on space settlement, since the desire for such an escape is a very strong motivator for many advocates of space settlement. I guess oppressed minorities are just supposed to keep a stiff upper lip and live with their oppression rather than try to find a better life elsewhere. Historical migrations are often mainly driven by a desire to escape religious, social, or political oppression, and I anticipate that many space settlements will be founded by those with such motives. This may not prevent war in space, but by allowing such minorities to breathe free in space may reduce war on the Earth.

Although I found the Weinersmiths' final comments referred to in the previous paragraph disturbing, their overall point is sound – settling space will not magically prevent war, especially war between space settlements. However, the mere existence of many space settlements may eventually induce Earth governments to unify, reducing wars on the Earth. Deudney in *Dark Skies* views that as a bad thing, and envisions a militarized Earth unifying to fight the space settlements. But just as possibly, it could be a good thing that is part of the natural evolution of solar system governmental organization. We will return to this idea in the Weinersmiths' Argument 7.

"***Argument 5: Space Exploration Is a Natural Human Urge***."

Here the Weinersmiths may be technically correct, but appear to have missed the main point. They argue that most of us are not famous explorers (true, but hardly needs stating), and that famous explorers were typically more concerned about gaining control over resources via priority rights than exploration (also probably true). Yet this line of thinking misses the point – humans are curious animals. Of course, we are not the only curious animal. Cats certainly are. Raccoons are. Mice are. Curiosity, on the average, has considerable survival value or it would not exist. The animals that cower in their burrows sometimes are safe, but also miss out on new food sources and other benefits of exploration. Of course, curiosity can be expressed by exploration in many areas, such as, for example, the study of parasitic worms. But all this knowledge has long term survival value. Somehow, it all seems to come in handy eventually. Surely this applies to exploring space as well.

None of this means that only because we are curious, we ought to explore, develop, and settle space. However, it is easy to see the Earth as our "burrow" which if we never leave, will eventually become our tomb. Which brings us to the authors' argument that humans spreading around the globe is of no importance because many animals and plants also spread around the globe and are surely not motivated solely by a natural urge to explore. As the Weinersmiths point out, migrations of humans may most often be motivated by "warfare, persecution, and starvation." The authors seem to be missing the point completely. Humans (and animals, and plants) spreading around the world maximizes species

survival, and further spreading into space will most probably also maximize the probability of the human species surviving. Viewed in this way, what is important is that we settle space, not that we do so because of a psychological need to explore.

The Weinersmiths then dismiss the idea that a lack of the exploration of space will lead to stagnation, saying "a lot of cool stuff has happened since the 1950s." This appears to be simple ignorance of the works of many serious scholars. There is a cottage industry of books arguing that since the 1960s, or sometimes 1970s, there has been a significant decline in economic and technological growth, the ubiquitous smartphone notwithstanding. For some examples, check out:

- *The Conservative Futurist: How to Create the Sci-Fi World We Were Promised* by James Pethokoukis (2023),
- *Where Is My Flying Car?* By J. Storrs Hall (2021), and
- *The Great Stagnation by* Tyler Cowen (2011)

The slowdown in GDP growth is not mere paranoia, but an economic fact. Part of the problem with seeing clearly the stagnation all around us is that we need to compare ourselves to what might have been, not to the 1950s as the authors do. Would we have a significant climate change issue if we had deployed nuclear power on a massive global scale since the 1960s? Perhaps, but it would certainly be much less of a problem than if the nuclear industry was not strangled by NIMBY, regulation, and lack of investment. And one of the technologies that way underperformed until the advent of SpaceX is spaceflight. Arguably, when NASA turned away from space solar power and space settlement in the 1980s, this propelled us on a long decline that only the advent of a "black swan" in the form of Elon Musk has pulled us out of.

"***Argument 6: Space Will Unify Us***."

Here the Weinersmiths are almost certainly correct in the short and even medium term. As they point out, we cooperate in space when we are getting along on the ground. They do seem to miss that one real benefit of the ISS, which was not to have super-expensive meals of "apple pie and borscht," but to keep Russian scientists employed building something other than weapons for rogue states like Iran and North Korea.

The authors then argue that even if joint space projects did cause rivals to get along, this would be misguided since "disputes can and should be solved by conventional politics." There are two problems with this line of thinking. First, if joint space projects really did bring rival sides together, there are a lot of folks who would prefer that to "conventional politics" which the Weinermiths appear to imagine to be well dressed diplomats sipping coffee in Geneva but in reality is just as often the brutal resolution of differences via the most destructive and cruel warfare as we are currently seeing in the Ukraine and Gaza. Second, there are joint space projects like space weather alerts, planetary defense, and the remediation of space debris that most rival states would find to be in their self-interest. Should we not pursue these vital projects out of a distaste for Chinese human rights practices or Russian trench warfare? There may be groups and countries simply too insane to ever cooperate with, but if this includes China or Russia, the human future will most probably be short.

In the longer term, there is a case that space will unify us, if we define "us" to mean the Earth. As the space economy grows and more and more space settlements are built, the time will come (not soon, of

course) when the economic center of gravity in the solar system shifts from the Earth to space, rather as the development of the Americas led over time – and a lot of wars – toward the unification of Europe. Daniel Deudney in *Dark Skies* envisions the Earth militarizing to fend off rapacious spacers, but just as is the case with the European Union, this process may be far more peaceful and democratic than Deudney fears.

"Long termism" is not a good way to make decisions about space settlement and that applies here as well. Just because in the long run, space settlement may lead to the peaceful unification of the Earth, this is not a good argument for space settlement due to the speculative nature of the "good" being put forward. In the same fashion, the fear that space settlement may lead a despotic and militarized Earth is not a good argument against space settlement due to the speculative nature of the "evil" being put forward.

This one looks like a solid win for the Weinersmiths. Space expansionism is not likely to unify the Earth in the short to medium term, but even if this did happen long term, the "Earth unification" justification for space settlement is a weak argument at best.

"***Argument 7: Space Will Make Us Wise***."[9] Here, the Weinersmiths go after Frank White's Overview Effect. The first hint that a "straw man" is being put forward lies in the title – "Space will make us wise." This is a significant misstatement of White's theory of the Overview Effect, which in fact merely asserts that looking back at the Earth from cislunar space will lead a high percentage of viewers to insights that are more slowly developed when living on the planet's surface. In particular, many will see that the Earth from a distance is a whole system in which everything is interconnected and borderless. Similar insights might be obtained by global travel or taking a class in ecology, but they come rapidly when looking out of the cupola on the ISS, or on the Moon.

Specifically, White says, "People who live in space will take for granted philosophical insights that have taken those on Earth thousands of years to formulate." The authors actually get this one sentence right and start their argument with it. However, the rest of their assertions conflate "living in space" with "exploring space," and insights with wisdom. They may be right that there is no good argument that "space will make us wise" but this has never been asserted by White. He has done extensive research via some 50 astronaut interviews, and makes a good case that the Overview Effect is real. He argues that the experience has an impact on people who travel off-world, but only hints at what it would be like to live there permanently. For example, let's say you are considering living in France, and you spend a week in Paris. You would have some idea of what permanent residence there would be like, but you would not know the full impact of making such a move. Also, this is not the same as asserting that living beyond Earth will make us "wise" or "moral." In particular, the Wienersmith attack on their "straw man" goes off the rails when they cite cases of "astronauts behaving badly." The Overview Effect says nothing about moral behavior, so this part of their argument is irrelevant.

The Weinersmiths indulge in an additional misunderstanding when they suggest that "space will make us wise" is a key concept in the space community's argument for large-scale space settlement. White would argue that it is an argument for people visiting and living in cislunar space, because their insights about the Earth will be beneficial to terrestrial society when they return home for a visit. For example, they will share their experience of interconnectedness and the reality that we are "all in this together." "Bringing the Overview Effect down to Earth" could translate a psychological experience into a sociological one that would mark a new era in life on the surface.

At best, then, one might hope that those who settle cislunar space experience the Overview Effect as White defined it. This will a benefit of space settlement, but is not the major justification for it. The Weinersmiths do not refer specifically to any space advocate who makes such an argument.

Although less well known, White extended the Overview Effect to consider the change in consciousness resulting from being far from the Earth. He calls this "the Copernican Perspective." By this he means that someone born and living on Mars is going to connect more with an awareness of the solar system as a whole than the Earth, which will merely be a point of light in the Martian sky. Some may tremble at this development, but there is no more reason to think that distant Martians will dislike Earthers than to fear that Australians will naturally dislike the French because of the distance between them. In fact, Martians may come to love the Earth even more than those who remain on the home planet. It might be remembered as a place with vast oceans of water, a breathable atmosphere, a planet where dust storms are relatively mild events.

Another path the Weinersmiths do not pursue to any great degree in A City on Mars is the idea that due to self-selection and the Founder Effect, spacers may, in fact, actually be much smarter on the average than those remaining behind on the Earth. Such a trend does not require any new technology, but in a hypothetical scenario where spacers practice germline engineering while it is banned on the Earth, such differences may become a vast gulf. In this case, the Weinersmiths would be profoundly wrong – living off-world would have made those who live there, if not wiser, at least more intelligent. Somehow, I do not think the Weinersmiths would greet this outcome with joy.

"***Argument 8: Creating Nations in Space Will Reinvigorate Our Homogenized Bureaucratic, and Generally Wussified, Earth Culture.***"

Here, the Weinersmiths have lumped together a variety of ideas under a somewhat confusing title. Certainly, some space advocates point to the increasing homogenization of life on the Earth as something that space settlement forms a response to. The authors focus on the loss of minor languages as a metric for earthly homogenization, and then clap back by suggesting that since Netflix will be available on Mars, space settlement will not create greater language diversity. This entire line of thinking rests on the debatable premise that lack of language diversity is an appropriate metric for cultural homogeneity. Many exogenous forces impact language diversity, and the rapid growth of AI language translation suggests that neither cultural homogenization on the Earth nor future space settlements are the most important factors in this process.

Some space advocates hope that space settlements will increase cultural diversity, but this is a 2nd or even 3rd tier argument for space settlement, and not one that stands on its own. Space settlements will almost certainly exhibit significant drift from the "homogenized" earthly way of doing things with unique cuisines and diets, different art forms and recreations, and so on. A key part of O'Neill's vision was the ability of diverse groups to live their own "best lives" in settlements that they build to their liking, physically, politically, socially, and economically. These settlements may indeed over time become less homogenized as they evolve on their own paths.

Next, we come to the "Wussification" argument. There can be little doubt that the idea of the space frontier as a place that will mold a new human – a more serious, harder working, and more dynamic human than people are thought to be on the Earth – motivates some space advocates. This might be most true in the early generations of space settlement, but over time as space settlements matured it

might become less so, although surely with a distinctive new culture. Over the long run, those heading toward space would become less selected and less elite. The vision of opening the space frontier to all is a key part of the "DNA" of space advocacy groups like the National Space Society and the Space Frontier Foundation.

Although some settlement advocates tie such ideas to the "Frontier Hypothesis" of Turner, as the authors point out this is not a helpful direction, in large part since the conditions on the American frontier were rather different than those to be found in space. The fact that post-modern historians feel they have deconstructed the Frontier Hypothesis as proposed by Turner seems mostly beside the point. Humans have pushed against the frontier since our very beginnings in Africa, making the rightness or wrongness of Turner's ideas irrelevant to space settlement.

The Weinersmiths then turn to a variant idea that "the harsh world of space and the need for robotics will result in a vast increase in creativity." They respond with their "Necrosphere" thought experiment, in which engineers are forced to live in an artificial space-like environment to boost their creativity. Although this idea has been seriously explored in science fiction, notably in the 2014 miniseries *Ascension*, the authors are correct that as they describe it, the "Necrosphere" is a stupid idea, notwithstanding all the amazing technology the crew of the Ascension develop. A similar idea is also used in Fred Pohl's story *The Gold at Starbow's End.*

There is an obvious weakness in their response – the engineers and scientists working to build space settlements will not be working in "Necrospheres" but in office buildings on the Earth like the rest of us. By the time significant numbers of people live in space, the "Necrosphere" thought experiment will be irrelevant, just as the thought experiment concerning the productivity of naked engineers in New Jersey during the winter became irrelevant once they were all working in heated glass and steel office buildings.

A deeper response, which I will call the "Skran Version of the Frontier Argument" goes like this: the key to technological progress is pressing and well-defined questions. What made Bell Labs great (in the day) was that it had total freedom and solid funding to purse one question – how can we have better telephone service? From this one question came the transistor, the 3 degrees K background radiation, twisted pair ethernet, superconductivity, information theory, charge coupled device cameras, communication satellites, UNIX and C, and much more. Such is the power of a pressing well-crafted question. The alternative way to organize research is "investigator driven" such as the National Science Foundation engages in. Here, grants are given out to explore ideas proposed by various investigators, who may or may not create something useful. This approach has a good track record, but arguably not as good as the question focused method. Both approaches are needed, and valuable, but my suggestion is that "How can we settle space?" is a challenging question that will create a lot of good results for humanity. It is multi-faceted and concrete. If we can live in space, many issues we face living on the Earth will become trivial to solve. And a fresh, focused start is key to rapid progress, relieving the burden of extraneous requirements and distractions. I have no way of proving that "How can we settle space?" will be a "productive" question, but I think my formulation at least makes the case for why there is a "spinoff" argument for focusing on space settlement.

By focusing on homogenization and "Wussification," the Weinersmiths have not fully engaged in the issues being raised by space settlement advocates. Part of the value of a frontier is as a pressure valve where disgruntled political, social, and religious minorities migrate to rather than engage in terror

campaigns to win what they perceive as their due. This idea may not appeal to the authors, with their belief in settling our disputes via the political process, but rest assured, there are a large number of groups who do not want to rely on the "normal political process" which in many cases has failed them. For them, the choice is war/terrorism vs migration.

As space settlement grows, there inevitably will come a growing degree of social evolution and divergence, leading to less overall homogenization. This lack of sameness is threatening to any ideology seeking to impose their "universal" vision on the rest of us. It is not easy to impose an ideology on the Earth; imposing one on the entire solar system will be much harder. Some of us think that might be a good thing.

Hidden behind the opposition of some to space settlement is the fear that it will actually be outrageously successful, and the winning ideas of the spacers will then be adopted/imitated on the Earth. There are at least two variants on this argument:

- If capitalism is allowed to exist in space settlements, and becomes very powerful in space, then free market ideas will end up being imposed everywhere on the Earth where they are currently not strong. Therefore, we must ban free markets and private property in space.
- Spacers will develop germline genetic engineering to deal with space radiation and other hazards. Also, spacers will develop radical reproductive technologies like artificial wombs, and further will abort any less than fully able fetuses. These ideas and technologies will be the foundation of rapid economic growth in space, and will end up being imposed or imitated on the Earth. Therefore, we must ensure space settlements never exist.

These two points contain a morally bankrupt idea – that we must limit or ban space settlement to prevent our ideological foes from using space settlement to advance ideas we do not like. And yet this is where the debate truly lies, not where the Weinersmiths see it. Overall, the authors missed the mark with their discussion of Argument 8.

"Is There Any Good Case for Space?"

Argument 1: The Cathedral of Survival

The Weinersmiths believe there are two "good arguments" for space settlement, the first of which they call "The Cathedral of Survival." They conclude this is "A good argument over the long term assuming you like humans." Most[10] space settlement advocates like humans (it is pretty much a requirement to join the club!), and if you hate humans, we are not going to have any kind of reasoned discussion. The key point though is the phrase "long term." Even Daniel Deudney in *Dark Skies* is willing to consider the idea of space settlement millions of years in the future and he agrees that if we don't leave the Earth within 800 million years or so we are doomed. Hence, all we are really debating is timing. I've addressed the "closing window" debate earlier in this article, but the outcome is that we need to press for space settlement hard now to have any chance of building a real space settlement 100 years from now. And between now and then we will build a lot of things that are on the path to building a space settlement. All those pesky questions about space settlements becoming sovereign nations lie at least 100 years in the future. But the question of who is allowed to mine the Moon is an issue RIGHT NOW. And the answer to that question will determine whether there ever are any space settlements.

"Argument 2: The Hot Tub Argument"

Basically, the "Hot Tub Argument" is the view that if someone wants to settle space, let them, just like we are happy to allow our neighbors to buy and use hot tubs. This isn't a reason to settle space, so it seems a bit odd to put it forward. It is more a reason to stand aside and let Musk and Bezos and the NSS and all other interested parties settle space.

"**The Fly in the Space Ointment**"

Then the Weinersmiths argue against their pro-settlement arguments. Against the "Cathedral" argument, they trot out Deudney's fears that space settlement will decrease our chances of survival, not increase them. And against the "Hot Tub" argument they ask whether space settlement is more like a hot tub or a nuclear weapon. The entire rest of the book then elaborates on their anti-space settlement ideas.

Their ideas are worth considering in detail, but the short argument against the "Deudnist" thinking is that it is a form of negative long-termism. We are asked to believe that spacers will inevitably speciate and become xenophobic psychopaths that wage wars of extermination against each other and against the Earth. Of course, this might happen, but it is pure speculation, and I reject the idea that speculation – good or bad – about far future conditions is a good way to make decisions today, mainly because it can be used to justify virtually any course of action via the construction of an unlikely scenario in the far future.

The short argument against the "nuclear hot tub" is that space settlement is not a nuclear hot tub. Sure, stuff dropped from space is dangerous, but there is no short to medium term danger of spacers blasting the Earth, and in the long term the spacers probably won't much care politically or militarily what happens on the Earth, as long as the Earth has the relative military potential of Luxembourg or Madagascar, and as long as we have created an accepting and supportive solar system wide "Federation" to which I will return later in this paper.

Discussion of Chapter 2: "Suffocation, Bone Loss, and Flying Pigs: The Science of Space Physiology"

"The Prehuman Space Age"

People writing about space invariably feel the need to write some kind of space history introduction. And the Weinersmiths have dutifully provided one. You can skip it if you want. It is a bit funny, but more or less irrelevant.

"The Vacuum of Space, or Your Body Is a Soda Can"

The purpose of this section appears to be to acquaint someone who has spent the last 60 years or so under a rock with the idea that in space there is a lack of air (and pressure) which will kill you rapidly and messily. The problem with this material (and indeed, the problem with a lot of the material the authors provide) is that it seems to have been put in place just to scare the reader rather than as part of a rational discussion of issues related to space settlement. Toward the end of the section, some real space settlement issues are discussed, but only very briefly.

There is a short discussion of the relative speed of objects in space, and the disastrous potential results from collisions with space debris, natural and human created. By presenting the problem, but with no

history and no discussion of solutions, the reader is led to believe that things are much worse than they really are. The ISS has been in orbit in LEO (a crowded zone) for over 20 years, and there has never been a crew injury or fatality for this reason. Real space settlements will (mostly) be in much higher and much less crowded orbits. Perhaps more importantly, they will be armored against radiation to a much greater degree than the ISS, and that same radiation armor will provide significant protection against space debris. Space settlements on celestial bodies will be buried in thick layers of regolith, which again provide substantial protection. Nothing about this discussion should be understood as making light of issues related to space debris; they are real and they need to be addressed, but they are not remotely show-stopper problems for space settlement.

A more substantial issue relates to the potential in a space settlement for bad actors (whether would-be tyrants or terrorists) to cut off or contaminate the atmosphere supply. Mention is made of "engineering for liberty" as suggested by Cockell[11] to ensure that the air supply is not easily turned off or compromised. This leads directly to the observation that due to a lack of attention by space settlement advocates to the details of habitat design, these issues loom larger than they otherwise might. Additionally, O'Neill did not appear to put any effort into considering what might happen if a well-armed, well-trained crew of fanatics tried to shut down an O'Neill station with maximum carnage. Once any reasonably competent designer starts to think along these lines, the need for extensive redundancy, isolation, and resilience in settlement design becomes clear. No system like this will be perfect, and our lives on the ground are more vulnerable than many realize to these sorts of threats. Space settlement advocates need to pick up the challenge and produce detailed designs that by their very nature strive to minimize these issues.

"Explosions and Nudity: Lessons on Radiation in Space"

Here we find a large mass of material tutoring us on the badness of radiation. It should come as no surprise that radiation is bad for humans. There is a funny ISS story about an ammonia leak that is interesting, but there is no discussion of how a space settlement might protect against radiation, leaving the impression that space settlement advocates are ignoring this vital issue. Additionally, there is a good bit of off-topic discussion of the radiation issues associated with traveling in space, which are quite different from the issues associated with space settlements, mainly due to the limited ability to cost-effectively shield a powered space vehicle.

Just a hint here – any real space settlement will have very significant radiation shielding, consisting of some combination of water and regolith. There may be real issues with limitations of such shielding and the interaction with the human reproductive cycle of the radiation that penetrates any reasonable level of shielding, but they are not mentioned here.

"Space's Special Problem: Microgravity"

This section is one of the most irrelevant in the book. Radiation is at least a real problem that must be addressed in order to settle space. Let me save you the trouble of reading this section: microgravity is bad for humans. It is bad for humans in many ways. There is no known method of ameliorating the effects of microgravity completely. Hence, I guess we will never settle space, or at least we will be limited to the Moon and Mars where there is at least some gravity?

No remotely serious space advocate believes humans will live in microgravity for more than short periods, barring far-future advances in bioengineering. Humans need gravity to thrive – the only question of importance is how much gravity? The safe approach is to build rotating space settlements that provide 1 full Earth gravity. Maybe we can thrive on Mars, and even the Moon, but right now we just don't know.

Why do the Weinersmiths spend so much time – five full pages – for a topic (the horrors of living in microgravity) that merits a paragraph with a few references? Unclear, but it does fit with the pattern of telling scary stories about living in space.

"At-Spome Medical Care: Trauma Medicine Off-World"

The section focuses on the challenges of performing surgery in microgravity, which are many. Although this section is of some interest to those planning future space exploration, it is of zero interest to future space settlers, who are going to be living under a significant gravity field, if not a full Earth gravity.

"The Future: Worse?"

First, the authors suggest that these issues will become worse as less healthy people start to fly in space. Second, they argue that the scale of our ignorance about living in space is vast, something which has more than a grain of truth. But then they reach the following surprising conclusion: "*We suspect that none of these problems preclude space settlement. …a giant rotating space base with thick shielding might fix pretty much everything*." This suggests that at most there are economic obstacles to space settlement. And it is certainly true that due to an almost total lack of research on rotating space stations, we are not much further along than we were in the 1980s with regard to this key technology. Space advocates are keenly aware of this problem, and would agree that resolving it is issue #1 for space settlement.

What are we to make of Chapter 2, then? It feels like a big bucket of warm FUD (Fear, Uncertainty, Doubt) which if written by someone not arguing against space settlement would drop the tiresome explanations of obvious challenges with well understood solutions, and focus more deeply on what remains to be done to make space settlement work.

<u>Discussion of Chapter 3: "Space Sex and Consequences Thereof"</u>

"Getting Strange in the Lagrange, or, Can You Do It in Space?"

This section provides a host of ribald tales and speculation about zero-gravity sex, some of which are mildly interesting. The Weinersmiths are to be commended on their extensive research on this topic. However, since space settlers will not live in microgravity, the section is basically irrelevant to the topic of space settlement.

"A Bun in the Space Oven, or Reasons Not to Get Pregnant While Going Around the Earth at 7.8 Kilometers per Second"

There is, again, a good bit of research on display here, but you can skip reading it. The summary is (1) gravity adapted mammals reproducing in micro-gravity is a terrible idea, and (2) mitigations are more fanciful than anything else. To a significant degree this applies to lunar and Martian gravity as well.

Things might work out fine in 1/6th and 1/3rd gravity, but this is just speculation. It may surprise some, but space settlement advocates know all this already, which is why many at the NSS argue that rotating space habitats are the single best approach to space settlement with a high probability of success. "Martians" think that living on Mars gives us a "sporting chance" if you like to live dangerously and are cavalier about the risks to kids. But personally, I want to see some experiments first, which puts me in the same camp as the Weinersmiths on this question. Also, as will be developed later in this paper, the Weinersmiths themselves suggest a solution that fully enables the settlement of low-gravity locations.

The problem comes when the authors say "Ideally, this would at some point involve something like a primate center in space, complete with a monkey day-care center…. This will be very expensive and time consuming and comes with its own ethical considerations. If there is no urgent reason to settle space, what is the ethical justification for a huge number of experiments on animals.…"

The authors see no reason to proceed with answering the central question impeding space settlement which they acknowledge will take a long time and a lot of money to answer, since they see no urgency to settle space. The result of this kind of thinking is predictable – 100 years on we will be having exactly the same conversation with no data to show for it. It is precisely because this question will take a long time to get a really good answer that it should be on the front burner, not the distant rear of the bus.

All space settlement advocates want is one measly decent sized variable gravity rodent lab in orbit. The one currently on the ISS is way too small for reproductive life-cycle testing. If the results looked good, we could move on to larger animals and eventually primates. Just a minor amount of thought reveals that if we start now with the rodent lab, in a decade we may have a good idea of the gravity level needed for humans to thrive. But that is only if we start now. And if we methodically start with lower life forms rather than primates, ethical concerns will be minimized.

The Weinersmiths at least acknowledge that there may be technical solutions in the form of creating artificial gravity via centrifugal force, which they defer to a future chapter. However, the authors put forward an idea I have not seen anywhere else, and which may be original to them. It is an interesting one – we might construct rotating habitats around the Moon and Mars for use as birthing centers and creches, with the "life cycle" of the Moon/Mars settlers starting on the rotating habitat, and then continuing on the surface once a certain level of physical maturity was reached. Add to this the notion or Martian/lunar space elevators (which are much easier to build than on the Earth) to make access to these rotating habitats easier, and the likelihood of a successful Martian or lunar space settlement goes way up.

The authors also consider the rotating track approach to adding gravity to the Mars and Moon, dubbing this the "pregnodrome." They describe this as "costly, dangerous" although precisely why isn't made all that clear. Next, they cast shade on the notion of artificial wombs with radiation proof cladding, something they report was considered at the 2021 National Space Society Space Settlement Workshop (disclosure – I was the lead organizer of this event). This is the point where the authors suddenly switch from considering the harmful impact of microgravity to focusing on radiation.

The Weinersmiths mention a basket of radiation-related social concerns and speculation about space settler life-cycle, but what is not presented is any real sense of whether radiation is actually an issue. For rotating space settlements, there is reason to think the answer is no. For settlements on the lunar or Martian surface the question reduces to how much – and when in their lives – settlers spend significant

time on the surface where radiation is hard to avoid. It is difficult to imagine as the Weinersmiths do that Martian settlers would cycle back to the Earth to have kids. A far less expensive and socially more likely outcome is that children and people of reproductive age will totally minimize their "surface time," with the result that perhaps only settlers who have completed their families are allowed to work "outside." This is certainly not how people live on the Earth, but there is no obvious reason it is not workable.

Next the Weinersmith take on biotech solutions to radiation. Their arguments are suffused with skepticism that it is feasible to create radiation resistant humans (even though many animals are much more radiation resistant than humans), but mostly they seem to view germ line genetic engineering as fundamentally unethical. Or perhaps more accurately, they worry that germ line engineering, along with the abortion of non-viable fetuses will be highly incented by living in space, leading to situations where space settlers will both modify their children and terminate those that do not meet the desired characteristics. A number of space advocates (none associated with the NSS) are quoted as advocating these kinds of ideas.

News Flash: Settling space is not going to resolve ethical debates about germ line engineering and abortion. There are deeply entrenched sides to these debates on the Earth, and no doubt there will be in space as well. Saying we should not settle space because this or that ethical position that I don't like may gain strength from future space settlers seems like nothing more than the imposition of your ethical position on those with different views. It is absolutely true that most space advocates prefer to avoid these kinds of discussions, but at some point, that will no longer be possible. I fully expect to see space settlements where abortion is virtually a sacrament, and others where it is viewed a high moral evil. By the same token, there will be settlements that practice germ line engineering and those that ban it.

Personally, I advocate for research to genetically increase human radiation resistance since I suspect it will be of great benefit to people living on the Earth right now, and might even greatly increase resistance to cancer. However, at this point there is no reason to believe this technology is essential to space settlement.

"Going Big"

Buried at the end of Chapter 3 lies an important proposal on the preferred strategy for space settlement. It is in these kinds of discussions where much of the value of the Weinersmiths' book lies. They are skeptical of "bootstrapping" as an approach to settlement, which they view as creating unnecessary ethical risk. In this methodology, which is utilized in SpaceX's Mars settlement planning, each expedition builds on the last, with the expeditions gradually growing in size over time, but eventually resulting in rapid self-sustained growth of the settlement. The authors concern with the approach is that there is potentially a long period in which the space community is fairly small. This creates psychological and sociological issues, as well as imposing a lower living standard due to a lack of access to different kinds of specialized knowledge we often assume is readily on hand, say for example, a dentist who just does root canals.

Let us consider an alternative to the Weinersmith's proposal that we "…wait until you have the data and technology you need to safely and ethically move forward…and then settle a very large number of humans during just a few years." There is clearly something to be said for their approach, but they are

mainly responding to Musk's plan to build a city on Mars. There are other ways to settle space while minimizing risks to the settlers other than waiting 100 years for the job to be easy. Another critique of their proposal is that technology just does not develop this way – there are always a long series of modest developments that very gradually lead to mass usage. There is no way of compressing this learning, where each step builds on the next. Attempts to plan, design, and build everything up front lead invariably to excessive costs and project failure. In other words, we can only build a very large space settlement after we have built a series of precursor settlements of smaller sizes, going all the way back to the humble ISS.

The Weinersmiths imagine that "going big" will allow us to create a space settlement so large that we can avoid any kind of ethical dilemmas. As a thought experiment, imagine that we have built a space settlement the size of the planet Earth. Do we think that doing so will resolve all our ethical dilemmas? I fear the Weinersmiths are engaging in the same kind of wishful thinking they accuse space advocates of doing. Of course, it is highly desirable to minimize the spartan, small-crew stage of a settlement by rapid, regular growth of capabilities and population. Those who go early will go knowing they are at much greater risk than those who come later. And the authors need not worry – even on Elon time we won't be starting construction of the city on Mars in earnest for 20 years. More likely it will take longer, so assuming we push hard now, most of the open questions related to space settlement will have solid answers by then. But the time to do the work is now, not in 100 years.

Discussion of Chapter 4: "Spacefarer Psychology"

The Weinersmiths present themselves as having a moderate position on this matter, saying "Psychology in space is a serious constraint on space settlement, not because of dramatic problems, but because space settlements may be broadly similar to Earth in their rate of mental illness. Given that Earth has lots of facilities and specialists for this sort of thing, space settlements should do likewise, which means once again that a large settlement with a large population is desirable."

They follow this notion with lots of material about astronauts being liars and the problems of small teams in tiny cans. For the most part this is all irrelevant, except with regard to the very early stages of settlement, which will feature small crews in cans. But they also present a lot of material suggesting that, in fact, highly selected astronauts – and submariners and polar explorers – have coped fairly well with the small teams and the tiny cans, so, assuming rigorous selection of early groups of settlers, there is not likely to be a serious issue. There is a lot of interesting space history in this chapter – it is simply not that relevant to space settlement.

On page 95, the authors say "These sorts of screening mechanisms are very important, but will not work well for a permanent settlement…. Standards will have to fall." They further add that "Another source of subpar candidates will be your children." Here at last we have something worth taking a closer look at.

The Weinersmiths have the idea that the average level of mental health in space settlements will, over time, verge toward the average level of mental health on the Earth. There is good reason to think that this will not be the case except in the very long run, and perhaps not even then. Firstly, even if we select 1,000,000 candidates for Musk's Mars city, since the current population of the Earth is 8,000,000,000 people, we are picking 1 in 8000 people to go to Mars. This is an extremely high level of selectivity. It is a

research project to determine a good Earthly model, but one might expect something like Bell Labs, Sandia Labs, or some other large research institute with 1,000s of staff members would fit the bill. Typically, every single person in such institutes has a master's degree in something, with a very large fraction having PhDs. And places like Bell Labs or Sandia are limited by law and custom in terms of selectivity. For example, one place to start in terms of being more selective would be exclude anyone with any relative who was schizophrenic. The likely consequence of this decision would be that the space settlement would have very few schizophrenics to start with (hopefully zero), and in subsequent generations schizophrenia would occur at a much lower rate than on the Earth.

The point of all this is that space settlements with any kind of reasonably high level of selectivity are going to have much lower incidences of all kinds of mental health issues than are present in a typical large city on the Earth. And the settlement organizers are going to want to bring on the most mentally stable, productive, and intelligent people they can find – and they will test their teamwork before putting them on a rocket. For a long time, there is going to be a requirement that every settler contributes significantly to the community - no one is going to want to be living on Mars or in an O'Neill cylinder surrounded by drug addicts and schizophrenics.

And because the genetic factors related to mental health issues will be much lower among the space settlers than in a typical Earth population, children born in space will have, on the average, fewer mental issues than on the Earth. In fact, this kind of "founder effect" is part of the entire point of creating a new settlement far away from existing populations.

In the very long term, the Weinersmiths are correct and standards will fall. But this will occur when there are 100s of millions or billions of people living in space, and there will be extensive mental health facilities on Mars and elsewhere. Even then, the cost and challenges of emigrating to space are likely to create a significant filtering effect. How many homeless drug addicts (a high proportion of drug addicts have mental health issues as a comorbidity) living in Seattle emigrate to New Zealand each year to become sheep farmers? I am betting the answer is zero.

The Weinersmiths focus mostly on settling Mars, stacking the deck against space settlement. In the view of most NSS members, the first orbital space settlements will be in cislunar space. For all such early settlements, as well as those on the Moon itself, the most likely approach to severe mental illness would be returning the patient to facilities on the Earth. You would need some on-site mental health support – psychiatrists and psychologists for evaluation, as well as some therapists – but on a much smaller scale than is typical on the Earth. And since Earth is not far away, any psychiatric medicines needed will be within their normal shelf life.

It is only when you add in the long journeys to and from Mars that things start to get difficult, which is part of why NSS Leader Eric Drexler as long ago as an October 1984 L5 News article argued for cislunar settlements over Mars settlements as the place to start[12].

The does raise the question of, assuming humans can thrive in 1/3 gravity on Mars, how can we overcome the problems the Weinersmiths envision for space settlements so far from the Earth? One answer is to defer settling Mars while focusing on cislunar development and settlement. But just deferring settling Mars will not automatically solve the challenges that must be overcome. This points out the big flaw in the Weinersmith's "go big" a long time in the future approach to space settlement. Just waiting will not automatically create any of the technologies needed to support a distant space

settlement. If we want to settle Mars, or points further on, we need some specific kinds of technology that will not spontaneously appear with the mere passage of time, creating the need for near-term space settlement focused research.

Additionally, "going big" fast is in practice impossible. There will be a first ship to Mars with a modest crew, perhaps 24. It will take decades of hard work to move from 24 to 100s and then 1000s of settlers. For a long time, mental health support on Mars will be very limited by the small population. If humans had practiced what the Weinersmith preach, we would not have settled the Earth, let alone space. Many times, small groups of humans went far beyond the support structures of their homeland, or even their home tribe, and dealt with challenges as they came. Consider as an example early humans crossing the Bearing Strait land bridge and settling the Americas. Did they "go big" and look for a large mental health infrastructure before crossing over??

Technology is advancing rapidly, and the ability to produce a huge variety of drugs in a small package seems like a project of decades, not centuries. Such a capability would be of great value on the Earth as well as in space settlements. Additionally, powerful psychiatric AIs may reduce the need for a large mental health staff at a Mars settlement. Artificial intelligence technology is advancing by leaps and bounds right this minute, and it is not impossible that by the time I finish writing this long article, a true AGI will exist (not joking here). If there was a method of "suspended animation" to allow the severely mentally ill to be returned to the Earth, or fast nuclear rockets for the same purpose, this would make a big difference in the amount of mental health staff needed on Mars. All these technologies would have real benefits on the Earth, so why not pursue them now, with a focus on using them to settle Mars?

After proposing that the seriously mentally ill be returned to Earth for treatment, we need to grapple with two issues that will arise:

- The family of the mentally ill person may wish to return with them.
- Since almost by definition, a severely mentally ill person will not ever return to anything like the level of functioning needed to qualify to join a space settlement, in practice returning the person to the Earth is a permanent exile from their friends and family.

The decision to send a patient back to Earth will be a major one, and their family may lobby to keep them on the settlement. Dealing with this situation requires serious thought. Early on, the best approach may be to provide a generous subsidy to allow the entire family to return to the Earth. But it is easy to imagine a situation where although the parents of a child are willing to return to Earth, the child's siblings who have never been to Earth will resist this idea. The idea of such a family split may seem shocking to modern day Americans, but some of my great-grandparents emigrated from Europe to the U.S. by themselves as teenagers, surely a more perilous course of action than staying behind on the settlement where you were born.

In conclusion, the authors raise some goods points about the need to address mental health issues when settling Mars or other similarly distant locations. However, their arguments just do not apply to cislunar settlements, and their overall analysis is overly pessimistic in terms of the likely need for mental health facilities in any space settlement.

I am "part Weinersmith" on this issue. There are real mental health challenges to overcome in order to settle Mars, but the best way forward is to:

- Develop and settle cislunar space as rapidly as possible over the next 50 years.
- While doing so, develop the technology needed to sustain mental health in a Mars settlement without requiring it to be of gigantic size.
- When ready, start settling Mars, possibly much sooner than 50 years in the future, but not this year. Realistically, it will be ten years before SpaceX is ready to send significant numbers of Starships to Mars anyway.
- Accept that whatever support we provide for a distant settlement, those who go will be taking the same kinds of risks humans have taken throughout history as we moved to new lands.

Discussion of Chapter 5: "The Moon: Great Location, Bit of a Fixer-Upper"

"The Case Against the Moon"

The Weinersmiths recount in sharp but accurate prose the various problems with Moon – radiation, two weeks of night, lack of nitrogen and carbon, extreme temperature variations, no protection from radiation by an atmosphere, super-scratchy regolith, etc. Although the authors are clearly not lunarians, it is hard to say they are exaggerating the problems with settling the Moon. They even reference a paper from the NSS Space Settlement Journal (June 2021)[13] to buttress their case that there are no resources on the Moon worth mining and bringing back to the Earth. I have long held that the potential value of Helium 3 mining on the Moon is greatly exaggerated, so this topic seems like one that we agree on.

"The Case for the Moon"

The authors do a reasonable job of arguing the pro-Moon case at its best. The Moon is a great place to start since it is conveniently located near Earth and much easier than the Earth to launch from. Additionally, the lack of a lunar atmosphere allows inexpensive to operate mass drivers to launch materials to orbit for something approximating the energy cost of doing so. Plus, certain useful materials, notably oxygen, aluminum, silicon, and iron are relatively abundant in the lunar regolith. Oxygen at 43% by weight is especially plentiful and relatively easy to extract by heating.

This section is flawed by a somewhat patronizing lecture to nerds about waxing enthusiastic about mining low concentration elements when it is harder than it seems. This is all true, but may be irrelevant for a number of reasons. One is that the best places to mine iron on the Moon are almost certainly locations where large nickel-iron meteors landed long ago. Another is that lunar mining seems likely to involve large scale regolith processing. Imagine a system that scoops up the regolith and then heats it to exact oxygen (the easy part) and then uses other means, possibly biological, to concentrate the trace elements. The point is that you are doing this for the "big three": oxygen (43%), silicon (21%), and iron (13%). The other stuff is just a by-product of a larger system. And you can always go back and process the slag more later. In other words, no one will ever process lots of lunar regolith <u>just</u> to get at some trace element. An important detail often overlooked lies in the variation of elemental concentration from one site to the next, and we have sampled a fair number. Titanium may seem like a "trace" element in some locations, but is more abundantly present at the Apollo 17 landing site.[14]

“The Moon’s Upper Crust”

Give the authors credit for expounding on the valuable geo-physical features of the Moon – lava tubes, peaks of eternal light, and craters of eternal darkness. They are pessimistic on the total amount of lunar water – and they may be right – but not so long ago we were convinced the Moon was totally dry. After more exploration, we will see how much water there really is. But their point remains, in the grand scheme of things lunar water may be very helpful, but there is not a vast amount of water, and certainly not enough for a lot of rocket launches. One thing the Weinersmiths appear to have missed about the Moon is the potential for local manufacture of aluminum-oxygen rockets. This may sound silly, but it definitely works, although with a lower specific impulse (ISP) than most other fuels.

The peaks of eternal light and craters of eternal darkness may be very significant in the near term as we return to the Moon, but the lava tubes have greater long-term significance. They provide a very favorable place with moderate temperatures and natural radiation shielding to build lunar bases and eventually settlements, assuming the gravity issue can be worked out.

“Who Wants to Settle the Moon?”

The Weinersmiths are basically correct in concluding – no one! The Moon is instrumental in many ways, but not a great location for early settlements. But the Moon does not need to be “settled” to be an industrial center that makes orbital space settlements economically possible. Large, mainly robotic mines and factories might feed iron and aluminum stock to several mass drivers that launch the material to orbital construction sites where rotating settlements are constructed. The population on the Moon would be more like that found today on oil drilling rigs – technical specialists that rotate regularly back to the Earth or orbital stations. In fact, the first orbital stations might be built as places for the families of the lunar workers to live in Earth-gravity without the cost of returning the workers to the Earth.

The Moon: My Own Conclusion

In spite of the nits picked above, the Moon chapter is one of the best chapters in the book. It is suitable as a somewhat skeptical but fair description of the why the Moon might be important in spite of what seem like obvious problems. But as will be seen, because the authors come down strongly against free space settlements, they don’t fully appreciate the critical importance of lunar economic development.

The chapter does not consider at all whether there is an economic future for the Moon based on something other than a massive mining operation to fuel rockets to Mars or similar projects. Could tourism alone support a significant lunar economy? Tourism combined with special purpose telescopes – infrared telescopes in eternally dark craters and radio telescopes on the far side of the Moon? Adding in the sovereign lunar bases that will surely come to exist once Starship enables them? Such things can only be determined for sure by allowing companies to move forward with Moon-focused business plans today, rather than waiting for some nebulous future when we are “more ready.”

Discussion of Chapter 6: "Mars: Landscapes of Poison and Toxic Skies, but What an Opportunity!"

"The Case Against Mars"

The Weinersmiths recount the various issues with Mars – thin atmosphere of carbon dioxide you can't breathe, poisonous perchlorates in the soil, 1/3 Earth gravity, very long travel times compared to the Moon, massive dust storms, no magnetic field to protect against solar radiation, and ¼ the solar radiation that arrives on the Earth. They beat the drum loudly about the dangers of perchlorates, although this is good reason to believe the problem is manageable. Perchlorates are water soluble, so they can be cleaned off surfaces with water. There are a variety of ways to remove them from water, but one of the more interesting ways is via bacteria that consume perchlorates and release oxygen. Additionally, the effects of perchlorate on the thyroid gland are reversible, and we have well understood medical technology for managing thyroid problems. This is not to be overly Panglossian – perchlorate damages the lungs and harms fetal development, so a strong system to keep settlers away from dust will be a required feature of any Martian settlement.

"The Case for Mars"

As the authors put it "… the location isn't great, … but "… Mars has all your favorite elements: oxygen, hydrogen, carbon, nitrogen!" And lots of water – not compared to the Earth – but compared to the Moon water is abundant. There is a carbon dioxide atmosphere, which is helpful in making methane rocket fuel via the Sabatier process which takes in carbon dioxide and hydrogen while giving off methane and water. The day is almost the same as on the Earth – 24.7- hours, and the climate, while not balmy, is a vast improvement over the Moon, reaching what we think of as room temperature during the summer at the equator. Add in the excitement of the search for possible ancient Martian life, and things seem to look pretty good for settling Mars. Certainly, Elon Musk is all in on this planet.

"Who Wants to Go to Mars?"

The Weinersmiths are not correct in concluding that "just about everyone who wants to do space settlement" are Martians although they are wise to dismiss terraforming Mars as a project for the far future. As noted by L5 Leader and nanotechnology pioneer Eric Drexler, Mars is just not the best place to start.[15] The most important reasons why are (1) distance/deep gravity well, (2) lack of short-term economic motivation, and (3) 1/3 of Earth's gravity. Additionally, Jeff Bezos is not enthusiastic about Mars either. Plus, as we will see in a future chapter, the Weinersmiths try too hard to dismiss solar system locations other than the Moon and Mars, including Venus and Titan, each of which has supporters in the space settlement community.

Mars: My Own Conclusion

There is an element in the authors' approach of building Mars up as a settlement destination so it can be torn down later. We will settle Mars eventually; it just isn't likely to be the first place we create a true settlement. The most important reason is that we don't know if humans can thrive in 1/3 Earth gravity. Even if the answer was a solid yes, or if those slanted rotating tracks proved to be practical, Mars is still really far away compared to cislunar space, and that is where space settlement needs to start.

Discussion of Chapter 7: "Giant Rotating Space Wheels: Not Literally the Worst Option"

"The Case Against Open Space Settlements"

The Weinersmith's big reason for being against "Open Space Settlements" (normally called "free space settlements" or "orbital space settlements") is that they think it is a lot more work than settling Mars or the Moon. Sadly, this chapter seems hastily written and rather short. There is a lot of discussion about why you can't build a small rotating space settlement, and hand-wringing about how expensive the ISS was to construct as though this number had anything to do with the costs a private construction firm would incur building a larger orbital structure. We've already seen the dramatic drop in satellite costs/kg in the context of the not-really-mass-produced-but-no-long-bespoke SpaceX Starlink satellites. As space development proceeds, costs will come down even more.

The obvious solution to some of the authors' concerns is to just build a big space settlement. Not a really big one, but big enough so that all the "smallness" issues go away, including any need for rapid mass rebalancing, although in practice this is just pumping water from one tank to another. Fortunately, building a big toroid reduces to building a tube with a diameter that is a tiny fraction of the radius of rotation. Thus, the "bigness" of at least some rotating settlements is less than you might initially think. For example, in *Space Settlements: A Design Study* (NASA SP-413, 1975), the single torus design for 10,000 persons has a major axis of rotation of 830m, and a minor diameter of 64m. And building that 65m diameter toroid reduces to building a machine with the diameter of 65m that is empty in the middle and that is wide enough to incrementally build segments of the toroid from standard parts. For comparison, the ISS is 108m in its longest dimension[16]. Surely an orbital space settlement looms as a large project, but not so large as it may have seemed in the past. Least someone accuse me of understating things, the structural mass (excluding shielding and atmosphere) of the toroidal space settlement in this study weighed in at 150kt, about 300x the mass of the ISS. Yes, this is a big project, but at the same time, this is only 1,000 Starship/Superheavy launches. These numbers would only apply if the settlement was built in LEO; the preferred approach is to use lunar materials and construct it in a high orbit.

The authors then argue that if we have the industry to build a free space settlement, why don't we just use it to build a settlement on Mars or the Moon. The answer, of course, is that Mars is far away, and no lunar settlement has the following advantages:

- Continuous solar power
- A high probability that humans will thrive in the gravity provided
- A much firmer legal basis for operations
- Can be moved to different locations in the solar system to seek economic advantage

Also, no scratchy regolith or nasty perchlorates out there at L5. FYI – no Mars settlement will have these advantages either.

The Weinersmiths then take on the argument that orbital space settlements will provide new land with a controlled environment by suggesting that the same result can be achieved on the Earth by building skyscrapers, etc. This thinking seems obtuse – no archology on the Earth has any potential for the following:

- Physical/temporal separation from the Earth

- An opportunity to create a distinct culture via separation
- Any degree of safety from disasters that threaten the Earth, i.e. super volcanos, etc.

Additionally, covering the Earth with massive buildings seems a terrible idea. Far better to have most of the human population in space while making the Earth mainly a park.

And then they review the straw man idea we will export population to orbital settlements to save the Earth, only to dismiss it as unworkable (see the response to this topic above).

It seems odd that the authors do not mention one of the biggest challenges to building orbital space settlements – finding nitrogen for the atmosphere. Advocates of free space settlements tend not to focus on this too much, but it requires a cost-effective solution, most likely mining the Earth's atmosphere from orbit. If you were building near Venus, the atmosphere of Venus would also be a possible source of nitrogen. Samples from the asteroid Ryugu have been shown to contain nitrogen as well, making this another potential source for further consideration.

"The Case for Open Space Settlements"

The authors acknowledge that only orbital space settlements provide any short-term assurance that humans could thrive on them. We just don't know what 1/6 or 1/3 of Earth's gravity will do to the human life cycle. They also note that nearby orbital nurseries might enable true settlements on Mars or the Moon, an idea that is worth serious consideration it has not yet received in the space settlement community, and that will be expanded on later in this article.

They then note that rotating stations have a variety of advantages as locations for industry in space, including ease of access (no gravity well), availability of many gravity levels, and potential as a tourist destination that supports cool sports. The Weinersmiths are skeptical of this idea, but the company VAST[17] has already embarked on the design of such a destination, so the answer may emerge sooner than they expect.

Finally, the authors note that a rotating space settlement would function very well as an Earth-Mars or Earth-Moon "cycler" to enable safe passage to these destinations. Their argument is that this is a very limited market, not a big driver for the construction of orbital space settlements. However, as I will expand on in the next section, just providing cyclers to support inner solar system destinations could be a significant market for orbital space settlements.

Open Space Settlements: My Own Conclusion

First, "Open Space Settlements" is a dreadful name. Open to what??? Often used is "free space settlements" but this can be confusing as well. Are they rent free? Or libertarian? Hence, "orbital space settlements" is used most often as being accurate and less confusing.

The Weinersmiths are so down on orbital space settlements that they didn't bother writing a section on "Who wants to live in open space settlements?" They note "… they have for decades been the main pursuit of the National Space Society" (nss.org), which is true. They also associate the case for orbital space settlements with a particular period in the 1970s "…when it appeared that environmental degradation was going to cause imminent worldwide famines, and when the price of space launch appeared to be falling rapidly." But they continue, "But the widespread famines never came, renewables

got cheap, and space travel has remained relatively costly, even accounting for recent changes." The obvious rejoinder is that a lot of people are again worried about famine brought on by climate change, and unlike in the 1970s, the price of accessing space is actually – and not theoretically – dropping. And renewables are not cheap sources of baseload electricity.

One thing the authors miss is that there is a much better short term economic argument for cislunar orbital space settlements that for settlements on Mars. They say (page 155) that "If we could take a vacation in any space-settlement concept, we'd always rather a giant space toroid than the dusty wastes of Mars or the Moon." My guess is that many others would agree, especially when they realize that a ticket to L5 costs less than a ticket to the lunar surface, and much less than a ticket to Mars.

Some potential reasons for the first few space settlements include:

- LEO tourist destination in those low-radiation regions near the equator.[18]
- Earth-Moon slow-boat cycler[19] that is some combination of a retirement community and a cruise ship with fantastic views and side trips to the lunar surface for those who pay extra.
- Saving money on crew transportation costs for the staff of asteroid or lunar mining companies.
- The variable gravity manufacturing facility (if VAST is already working on one, maybe we should take this seriously).
- A high security location for economic activity focused on intellectual property. Imagine a settlement that specializes in patent law.
- Cislunar condominium space cruise ship[20] modeled on existing ocean-going ventures.

The goal here is not to find a justification for building large numbers of orbital space settlements, it is to find a real business case for the first one – or two. After that costs will drop, and the number of applications will grow, even if they never include the manufacture of solar power satellites. Just providing cyclers to connect all destinations in the inner solar system would require perhaps a dozen space settlements. Ceres here we come!

One last thought – the Weinersmiths never mention Jeff Bezos and his interest in orbital space settlements in this section, although it seems relevant that the other space billionaire prefers them over Mars. Might Bezos know something that they don't?

Discussion of Chapter 8: "Worse Options"

My Opening Comment

This is the worst chapter so far in *A City on Mars*. It skips over a lot of interesting space settlement work that has been done, and dismisses what it does cover rather airily. Sadly, it lacks the kind of in-depth research that is on display in most of the other chapters, where even if the overall argument is wrong-headed, you get a host of amusing historical space anecdotes. The chapter starts with the opening line "The Moon, Mars, and space stations are the most common proposals for space settlement…." If I didn't like "open space settlements" I like "space stations" even less since it is fundamentally confusing – we already have two space stations in orbit right now.

"Asteroids"

- I have mixed feelings about discussing the asteroids as targets for space settlements. No one is ever going to "settle an asteroid." However, asteroids might be mined to build an orbital space settlement. When people write about "settling the asteroids" (and they do, although the Weinersmiths never mention any of the relevant papers or books) they are usually referring to a way to rapidly and cheaply use an asteroid to manufacture an orbital space settlement. In addition to the obvious approach of melting the asteroid down and using the resulting materials to construct an orbital space settlement, some other approaches include rotating an asteroid while melting it using concentrated sunlight.
- Putting a net over a rubble pile asteroid and rotating it.[21]
- Drilling a hole in an asteroid to place a rotating cylinder inside while using the asteroid as the non-rotating external radiation shield.

Rather than talk about the literature related to settling the asteroids (including the 1964 classic *Islands in Space: The Promise of the Planetoids* by Dandridge M. Cole and Donald W. Cox, which presages O'Neill in many ways), the authors focus on this notion: "Ideas for using asteroids to promote settlement tend to focus on the potential to make money by harvesting asteroid resources." Although space settlement advocates are interested in the possibility of the widespread usage of asteroid wealth, their greatest focus lies in using asteroid materials in space to build orbital settlements.[22] The Weinersmiths do get around to mentioning this on page 160, but since they have already dismissed orbital space settlements as a realistic prospect, the value of using asteroid resources (no gravity well and elements not found on the Moon) to construct things in space just does not impress them.

This section trots out the common argument that space mining will never work because it if does the cost of platinum will plummet, etc. and no one will make any profits. Additionally, the children now slaving in poisonous mines on the Earth will be put out of work. The flip side of these events might be viewed as positives by others:

- Materials like platinum will be as inexpensive as aluminum and can be used in countless ways to better everyone's lives. Note just because a material sells at a low price does not mean you can't make money selling it. Supermarkets run on a 3% profit margin as one example.
- Dangerous, polluting mines on the Earth can be shut down.

An entire book could be written about the benefits of mining the asteroids. And many such books have been written, including *Asteroid Mining 101* (John S. Lewis, 2014) and *Asteroids: How Love, Fear, and Greed Will Determine Our Future in Space* (Martin Elvis, 2021). The Weinersmiths reference the Elvis book a number of times in *A City on Mars*, but appear to have found his excellent work unconvincing. One reason these authors may not have impressed the Weinersmiths is that asteroid mining advocates often gloss over how asteroid mining can be done inexpensively. But one thing is certain – if we can't mine the asteroids more cheaply than we mine Africa or Arizona, we won't be eating with cheap platinum flatware.

Concerns expressed by the authors about a few rich folks getting richer mining asteroids seem at best a long-term prospect, and more like an example of cognitive dissonance on their part. If asteroid mining is

pointless and unprofitable, then there will be no asteroid barons. If asteroid mining leads to vast riches for a few, this could only be if they were mining and selling large amounts of materials cheaply to many people, and those people would surely benefit from the wide availability of inexpensive materials and the reduced pollution from mines on the Earth.

The Weinersmiths seem concerned that there is only one "closest" asteroid energetically, and worry that Musk or Bezos will grab it first. But there are lots of almost as close asteroids, and we are finding more all the time. The difference between "bringing in the steel" from the closest vs second closest asteroid represents just a small fraction of the mass of the asteroid being mined being used as fuel, and it is hard to see this as giving some vast advantage to mining the single energetically most close asteroid.

"Venus"

The authors really give the heave-ho to proposals to settle Venus, although a case can be made that Venus is the easiest to settle location in the inner solar system as expounded by Geoffry Landis from NASA Glenn[23]. *A City on Mars* does not mention the Landis paper in either the notes or the bibliography.

There are a large number of positives for Venusian cloud cities including:

- Readily available oxygen and nitrogen, which are a lifting gas on Venus
- Essentially 1 gravity, and real gravity rather than pseudo-gravity
- Pressure and temperature at the right altitude that are Earth-like
- Venus is easier to reach than Mars
- Reasonable chance Venus could export nitrogen to orbital space settlements more cheaply than the Earth

The challenge is where do you get the metals needed to build the cloud cities? The answer is probably an asteroid or few that you move into orbit around Venus. There are other issues – winds, corrosive atmosphere – but I'd bet that someday the cloud cities of Venus will be a popular tourist destination even if they are not heavily populated.

"Mercury"

The Weinersmiths don't consider what Mercury might be good for eventually, but they do make a strong case that it is not a prime short to medium term space settlement target. In the long run I would not be surprised to see something going on there – robotic mining, or using solar power to manufacture anti-matter – but we are looking a long way out.

"The Outer Solar System"

The Weinersmiths give the entire outer solar system only two paragraphs – not even a half page! In some sense I can't blame them, as settling the outer solar system is a project for centuries from now, when the inner solar system is well settled, and fusion power a commonplace. Additionally, living in the outer solar system is mainly going to be via fusion powered orbital settlements, so if you think those would be impossible, then you are naturally going to easily put aside the outer planets.

There is a growing literature advocating for Titan as a settlement target[24], while the Weinersmiths fail to mention Titan at all. I am not a big fan of Titan, especially on any kind of short to medium time scale, but

in a book about space settlement, I would expect to see more on space settlement and fewer irrelevant old astronaut stories and jokes about Herman Oberth.

"Other Suns"

The entire rest of the universe gets dismissed in about one page. Again, on some level this is understandable, since interstellar settlement seems a project for many centuries in the future – after the solar system, including the Ort Cloud and the Kuiper Belt, have been populated. The one-page essay is a superficial argument that generation ships won't work. Arguments that interstellar space settlement must be necessarily impossible appear in works as diverse as Kim Stanley Robinsons' *Aurora* and Werner Herzog's documentary Last *Exit: Space*. Regardless of the merits of their arguments, surely interstellar travel remains distant, and hardly worth the time to refute at length, causing one to wonder at the energy being devoted to attacking the idea. One speculative thought is that Robinson, Herzog, and their ilk may fear that if we discover Earth-like exoplanets in the near future, interest in space exploration and settlement will explode, with greatly increased drive toward rapid settlement of more nearby locations.

There is a considerable literature on interstellar travel and colonization. There are several ideas that I suspect will be involved when we eventually set forth to the stars:

- Laser propelled solar sails, combined with intermediate "way stations" along the way.
- Gradual, rock by rock expansion toward the stars, with the result that traveling to the stars will be more like humans expanding over the Pacific, and on a time scale of 1,000s of years. The so-called "ethical" issues of sending off a generation ship will have no salience – we will be talking about moving the home you have always lived in just a bit further out.
- We won't send a single habitat. The minimum to have a reasonable chance of success is three, with the crew for two ships spread over three to allow for the total loss of one. And more likely, a fleet will go, further reducing the issues associated with sending a small group that drifts culturally over time.

You may be thinking – gee – these kinds of projects are way too expensive for the Earth to support – and you would be correct. But they are almost a frivolity for a solar system with millions of orbital space settlements and a population of 100s of billions.

Worse Options: My Own Conclusion

A long time ago, I read an article in Analog Science Fiction about how difficult it would be to build a hydrogen bomb. The writer complained that to start the fusion reaction, it would take the heat of an atomic blast. And this was exactly, as it turns out, how hydrogen bombs work – they start with an atomic bomb!

Often, when you explain how something is not possible, you lay the seeds of how it can work. And I think the Weinersmiths are on to something with their concern about "going big" that space settlement advocates need to address. The question is – how can we avoid a long period far away with small crews in cans boot-strapping settlements? Some element of boot-strapping is essential, and earlier settlers are not going to have all the benefits of living in a modern city, but still, the authors raise real concerns.

To answer those concerns more fully, I am going to outline a system for space settlement using one of their ideas, and a number of other ideas from various places. Space settlement is likely to proceed in stages, in temporal order:

- Cislunar settlement, including access to Near-Earth asteroids
- Inner solar system settlement – mainly Mars, Venus, Ceres, and the rest of the main belt asteroids
- Outer solar system settlement
- Kuiper Belt/Ort cloud settlement
- "Interstellar highway" settlement/building
- True interstellar settlement

The key ideas are:

- We will utilize a network of "Cyclers" that travel between the Earth and the target destinations. These cyclers will allow for large numbers of settlers to travel to the target in something like Earth-gravity and Earth-radiation levels. These cyclers are standard orbital habitats, perhaps with a variety of gravity levels to facilitate adjustment to the surface gravity of different destinations.
- We will settle objects that have low gravity levels by starting with a nearby orbital settlement that is built somewhere else and moved to the target. This means that the resources of a 10,000-person base are available from the get-go. Better yet, the orbital settlements offer Earth-gravity to support childbirth and child rearing. This may not be as big as the Weinersmiths hope for, but it is much bigger than a few folks in a can.
- To minimize the need to go into gravity wells, we will start with small objects with minimal atmosphere. Something like Ceres is a great example of a place to settle before Mars.
- As time goes on, we will learn how to build space elevators to connect the orbital zone to the resources on the ground where there is a meaningful gravity well.

The Moon is the place to start. We will perfect orbital settlements and mass drivers during this period. When there is a thriving cislunar economy, we will start building the first Ceres cyclers. Ideally, we build three – one is always going out, one is always coming back, and one ends up staying at Ceres. Note that just having cyclers for the Moon, Mars, Venus, and Ceres requires 4 * 3 = 12 orbital habitats. This calculation assumes the Earth as the "hub" but we might see Mars-Ceres cyclers as well. The "traveling" habitats would have relatively small crews and large numbers of passengers headed outbound. On the way back they would presumably be less full, but would also allow for regular, safe return of those who want to head back to the Earth. I suspect that there will be a number of tourists as well, enjoying a multi-year journey around the solar system.

We mine Ceres using mass drivers, and build more orbital settlements. Ceres has a lot of water compared to the Moon, so we have a good shot at this. The big issue is always going to be nitrogen, which will need to come from the Earth, Venus, or perhaps some asteroids. At first, all the orbital habitats will be constructed in cislunar space, but over time the focus of construction will move to further out locations like Ceres or Mars.

In this vision, settling Mars would be just like settling Ceres. First set up the cyclers. Then start mining Phobos and Deimos. Follow by building a base on the surface with at least a few orbital settlements around Mars offering full Earth gravity to raise children on, as suggested by the Weinersmiths.

The nice thing about this vision is that it allows us to "settle" Mars, the Moon, and Ceres with confidence since we know we can provide 1G gravity with a nearby orbital settlement. The main consequence is that people would have to organize their lives differently. You would be born and grow up on the orbital settlement, and then have kids yourself at a relatively young age. Sometime between 30 and 40 you might choose to start living on the surface. I am not at all sure how this would work out, but it does cover the corners of the box from an environmental point of view. It might turn out that very few people really want to live underground on the Moon or Mars. Or they might be eager to leave the cramped orbital settlements. Or they might like to bounce around. Excitement guaranteed.

Now this may not happen, especially if we rapidly develop fusion rockets, but it seems like one way we could settle the inner solar system with technology we have well in hand, or at least that requires no major breakthroughs.

Discussion of Chapter 9: "Outputs and Inputs: Poop, Food, and 'Closing the Loop'"

My Opening Comment

This is one of the better chapters in *A City on Mars*, although larded with too much initial irrelevant material on pooping in zero-gravity and freeze dried "space food." I suggest jumping to page 180, "A Farmer on Mars" and reading from there to the end of the chapter.

"Outputs: The Inevitable Space Toilet Discussion"

We find here a variety of amusing stories and space history tidbits, but since space settlers will not live in zero-gravity, this section is simply irrelevant.

"Inputs: Space Food—Bad, But Not as Bad as it Used to Be"

Another fine section filled with amusing stories and space history tidbits, but since space settlers need to grow their own food and not rely on freeze-dried imports, for the most part this section is, again, irrelevant. Certainly, all the information about how foods taste in zero-gravity is irrelevant.

"A Farmer on Mars: The Fresh Future of Space Food"

The authors provide a reasonable overview of the need for and possibilities of growing your own food in a future space settlement. My only complaint that the potential for growing meat in vats is sufficiently large in the context of a remote space habitat that it deserves much more attention than they give it.

"Closing the Loop: Building a Space Ecosystem and Then Not Dying Inside It"

The Weinersmiths provide a good overview of closed cycle ecology research, with a major focus on what was learned from the Biosphere 2 project. This section is well worth your time to read. The authors do yeoman's work in explaining to a mass audience why although many describe Biosphere 2 as a failure, it was quite a successful failure. One big learning – don't use concrete floors! You'll have to read the section to find out why.

“Space Composting! Not as Cool as Space Travel, but Very Important”

This section could almost be an NSS position paper. Yes, NASA should spend a lot more on closed cycle ecological research. Yes, this research would have benefits that go way beyond space settlement – stuff like creating more efficient, more productive agriculture on the Earth being one example. Yes, the Weinersmiths are on target with their enthusiasm for this project. There is a bit of a coda suggesting that alcohol, especially less energy intensive ways to create wine as opposed to hard liquor, will be important in making space settlements appealing and homey. No doubt there is some truth to this, but my prediction is that one dividing line among space settlements will be between “dry” and “wet” communities. Personally, I do not want to be working in zero-gravity construction with someone who started the day with some wine and a few edibles.

Outputs and Inputs: My Own Conclusion

Although I’ve dissed the first two sections for being irrelevant to space settlement, this chapter is one of the best in *A City on Mars*, if not the best. In spite of the Weinersmiths’ skepticism about space settlement written large, I suspect they would be happy to endorse large scale funding of closed ecology research of the kind needed to support space settlement. My main take-away is that the NSS might start a new project just focused on closed cycle ecologies with the idea of gaining support from those like the Weinersmiths that are not enthusiastic about near-term space settlement but have a genuine interest in some of the big questions it raises.

Discussion of Chapter 10: “No Place like Spome: How to Build Outer-Space Habitats”

My Opening Comment

This is one of the better chapters in *A City on Mars*. It may be a candidate for having the least irrelevant material, but it still has some, mostly added for humor value. The flaws lie in the logic, not the stuffing.

“Energy”

The Weinersmiths provide a useful and accurate description of the three main options for space power – solar cells, radioisotope thermoelectric systems, and nuclear reactors. They anoint nuclear power the clear winner. Solar is not so good on distant, sand storm obscured Mars, and radioisotope systems are too low power to be useful outside niche applications. And solar isn’t so good on the Moon either, due to the 2-week day/2-week night cycle.

Assuming you have already decided that Mars is where you are going to build your settlement, nuclear does indeed seem like the best bet. Solar power is the best choice for orbital space settlements (no night at all), but the authors have dismissed this option as a settlement destination already. Additionally, solar on the Moon with some kind of thermal storage might work pretty well, but is not considered. Also, solar power satellites around the Moon seem like a good choice, but are not mentioned either.

None of this matters that much overall. The Weinersmiths are big nuclear power fans, and seem content to rely on it to power space settlements, and indeed it is a reasonable choice. Having more good options just makes the case for space settlements stronger.

The space settlement advocate, however, needs to avoid over-reliance on nuclear power in space since there are those who are ideologically opposed to any usage of nuclear power. It is entirely possible to settle at least the inner solar system while using nuclear power only as a backup emergency power source. And yes, space based solar power would work well on both the Moon and Mars. Note that rectennas are much more resilient to dust storms than ground based solar panels.

"Shielding"

A reasonable and humorous description of shielding that focuses 99% on the Moon and Mars is provided. One thing missing here is any quantitative description of how much shielding you might need to get to Earth-surface radiation levels, but perhaps the authors recognize that since dirt is cheap, you can always pile more on your structures to get more shielding. In spite of all the weeping and gnashing of teeth earlier in the book about the dangers of radiation, the fact remains that as long as you live underground, you can achieve the radiation levels found at the surface of the Earth. And an added margin is cheap.

The Weindersmiths dismiss domes perhaps a bit too easily, and give little consideration to the many designs that use clever architecture to bring natural sunlight into the structure while still providing plenty of shielding. But even if we do have decent domes, we are still going to need the deep underground structures for most of the time we are there. As a thought exercise, consider a dome with water for shielding (and heating elements in the water). Your views would be bit fuzzy, but it might be a nice escape from the underground life.

"Your Home Away from the Homeworld: The Classes of Space Habs"

A reasonable summary of the potential evolution of habitats on the Moon and Mars is provided, with again total neglect of how this might be done for an orbital settlement. It is obvious that various kinds of habitats can be constructed from local materials on the Moon and Mars, so this is not a stumbling block for space settlement.

One odd comment stands out "But just to emphasize it once more – the bare existence of elements does not mean they're worth using. For instance, one paper in favor of lunar manufacturing suggests using an 1800 degree C furnace to melt titanium." First, one hopes we would mine titanium near the Apollo 17 site, where it was in the range of 2%-3% of the regolith, hardly a "trace" element. Second, since the melting point of titanium is 1,668 degrees C, we are going to need a furnace that runs higher than this to melt it. And this kind of furnace is a standard industrial product, not some mysterious hi-tech apparatus. And yes, it will need a lot of power. Industry in general needs a lot of power. Fortunately, sunlight is an abundant source of power on the Moon.

"Premium Real Estate"

The Weinersmiths here return to lava tubes on both Mars and the Moon, and re-emphasize just how much easier they make settlement by providing something like a pre-built habitat with shielding and lots and lots of space to grow. We need to explore the lava tubes in both locations to know for sure, but right now the smart money is on the first major Martian and lunar settlements being built in them.

No Place Like Spome: My Own Conclusion

This is certainly a good introduction to building settlements on the Moon and Mars. It is readily apparent that shielding, power, or habitat construction will not be show-stoppers for space settlement. Of course, orbital space settlements are left unmentioned, like some diseased relative hidden in an attic.

Discussion of Chapter 11: "A Cynical History of Space"

My Opening Comment

The point of this chapter is that the authors "…hope to also show you that however beautiful an aspiration space travel has been, it has also been a cynically wielded toll of militarism." Deudney's book *Dark Skies* contains similar material expounding on what can be best described as the "original sin" of space advocates, which is that their dreams rely on something, that is, the rocket, which is a nifty weapon.

"Rocketry from About the Year Zero to AD 1945"

The Weinersmiths provide, as promised, a cynical history of rocketry with an emphasis on Von Braun's sins in working for Hitler and using slave labor to build the V2s. There is no getting around it – Von Braun was totally amoral – and he turned a blind eye to the deaths that resulted from both the construction of the V2 rockets and their use in World War II. How does this relate to space settlement? Not clear, so moving on to the next section.

"The End of the War"

The Weinersmiths continue their cynical history by explaining the origins of the Apollo program, and how national space programs became vehicles for signaling the wealth and technical prowess of nations, and in particular the U.S. and the USSR. It is revealed that Kennedy was not interested in space, and at one point was considering a massive desalinization program as an alternative to Apollo. This is interesting but not big news to anyone even modestly informed about the history of the space program. From the viewpoint of space advocates, the main significance of the vast treasure pouring into space programs during the cold war was to raise false hopes that humanity was about to make a giant leap into the future. Once Apollo landed on the Moon, those hopes were dashed hard.

"The Early Space Age and the Origin of Space Law"

This section works hard to explain the background and motivation behind the Outer Space Treaty (OST) that we've been stuck with ever since 1963. The net is that people were afraid of the cold war spreading into space, and agreed to something that they thought would prevent that. Unfortunately, these efforts produced a myopic and hubristic treaty poorly suited to guide our future in space. This was perhaps inevitable. It is amazing that the U.S. and the USSR were able to agree on anything, so it is not surprising that the result was an attempt to avoid resolving any issue related to space beyond putting a damper on cold war rivalry by making space essentially "off limits" to national competition.

“The Creation of Space Law”

The final section serves to note that although the world has changed dramatically since 1963 when the Outer Space Treaty was created, the Outer Space Treaty has not changed at all. And therein lies the problem, which is examined at length in the next chapter.

A Cynical History of Space: My Own Conclusion

I can’t say that this chapter is filled with irrelevant detail. It is a decent, if cynical, review of the history of rocketry and the background to the Outer Space Treaty. However, it feels out of place in this book, which has shorted so many aspects of space settlement, to cover what really is just background in such detail. My cynical view is that it serves to create that “guilt by association,” linking space settlement to the Nazis, slave labor, the Cold War, and so on, although the idea of space settlement predates these terrible events. So, if you are not already familiar with space history, read the chapter, and play some uplifting music to counteract the cynicism. Otherwise, skip to chapter 12!

Discussion of Chapter 12: “The Outer Space Treaty: Great for Regulating Space Sixty Years Ago”

My Opening Comment

The authors open by saying, “The Outer Space Treaty is the closest thing to a governing document for space, yet space-settlement books rarely deal with it in any detail.” And they follow up with more text suggesting that space settlement advocates are particularly empty-headed when it comes to politics and law. There is, however, another possible reason space settlement advocates don’t drop a lot of ink on the OST – it is dreadful from a space settlement viewpoint – so many just assume that once the settlements are built the inhabitants will simply ignore what the Earthers might claim. Or there is an implicit, unstated assumption that the OST will be simply ignored, or that most major players will withdraw from it once things really get going.

I’m not endorsing these views – just reporting them. Also, in more recent times space settlement advocates have focused their energies on those features of the OST that the Weinersmiths refer to as “…allowing all sorts of behaviors that go right up to the edge of de facto land grabs.” From the settlement advocates’ viewpoint those loopholes are the only hope we have of ever settling space. This is because as much as advocates dislike the OST, they fear even more what would happen if a new multilateral process was started to create the OST2. Given the way the UN works, it is likely that the majority of votes would not be supportive of private property and settlements in space, so the status quo OST may be the best we ever get.

“International Law: Actually a Thing”

The Weinersmiths provide a useful summary of what international law is, how it is – and is not – enforced, and the two ways it comes into being. There are two methods: custom and international agreements. Hold that thought as it will come up again.

“A Brief Caveat Before We Get into the Nitty Regolithy”

The Weinersmiths continue with a sort of apologia that is really not needed. We know they are not expert space lawyers and we know the book is just their opinions. Further, we know that most big legal

issues in space law are unsettled and subject to a wide range of views. For example, the NSS once took a look at taking a position on the seemingly simple issue of where space begins from a legal perspective. After a good bit of study, the NSS Policy Committee (which included me) decided (1) there was no clear answer, (2) it was really complicated, and (3) it probably didn't matter that much anyway[25]. This outcome may apply to many space law issues – but not all, as we will see.

"The Outer Space Treaty of 1967"

This section does a good job, to my limited understanding anyway, of explaining what exactly the OST says. One salient point is that contrary to a popular delusion that Musk will run amuck on Mars, in fact he is completely bound by U.S. law once he is there. This means that in the short to medium term it is extremely clear what laws a given expedition or outpost will operate under. The long term, not so much, but we'll get back to that.

One of the major points of the OST is that it denies the right of any nation to claim sovereign control over anything in space. Since law flows down from the concept of sovereignty, this appears to make it impossible for there to be any settlements or property in space. But as the Weinersmiths describe, if the U.S. builds a base on the Moon, under the OST the U.S. legally controls the base, and in practice achieves something like sovereignty. It is a very unsatisfactory sovereignty with no private property, no inheritance rights, and no right to privacy from foreign inspections, but it allows practical denial of access, which is a key aspect of property. The authors don't like this at all, saying, "This is the sort of thing we are talking about when we say the current law leaves room for dangerous interpretations. Nobody is supposed to claim territory, but everyone is allowed to just situate bases on the limited premium real estate."

The authors also do a reasonable job of explaining how the right to extract and use space resources is evolving via customary law. The OST specifically allows the "use" of space, but provides little detail beyond that. There are existing precedents from the 1960s of both the U.S. and USSR returning Moon rocks and later selling them, and no one has objected. Someone may object to strip mining, but as the authors say, "…a case could be made that the U.S. interpretation is sliding toward customary." And from the viewpoint of the space settlement advocate, this is the last, best hope of actually developing and settling space. It is far from ideal, and there is some risk of conflict, but if we want to develop space on any kind of reasonable timeframe – less than centuries – this is how it is going to be done.

A final point remains that strongly favors orbital space settlements: space lawyers agree that "nations retain sovereignty over stuff that they put into space." Thus, the U.S. is sovereign over a space station build by a U.S. company using U.S. sourced equipment. This appears to set forward at least the possibility that the clearest legal path to space settlements is the orbital space settlement route that the Weinersmiths treat like an embarrassing relative. There is a fly in the ointment – although a few space settlements might be built with all Earth-sourced materials, building them on a large scale requires asteroid and lunar mining. Thus, the right to extract and sell space resources is crucial to space settlement. Without this right, there is little hope anyone will ever build any kind of large infrastructure in space. Assuming this all works out, the U.S. could give an orbital space settlement legal status as a city or state, as could any other nation if they also built orbital settlements.

“The Law is Weird”

The final section amplifies the Weinersmith’s fears that the perceived loopholes in the OST will lead to a U.S. vs China “gold rush” to control key real estate on the Moon by landing vehicles or building bases. Their fears are the hopes and dreams of space settlement advocates – that at long last the possibility of the Chinese really doing something big in space will wake up the U.S. government and motivate it to take the idea of space development and settlement seriously.

The Outer Space Treaty: My Own Conclusion

As far as I can tell this chapter is technically accurate, and a good introduction to what the OST calls for and what some issues with it might be. If you are reading *A City on Mars*, this is not a chapter to skip.

Discussion of Chapter 13: “Murder in Space: Who Killed the Moon Agreement?”

My Opening Comment

The short answer from space settlement advocates, notably L5 Society members (now the NSS), is “We did!” Like all such claims of political achievement different analysts may come to different conclusions, but there is no doubt that the L5 Society was very active in fighting the approval of the Moon Agreement, often referred to as the “Moon Treaty.”

“The Moon Agreement”

This section is just a quick introduction to the Moon Agreement and the fact that it is not likely to be the source of future space law since basically no one who has any real power supports it. Also, space settlement advocates, who have never had any “real power,” for the most part hate it. The authors suggest that if the Moon Agreement had created an International Space Authority (ISA), “…having such a framework would likely spare humanity from any current concern about a conflict-inducing Moon Race Part Two.” While they are entitled to their opinions, it is just as possible that if an overbearing ISA existed, we would see conflict in space between those trying to enforce it, and those attempting to defy it. Imagine hypothetically most of the world’s spacefaring nations united in the happy harmony of the ISA, singing sweet socialist marching songs, while a USA led by a President like Trump defies the ISA. What could go wrong?

“Shall We Socialize the Moon? Or, Ways to Organize Space Property”

The Weinersmiths here expound on the difference between rex nullius, res communis, and the common heritage of mankind in an entertaining and clear fashion. As a Cliff’s notes, rex nullius would be favorable for space settlement while most space advocates consider common heritage of mankind a disaster, but some aspects of res communis appear unavoidable in space. The Moon Agreement’s insistence that all property in space is the common heritage of mankind largely accounts for why only 18 nations signed the agreement, and one, Saudi Arabia, dropped out in 2023, leaving 17.

“Whither Lunar Socialism, or, What’s in the Moon Agreement?”

The Weinersmiths are cheerleading the Moon Agreement, but they are accurate in their description of what it entails – lunar socialism. No one can own anything at all ever in space, except with the

permission of an undefined and yet to be established "international regime." By now you may be seeing another reason that the Moon Agreement was unpopular.

"What Killed the Moon Agreement?"

This short section lays out the major reasons for the lack of support for the Moon Agreement:

- It was viewed in the U.S. Senate as socialism
- The lack of any clear notion of what the "international regime" would actually be discourages investment
- Space settlement advocates like the L5 Society fought hard against it
- The U.S. and USSR both did not sign it, probably out of self-interest as neither particularly wanted to share the bounty of space with everyone after each nation had just spent untold billions getting there.

Not much to complain about with this section – this is just a description of what happened.

"Into the Legal Breech! US Space Law and the Artemis Accords"

Here the Weinersmiths outline recent initiatives from the U.S., but with growing international support. There are three big developments:

1. The U.S. Commercial Space Launch Competitiveness Act of 2015 (signed by President Obama) which holds that U.S. citizens have a right to extract space resources and sell them.
2. An executive order signed by President Trump in 2020 that rejects both the idea of space as a global commons and the Moon Agreement.
3. The 2020 and on-going Artemis Accords, started under Trump but continued strongly under President Biden. The relevant parts of the accords call for the right to extract and own space resources and call for "safety zones" around such activities.

The authors seem surprised that by October of 2022, 20 nations had signed the Artemis Accords. I suspect they would find it alarming that by January 2024, the Accords had 34 signers, including India and all the major European space powers. No doubt even more alarming to them, by November of 2024 there were 48 signatories. This suggests there is a much higher level of support for the Accords than the Moon Agreement, and further that the momentum behind the Accords is growing.

The Weinersmiths summarize their fears thusly: "Again, that American safety zone isn't a claim to sovereign territory; it's not a claim that some lunar region is literally American. But it sure gets close. Throw in the limited quality of good places on the Moon, add the lack of any limits on the total number of bases nations can place, add that nations pushing the new interpretation is the one with the most space capability, and add that the two countries most interested in the best spots on the Moon are nuclear powers, and you have a recipe for danger."

Or you have a recipe for a competition that will end the long-post Apollo slumber, and jump-start humanities' movement into space.

A final note – the three U.S. initiatives were supported by first a Democratic President, then a Republican President, and then again by a Democratic President during a period of exceptional and

bitter partisanship. This level of unity on any issue is rare, and suggests that the legal path the U.S. is on that so worries the Weinersmiths has very strong bi-partisan support.

"A Race for the Heavens: Probably a Bad Move"

The authors start by noting that "Our impression…is that many [space geeks] are practically salivating for a new Space Race." I'd put it another way: space advocates feel betrayed and let down by the molasses river we called a space program post-Apollo. They tend to grasp at any straw that promises forward movement. The straw of the moment is a U.S.-China space race. For the longest time I have argued against promoting the idea of a U.S.-China space race, mainly because the Chinese just moved so slowly they did not seem like a threat to any reasonable person. More recently, as the Chinese have started to make real firsts, such as launching the first methane-liquid oxygen rocket to orbit in 2023, my views have started to evolve. But I am still pulling back on the reins – it is very easy to exaggerate the rate of Chinese progress, and if space advocates depend on this argument, we are at risk of derailing the future every time China has a major shift of direction. As just one example, I suspect a decision to invade Taiwan might suck a lot of resources out of the Chinese space program. How is the Russian space program doing these days?

The Weinersmiths move on to a particularly wrong-headed argument: "As we've argued, you cannot have near-term space settlements without a lot of major scientific and technological developments. All of that science and technology development can already be done under the OST. Even the highly restrictive Moon Agreement probably would have permitted the relevant knowledge and experience to be acquired." The authors confuse the idea that such research could in theory be done with whether it actually would be done. Lacking any legal foundation for space development and settlement such as laid out by the Artemis Accords, the most likely outcome is that 100 years from now very little progress will have been made toward space development and settlement. The recent increasing pace of space development is almost entirely driven by the economic potential of mega constellations and LEO tourism and manufacturing. Without a firmly established legal basis to mine, own, and sell space resources, we don't have a future in space beyond a few expensive robotic probes now and then, and there is little likelihood anyone is going to spend large sums on money on technology mainly useful in mining the Moon or developing any kind of space resources.

The authors have another core fear, expressed thusly: "We believe humanity in general, and possibly the long-term project of space settlement in particular, would be better off with an internationally managed system that regulated both where people are allowed to set up shop and what they're allowed to do with the local resources once they get there. It wouldn't be dynamic, …and frankly it would be very slow and bureaucratic and boring. But it would keep the peace while humanity gets its political and technological act together enough to make space settlement possible."

Again, there is a lot to unpack in this assertion. Do the Weinersmiths really believe that "humanity in general" should be regulated in terms of where they can live and what they can do where they live? This seems like a nightmare totalitarian state in its extreme form. Being told where you can live is a feature of dictatorships, not free democracies. Or perhaps they mean that you should not be able to build on wetlands, or dump mercury on your neighbor's yard?

The Artemis Accords provides a concrete initial answer – you can set up shop where you want, but not right on top of or so close to someone else that you cause harm. The only real issue comes with a limited

number of locations on the Moon that may be so constrained that conflict emerges. Most lunar resources – oxygen, aluminum, iron, silicon, titanium, etc., are widely distributed. And there are lots and lots of asteroids, even if there is only one "easiest to get to" asteroid. What is needed is some way of fairly dividing the small number of limited lunar resources, a topic we will return to later.

On a final point, the Weinersmith's seem to be indulging in the hope that if we just delay things enough, peace will break out and we will all settle space arm in arm singing Kumbaya. It may be just as likely that 50 or 100 years from now the Earth will be torn by vast battles between cyborg factions or different Artificial Super Intelligences (ASIs), and that in fact the current moment, scary as it can be, was actually a time of relative peace. If you say that in order for humanity to settle space, the U.S., China, and Russia must become one big happy family, you are saying that space settlement is not important and will never be done.

The Moon Agreement: My Own Conclusion

At this point I am coming around to the idea that *A City on Mars* is more a political book than anything else. The Weinersmiths mostly ignore the best path to space settlement (orbital settlements), while shoveling FUD about even modest steps toward using space resources – and the Artemis Accords are VERY modest. Aggressive would be the U.S. or China claiming the Moon, as one example.

Discussion of Chapter 14: "Commonsing the Cosmos"

My Opening Comment

Herein the Weinersmiths make their case that treating space as a "global commons" is a good path to avoid conflicts in space over resources, or so they believe. At least they admit, "To some this is a disaster. All those potential resources, all those places people might have lived and developed and commercialized have been left alone, to the detriment of human flourishing." But the problem with their analysis is that the deep seabed and Antarctica are NOT comparable to the entirety of solar system. One conclusion is becoming clear to me by this point in the book – the authors know that space settlement is more than just a remote possibility – it is something that might happen rapidly, their worries notwithstanding. Their reaction to this bright future is to throw political and economic FUD to slow down space settlement.

"Commons Sense"

This section contains a not particularly sophisticated explanation of the idea that a commons can be successfully managed using the ideas of Dr. Elinor Ostrom (Nobel Prize Economics). There can be little doubt that there are some "things" in space that are best managed as a commons. For example, "free space" between celestial objects is a natural commons in the same sense as the oceans of the Earth are a natural commons. In a somewhat different fashion, we are already managing geosynchronous orbital slots – a rather limited resource – via the international mechanism of the ITU-R and the World Radio Conference under the auspices of the United Nations. To my reading, these mechanisms track fairly well with Ostrom's eight "design principles" for common pool resources. But this is a long way from saying that all resources in space ought to be treated as common pool resources. Personally, I don't think anyone is going to ever live in space if they don't own their home – and their business – just like they do on the Earth in most countries today. More importantly, no individual or company is going to invest

huge sums into space development and settlement without certainty that they can keep the profits they make. And the Moon, Mars, and the asteroids collectively are so large that treating them collectively as a "commons" hardly seems necessary.

The Weinersmiths say "But there are other goals than efficiency. When we think about the future of the Moon or Mars, the goal may not be rapidly extracting maximum value. It may also be things like preserving a pristine environment or preserving humanity from blowing ourselves up in a territory dispute. To the extent these things are the goal, regulating space the way we regulate Antarctica is a good option." In this they are flushing not just private property and capitalism down the drain, but the project of space development and settlement in its entirety.

"The Antarctic Treaty System"

The Weinersmiths explain the history of this curious system at length, but don't engage that deeply with why there aren't serious efforts to mine in Antarctica. They suggest three reasons. First, a fear that mining might re-ignite sovereignty disputes. Since there are no existing land claims in space as there are in Antarctica, this argument does not fly – into space, anyway. Second, they report that the UN was concerned that less developed nations would be left out by the existing Antarctic claimants. There are no current land claims in space, but the issue of "benefit sharing" will surely arise, and does need to be addressed. Third, environmentalists were concerned about penguins and so on. This seems far less likely to be an issue with space mining, given the lack of life in space, with the possible exception of Mars.

But their discussion misses the main point – it is really hard to mine in Antarctica – much harder than they seem to realize. That miles thick sheet of ice – it moves. And the cold? Makes Mars seem balmy, at least at the equator. It may even be easier to mine the Moon or the asteroids than Antarctica once you cover the start-up R&D costs. But more significantly, no one thinks settling Antarctica will solve any of the problems addressed by settling space.

Having said all that, when the ice sheet melts, the importance of land claims in Antarctica will re-emerge, and some set of militarily powerful countries will stake claims and send large numbers of climate refugees to live there. And yes, we might see a big war over Antarctica. They'll have a bonfire with current treaties, and start firing missiles. Sorry to be the bearer of bad tidings. Antarctica works today because nobody cares – except scientists and penguins. The best way to avoid a war over Antarctic resources is to get space mining going ASAP so that they are irrelevant when the ice melts. Maybe, just maybe, we could then work out a global agreement to allow climate refugees to resettle there, and avoid a lot of bad things.

The authors discuss at some length how the Antarctic experience might apply in space. Their thinking is muddled since they believe that "If you want space settlements, arguably the two big goals are avoiding conflict and doing the research needed to learn how to settle space." There is already quite a bit of conflict in the world right now, so it seems unclear that avoiding space development is going to make that much difference in the Ukraine, Gaza, Taiwan, or the Korean peninsula. Even if starting lunar or asteroid mines does increase tensions between the U.S. and China, we are looking at 1% increase in a big number. And if no one has a legal right to live in space, own property in space, run a business in space, or pass on their property to their children in space, no one is going to seriously conduct space settlement research. Establishing those basic economic and political rights in space are the real foundation needed for developing and settling space. And yes, there does need to be attention paid to

benefit sharing and protecting some areas for scientific and heritage reasons, but these things can be done without declaring the universe the common property of humanity and slamming an iron heel on our space future.

"Governing the Deep Seabed"

The Weinersmiths seem to realize that the super-restrictive Antarctic rules will not work for space, and so put forward the United Nations Convention on the Law of the Sea (UNCLOS) as an alternative. This can be thought of as a modified Moon Agreement that does not require intellectual property transfer to developing countries. Although it might work in theory, it has been terrible in practice. Without going through the blow-by-blow, the International Seabed Authority has still not put in place rules for deep sea mining but may do so by 2025. A significant group of countries is calling for a moratorium on seabed mining due to environmental concerns. Norway has announced that it will start seabed mining in its national waters.

The entire seabed mining situation looms as an example of what not to do in space – set up an international committee that will then draft the rules for space mining at some distant point in the future. Another big difference between space and the seabed is that the seabed is connected to the Earthly ecosystem in way that the Moon and asteroids are not. There are real environmental issues here, and it may even be that seabed mining is a bad idea. Finally, no one wants to live on the seabed floor, and settlements on the deep-sea floor do not accomplish any of the goals associated with space settlement. For more on this topic, see my article *The Other Final Frontier: Why Not Build Undersea Settlements* in the Q1 2023 issue of *Ad Astra*.

"Where Do We Go from here?"

Here the Weinersmiths express their personal support for a space version of UNCLOS, but admit what they call "space settlement fans" are not thrilled by this idea, and propose alternatives that the authors think won't work. Although it is certainly true that a space version of UNCLOS is the least bad of the following choices – Moon Agreement, Antarctic Treaty, UNCLOS – this is like saying amputating your foot is better than cutting off a hand or your head. However, the authors are very correct that a serious attempt to impose space-UNCLOS would greatly slow down if not permanently stop all space development and settlement efforts rather than accelerate them.

Commonsing the Cosmos: My Own Conclusion

Much as a Jehovah Witness anti-evolution book was instrumental in convincing me that evolution makes a lot of sense, the Weinersmith's efforts to advocate for a big international agency to "run space" is far from convincing. However, their ideas work well as delaying tactics rather than serious proposals. They are unserious because they are taking a very short-term view which is entirely motivated by their fears that space development will increase international tension. A UNCLOS type regime is fairly obviously not a structure that will last if space settlement ever becomes a big thing – no one living in space would stand for it any longer than absolutely necessary. Strangely, they give no air time to the notion that China will just ignore any international regime and do whatever it wants in space, pretty much as China does whatever it wants in the South China Sea.

The Weinersmiths claim that "space itself is already a commons" but that is not what the Outer Space Treaty actually says. It is what the Moon Agreement said – and the Moon Agreement is dead. Sadly, the

idea of "space as a commons" keeps arising, vampire like, as a supposedly desirable future for humanity. Space settlement advocates know this, and they know that this idea, more than any technical or economic challenge, is the greatest barrier to space development and settlement. Fortunately, the authors are almost certainly wrong that the alternative ideas won't work.

Discussion of Chapter 15: "Dividing the Sky"

My Opening Comment

This is certainly a chapter of *A City on Mars* that ought to be read. It provides a critical review of the most significant ideas put forward to insert private property into the Outer Space Treaty. I am not aware of a similar, popular treatment of the ideas often asserted by space settlement advocates, and it provides special value in allowing the newcomer to easily avoid some of the ideas that don't make that much sense.

"Un-Locke Human Potential" (ULHP)

Here the Weinersmiths claim that space advocates who support private property in space particularly like these two thoughts:

- The U.S. 1862 Homestead Act
- "…that opening up a private property regime in space would allow rapid exploitation of space resources and development of space settlements"

The authors entertain the notion that although we may have been held back for the last 50 years by technical issues, it is at least possible that the lack of a solid legal foundation for developing and settling space is more of an issue now than 50 years ago since we have much improved technology for reaching and operating in space.

ULHP "Approach 1: Only Violating the Spirit of the Law"

"*Loophole 1: Martian Liberation*"

In this section the Weinersmiths throw darts at Dr. Jacob Haqq-Misra's ideas related to how we ought to govern Mars. A curious fact emerges – they refer to a paper by him that appeared in *Newspace*, but not to his much longer and no doubt more complete argument in his recent book *Sovereign Mars*. This is unfortunate since they are shooting at only one of the two ideas Haqq-Misra advocates, and to my taste the less realistic one. If your time is limited, you would be much better off reading *Sovereign Mars* than *A City on Mars*. Haqq-Misra seriously engages with governing Mars, which is much harder than taking pot-shots at other people's ideas. In particular, his vision of Martain settlement in Chapter 6 based on non-interference and exclusive economic zones seems like at least a reasonable starting point for how Martain governance might at least begin.

"*Loophole 2: The Moon Agreement Reverse Precedent Switcharoo*"

In this section, various ideas about space land grants advocated by Alan Wasser, a previous Chair of the NSS Executive Committee (full disclosure – I have also held this NSS office, although we now call it the Chief Executive Officer) are reviewed and dissected. The authors think Wasser is too tricky by half, and that his ideas lack real merit. They suggest, and I tend to agree with them, that Wasser is just dressing

up the U.S. claiming sovereign territory in space in a fancy suit, while allowing for other nations or groups to claim smaller amounts than the U.S. Due in part to the general unfairness of the Wasser procedure, it would surely be challenged, and challenged strongly. The circumstance in which something like Wasser's position would make sense is one in which another country claimed sovereign territory in space first. Oddly, the authors never consider this possibility as something that might really happen, or that we might need to respond to. Equally they do not appear to have a response to the far more likely circumstance in which a country ignores the OST while claiming to follow it.

"*Loophole 3: The Multilateral Menage*"

Here Rand Simberg's idea that a multinational group could recognize property claims in space, even if a national group could not, are poked and prodded. The Weinersmiths attack this on purely legal grounds, but his idea forms the basis for the Artemis Accords, at least in part. The real strength of Simberg's idea is that while the U.S. claiming property in space surely would face an uphill battle, if a group of nations did the same thing the battle is much less uphill. And as a thought experiment, if all the major spacefaring powers formed this agreement, it would be of little consequence whether the Outer Space Treaty was technically being violated. Of course, in this case the Weinersmiths should be happy as war in space would be quite unlikely.

"*I Got Holes in Different Areology Codes*"

Herein the Weinersmiths expound on the idea that Haqq-Misra, Wasser, Simberg, and Gingrich are not stupid, but like clever foxes are seeking to move the Overton Window toward private property so that at some future time one of their ideas may seem plausible enough and customary enough that it will be acted on. They are just speculating, of course, but political activists do these kind of things all the time. If you like the direction, they are dashing heroes. If you don't like the direction, they are evil reactionaries.

As the authors point out, by this point it is customary law that rocks removed from the Moon can be sold on the Earth, and are the property of those who first removed them, not some kind of "common property" of all humanity. Some view this with horror. To others it is the first step toward creating a free galaxy.

ULHP "Approach 2: Amending We Will Go"

This section focuses on space advocates who are "…bit more cautious." They don't want to ignore the OST, but they also don't want a giant bureaucracy in space.

"*Amendment 1: First Possession Plus Tax*"

The Weinersmith's don't say who proposed this, but they report that someone suggested you could claim land in space, but then you would owe an "existence tax" back to the Earth. As they correctly point out, if you were trying to get a settlement to revolt, this would be a good plan.

"*Amendment 2: Limited Possession*"

In this section, the authors discuss the issues with various approaches to dividing up land so that everyone might get something like a fair share. They point out some real issues, but since they are not trying to make this approach work, they aren't engaging with the best approaches. More importantly though, they present the "resource reservation" idea as requiring the OST to be amended, something

which, as we will see, may never happen. However, there are proposals to set aside resources for latecomers without using the idea of private property or amending the OST. See for example the NSS position paper "Terms of Reference for Benefits Sharing[26]." Contrary to the assertions of the Weinersmiths, there appear to be ways of making this work that would be satisfactory to both first movers and latecomers.

"*Amendment 3: Bounded Possession*"

Without reference it is said that someone has proposed amending the OST to allow geographically limited land claims. As the authors point out, first movers would have a big advantage with this approach. Additionally, a greedy group might claim many small parcels and try to use the non-interference clause of the OST to in effect "claim" large amounts of land.

"*Amendment 4: Possession Plus Parks*"

Here the idea is considered of allowing private property in space with large "parks" set aside. Mention is made of a particular proposal to reserve 7/8 of the Solar System as park. This idea initially seems crazy restrictive to the space development advocate, but it is not that far off base (see my response to this paper in Ad Astra 2022-4 titled *Greener Pastures Beyond Earth*). Even the strongest space settlement advocates like O'Neill and Jeff Bezos suggest setting aside the Earth as a park, so there is significant support for some level of parkiness across the board. Only Artificial General Intelligences (AGIs) bent on turning the solar system into computronium disagree. The Weinersmiths' don't really provide any strong arguments against this idea, possibly since at least to some degree it makes a lot of sense.

"*Amending We Won't Go*"

The Weinersmiths correctly point out that none of the above amendment proposals are likely to find sufficient support among the nations of the Earth to amend the OST. But some parts of the above proposals make a lot of sense. If only there was some way to adopt them without either amending or violating the OST….

ULHP "Approach 3: DIBS!"

The authors amuse themselves with making fun of various ideas to junk the OST and just start claiming land in space willy-nilly. As they point out, this will almost certainly lead to conflict and unhappiness. They also correctly point out that Elon can't just go to Mars and declare independence, at least not without the full-throated support of the USA. And then this is just another scenario where the U.S. would be dumping the OST and claiming land in space via the means of Elon Musk.

"Getting from Here to There"

The authors note that one strategy private property advocates might take is to fight all changes to the OST, and await a crisis, out which might come private property in space. Not letting anything slip here, but fighting all changes to the OST, including anything related to the Moon Agreement, is part of our grand strategy. It is just too risky to amend the OST, and space advocates have too little control over what might emerge. The Weinersmiths go on to say "we favor a managed commons…. It happened with Sea Law and plausibly it might happen again." As pointed out earlier, UNCLOS is a terrible example for space. To say it has "happened" in the sense that it is performing well is a gross exaggeration, and due to the many differences between the seabed and space, of limited relevancy.

The Weinersmiths allow there are two good arguments against the "managed commons." "…if there's really valuable stuff in space, a highly restrictive mineral rights regime would be stealing from humanity's future." The key thought here is "if there's really valuable stuff in space." The Weinersmiths don't think so, so there is no need for anyone to live there, and no need for private property as an incentive to develop resources. But this is patent nonsense. Space is full of valuable resources, including energy. The only question is an economic one – can we bring those resources to the Earth to benefit people on the ground? But with absolute certainly, resources in space will be immensely valuable to people living in space. Hence the need for strong property rights in space – both to live and to work there.

The second argument which the Weinersmiths describe as "the philosophical cases" (some of which they argued against in the first chapter) is the subject of the next chapter.

Dividing the Sky: My Own Conclusion

By now you may be wondering exactly what ideas those pesky space advocates are really pursuing. As mentioned above, we start with not amending the OST, and fighting hard against any kind of overall managed commons that generally applies in space. A managed commons already exists in geostationary orbital slots, and may be a good solution for a small list of limited space resources, mostly special orbits that have valuable properties.

The next step is incrementally move toward private property via customary international law. The key steps are as follows:

1. Establish the right to take a rock off the Moon, bring it back to the Earth, own it, and sell it [accomplished since 1972].
2. Establish the right to take a rock of the Moon, and sell it to someone on the Moon (targeted to be achieved by the USA/NASA as part of the CLPS program).[27]
3. Establish the right to process rocks on the Moon to produce oxygen, water, or other useful substances, and the use them on the Moon.
4. Step 3, except that the valuable substances are moved from the Moon to a depot in lunar orbit where they are stored for later use, or are incorporated into a satellite that is accepted as being the property of whoever initially built it.
5. The at-scale manufacture of anything in space with ISRU materials, and the recognition that the manufactured items are the property of those who manufactured them using a mix of Earthly and ISRU materials.

At this point we have a firm legal foundation to mine the Moon and asteroids, and use the extracted materials to build orbital space settlements that can be owned, sold, and inherited just like property on the Earth. We can then breathe a sigh of relief that the future of humanity in space is at least minimally secure. And note that with this direction we have yet to amend the OST or establish private property on a celestial body or make any "land claims" on the Moon.

There are a few loose ends here about how we manage mining on the Moon, but I'll get to them as I respond to the upcoming chapters!

Discussion of Chapter 16: "The Birth of the Space State: Like the Birth of Space Babies, but Messier"

My Opening Comment

Here we find another chapter of *A City on Mars* that most space advocates will find of interest. Starting with a short history of the Asgardian efforts to set up a state in space, I found a lot of relevant stuff here. Note that this Asgard has nothing to do with Marvel Comics – something that you already know if you are a hard-core space settlement proponent. And the Weinersmiths are certainly right – for many space advocates, the long-term goal is the creation of nations in space. Specifically, independent nations that can go their own way and chart a new path for humanity.

"What is a State and Do Three-Kilogram Satellites Count?"

The Weinersmiths explain that according to the 1933 Montevideo Convention, which they apparently view as the holy writ on this topic, a state must have (and this closely follows the actual text of the Convention):

- A permanent population
- A defined territory
- Government, and especially "effective" government
- The capacity to enter into relations with other states

The authors then drop a fair amount of ink shredding the Asgardians' ideas, which, as they point out, clearly will not result in the Asgardian cubesat being recognized as a state. A big obstacle to having a state in space appears to lie in the inability of such a state to own territory on a celestial body under the OST, thus making the "defined territory" impossible to achieve.

Since the Weinersmith's have dismissed the idea of orbital settlements as being technically infeasible, they have at the same time dismissed the easiest path to space statehood. Let us imagine that a nation or corporate entity constructs an orbital settlement in cislunar space. This works better if several are built, but only one is needed. The country with the smallest population is the Vatican City, with 510 inhabitants. The next largest "smallest" country can be found in the Pacific Ocean – the island of Tuvalu with 11,312 inhabitants. O'Neill's Stanford Torus design targets 10,000 inhabitants, so it certainly appears the population criteria might be met with a single orbital settlement.

I put forward the claim that such an orbital settlement with 10,000 inhabitants has a well-defined territory. It may not be on a planet or moon, but surely the shielded hull demarks their territory. And under the OST, such a settlement, constructed of a combination of elements from the Earth, the asteroids, and the Moon, can be claimed as the sovereign territory of the state under which the entity constructing the settlement operates, and based on the evolution of customary law described above.

It seems straightforward to create an effective government for an orbital space settlement. After all, Tuvalu is recognized as having an effective government, so there is an existence proof at this population level.

We now come to the fly in the ointment – the "relations with other states" part. The first step is that the launching state would have to internally decide to recognize the orbital settlement as a nation. The Weinersmiths seem skeptical that any nation would do this, but mileage varies. Newt Gingrich seriously proposed recognizing a state on the Moon (and was laughed at by many), but in a world where the

orbital settlement physically existed, one suspects the laughter would be muted. This first step is not automatic, and might take a long while to occur, but it is easy to imagine that there might a country that does this just to set the precedent that it can be done. Then the question becomes what do other states think? Will they recognize the orbital settlement as a new nation, or not? Let's come back to this point after looking at the next section of the chapter.

"Let's Have the Talk About Where Baby States Come From"

"*Self-Determination and Your Mars Base*"

In this section the Weinersmiths discuss the role of self-determination in the efforts of Quebec to become independent unilaterally from Canada. The Canadian Supreme Court held that since the inhabitants of Quebec were not being oppressed, they have no right to declare independence under international law. The implication appears to be that a putative state in space would need to be oppressed to seek self-determination.

There appear to be two problems with this argument:

1. The people running the bigger group often feel the smaller group is not being oppressed, but for some odd reason the smaller group disagrees, declares independence anyway, and starts a revolt. This worked well for the American colonists, but less well more recently, for example, for the Kurds. In the case mentioned, the Canadian government granted so many concessions to Quebec the population didn't feel like revolting.
2. More importantly, the bigger state might want to encourage the spin-off state to set a precedent, in which case the establishment of the new state would be by mutual agreement, obviating the need to invoke a claim of oppression.

"*Bangladesh and the Power of Self-Determination*"

In this section, the authors recount how Bangladesh became independent from Pakistan. Here the Bangladeshis clearly were being oppressed, resulting in eventual widespread recognition of Bangladesh, and they had the help of a major power, India, in their revolt. Also, India is between them and Pakistan, so the practical ability of Pakistan to hang onto Bangladesh was quite limited.

All this story suggests is that the geopolitical situation has a lot to do with whether a secession revolt succeeds. This has always been true, and it always will be true. But again, it only applies in the case of an actual revolt against oppression, which may or may not be the case.

"*Northern Cyprus and the Limits of Self-Determination*"

Here the authors examine a case superficially like that of Bangladesh, but different mainly in that the Turkish Republic of North Cyprus has not gained widespread international recognition. I found their explanation of why this might be the case muddy at best. However, this might correspond to a situation where a U.S. based entity founded orbital space settlement, with the support of the USA, declared its independence, but no other country recognized the settlement as a state. That would-be state would carry on, but without UN membership, functionally still part of the USA, just as the Turkish Republic of North Cyprus is functionally a part of Turkey.

There is a significant difference between our hypothetical U.S. spun out space settlement, which I will name "New USA" to ease the discussion, and the case of Cyprus. Namely, one can build more and more space settlements in more and more places, and at some point, they will become so significant that recognition will get harder and harder to withhold. In the long run, the Solar Federation of Space Settlements might refuse to recognize any Earthly nations but the USA on the grounds they are economically insignificant. This may not be the outcome the Weinersmiths are hoping for. It would, however, be an excellent long-term strategy for the USA, and broadly similar to British policy toward the USA after the War of 1812.

"*The Uncommon Problems of State Creation in Space*"

Herein the Weinersmiths expound on what they see as the special challenges to state creation in space. They allow that space settlers will eventually, and perhaps even rapidly, become a recognizable "people" capable of self-determination. They then consider whether space settlers might be able to consider themselves persecuted. Thankfully, the authors understand that the OST by itself will almost certainly come to be viewed as oppressive by people living in space.

The Weinersmiths fail to consider the most likely scenario – space settlers who engage in a religion or philosophy that is unpopular on the Earth and seek freedom to follow their own values in space. Such a "people" starts out persecuted – if they weren't being mistreated, such people probably wouldn't be interested in leaving the Earth – and might be more persecuted once in space.

Finally, explaining this at length is for a future book, but after consultation with experts on the process of state formation, I was informed that being oppressed is just not a generally recognized requirement, regardless of the views of the Canadian court system.

The Weinersmiths then introduce the notion that if the Earth views space as a "commons," then declaring a new state in space will be "taking" from every human, making it unlikely that a space state will achieve recognition. As previously mentioned, declaring an orbital space settlement a state appears to side-step this issue quite handily. It might even be possible to perform a similar thing on Mars. A collection of settlements might seek independence, and they are all connected by enclosed, pressurized roads or tunnels. They don't own land on Mars, but they own all the built structures, including the "roads." And they declare independence.

The key question is not going to be population, defined territory, or effective governance. It is always going to be recognition. Sadly, a very possible scenario is where one nation, say the USA, which has declared it does not consider space a "global commons," recognizes a state in space, but many other nations refuse to do so because they believe space is a "global commons." This might well lead to the war the Weinersmiths fear, but fortunately there is a path forward, and we are making good progress on it.

"*Kosovo and Why Self-Determination May Just Not Matter if the Geopolitics Doesn't Work*"

This section focuses on why a number of states refused to recognize Kosovo as being independent from Serbia. It boils down to the idea that if they recognized Kosovo, then local successionist movements in their countries would deserve recognition, and that was an unacceptable outcome.

However, this analysis would only apply to the case where, for example, a Russian founded settlement on Mars wanted to succeed from Russia and become a state. It is indeed true that many Earthly nations might not want to recognize a secessionist state in space just as they don't want to recognize one on the Earth. And yet if the secession is mutually agreed, the case would not be the same, and the chances of recognition of the new state would be much better.

Having said that, the Weinersmiths are totally correct in this limited matter. Regardless of the exact scenario, the creation of a state in space ultimately requires geopolitical support, which may not be easily obtained.

"The Awful Path to Space Nations"

Having laid out in some detail that idea that there is no clear and easy path to a space nation, the authors pitch that, "We think the ideal scenario if you have to have space nations would be to achieve Earth-wide consent to a new state in space." They add that this means, "if you want an independent space nation, you've got to have something like a harmonious Earth." At this point we have drifted from a serious discussion to la-la land. First, achieve world peace, then settle space, then recognize new nations in space. No problem.

Dividing the Sky: My Own Conclusion

Let us now return to what those pesky advocates of space settlement have in mind as an alternative to "first achieve world peace." Although the path to a space nation via an orbital settlement seems a lot easier than via a settlement on a celestial body, in the end this is a geopolitical issue. If significant Earthly powers ideologically insist that the universe is a global commons, and space nations are deeply offensive to them, there is going to be conflict. Just to point out the obvious, the refusal of a nation on the Earth to recognize a nation in space on the grounds that the Earth as a whole owns everything in space in common reeks of entitled colonialism and imperialistic hubris.

Consider the following way forward. Let us imagine that Earthly nations sharing many political ideals ("the democracies") formed a league to operate in space. Let us further imagine that a rival group ("the authoritarians") formed a similar rival group. Then let us further imagine that each rival group begins to explore, develop, and settle space. At some point one of the groups wishes to recognize a spin-off state in space. All members of one of the two groups rapidly recognize the new space state. The offer is put on the table – if the nations of the rival group recognize our space spin-off states, we will recognize yours. Now there may be nations not in either group that refuse to recognize any space states, but – news flash – all the powers that matter <u>are</u> in one of the groups, so it won't matter much in the long run. And there will be a strong incentive to all nations to join one, or perhaps both groups, to maximize their chance of benefiting from the development of space resources.

We are well on the way to this scenario. The "democracies" group is bound by the Artemis Accords, and the "authoritarians" are bound by whatever China plans to do. Does this approach ensure peace in space via some magical means? Certainly not, but it creates a framework under which the rival groups consisting of a very significant part of Earth's population can potentially recognize space nations (note the "groups" include the USA, Russia, Brazil, China, Japan, India, plus a number of African nations and all the major European countries – this totals up to a lot of people).

The Weinersmiths think space states ought to take a long time to come about, and my guess is that they will come more slowly than some space advocates think. It is easy to imagine the rival groups just mentioned growing in strength as they explore, develop, and settle cislunar space, in time reaching out to Mars and the asteroids. This process might continue for many decades, or even centuries before the need becomes acute to spin off a new space nation. The advent of political independence in space seems likely to be associated with a situation where space settlements are significant economically, have large populations, and are increasingly self-sufficient. All this will take at least 100 years, and perhaps a lot longer. But the process needs to start in earnest right now, with establishing the right to utilize space resources for profit.

Discussion of Chapter 17: "There is No Labor Pool on Mars: Outer Space as a Company Town"

My Opening Comment

This chapter begins a shift from the examination of the feasibility of space settlement to a dissection of the problems that might derive from the success of space settlement. As such, there is a significant influence felt from Daniel Deudney's anti-space settlement book *Dark Skies.* However, the first chapter focuses entirely on the fear that a Musk or Bezos created "company town" will impose a tyrannical rule on its inhabitants. As we will see, there is something to this concern, but probably much less than is feared.

"What is a Company Town?"

The Weinersmiths explore the definition of a company town along with some colorful examples thereof. This section provides useful background, although one gets the sense that academics may not have the self-insight to grasp that many university towns are just as hermetic and weird as Fordlandia, and perhaps more so. Some even find them oppressive. But the point remains that at least in some cases, isolated space settlements may drift socially in odd and finally dangerous ways.

"On the Care and Feeding of Space Employees"

There is no getting around it – whether you have a capitalist system or a communist system – company towns have enormous power over their citizens, and this power can readily be abused. And the level of control in a space settlement appears certain to exceed that found in an Earthly company town. To their credit, the authors provide examples of problems with both capitalist and communist "company towns."

"When Company Towns Go Bad"

"*Unionization Attempts*"

It should come as no surprise that attempts to form unions in company towns lead to conflict. The Weinersmiths suggest that one way to avoid this on a space settlement might be to start out with some kind of employee union. However, as they note, the two prospective major builders of company towns in space – Jeff Bezos and Elon Musk – are notorious for their non-union companies.

"*Economic Chaos*"

The authors point out that company towns by their nature tend to be "mono-towns" with one real profit-making business. If they had a large, diverse economy they would not be company towns. As a

result, space settlements will initially be vulnerable to economic downturns. On Earth, the town typically just folds up, but evacuating thousands of space settlers from Mars appears challenging. And the Weinersmiths add to this the concern that space settlers may be physiologically unable to return to the Earth in any case.

"When Company Towns Go Not-as-Bad"

"*When Reputation Matters*"

The Weinersmiths report that the major pushback they received when raising concerns about "bad" company towns was that a bad reputation would make it difficult to recruit new workers. They reply by raising the specter of "closed" space settlements that have limited communication back to the Earth. While it is certainly true that a fear of reputational damage will restrain many "company towns," the need to have extensive communication from space settlements to Earth and from space settlement to space settlement appears essential to create a positive environment for workers.

"*When the Law Favors Workers*"

Here the authors note that early space settlements will operate under the law of some Earthly nation, which may strongly favor labor rights. To this they raise the concern that space settlements may operate under a "flag of convenience" nation with weak labor laws.

"On the Economics of Survival Bubbles Separated from Home by Death Void"

The Weinersmiths return, as they usually do, to the notion that we ought to wait to create space settlements until they can be rapidly built into diverse economies with rich transportation networks, removing all the pesky issues they raise, including that of company towns. Strangely, throughout human history essentially all migrations involved small groups taking large risks, in many cases with essentially no chance of returning home, and certainly without carrying a vast infrastructure with them. And yet, here we are.

The authors express a deeper fear than the mere absence of a large support network when they say, "…we worried that a society founded on letting evolution take its course against children might not pair wonderfully with a future in which societies can ever more easily sling large objects around space." They seem to fear cold-eyed space settlers becoming heavily armed Spartans bent on controlling the Earth, and hope that the best way to avoid this is to only have lux space settlements full of many friendly faces.

There Is No Labor Pool on Mars: My Own Conclusion

Let there be no doubt – there are serious issues raised in this chapter that must be answered by space settlement advocates. The short-term answer, as I have suggested earlier, is that for quite a long while, space settlements will operate relatively close to the Earth, and under strong control by Earthly nations. There will be no greater risk of an oppressive company town in cislunar space than in Texas, which is to say, not zero, but not large either. A company town represents only one way to organize a space settlement, and I expect to see many others, including situations where everyone buys stock in the settlement "business," or becomes the owner of shares in a condominium. The more settlements and the more transportation systems there are, the more labor mobility will exist. The key requirement is a vital, open, free market with lots of competition.

If we use cycling orbital settlements to support Mars colonization, from the beginning it would be relatively easy for large numbers of settlers to return to the Earth. Additionally, from the start there would be greater economic diversity – and at least the possibility of unhappy settlers leaving "Muskietown" and working on the nearby orbital. Requiring the orbital cyclers to be owned by a different company than the Martian surface settlements seems like a great way to ensure access back to the Earth.

In the longer run we can expect to see clusters of orbital space settlements close enough together that labor mobility will be a non-issue. As settlements on the Martian surface grow in number, again labor mobility will become a non-issue.

And yet, there will be periods of time and particular areas in space where bad things might happen due to a lack of labor mobility. Two needed "common laws of space" suggest themselves:

- Each settlement must provide uncensored access to communication links both to the Earth, and to other settlements.
- Each settlement, regardless of how organized, must put aside a bond to return a new settler to the Earth, or to another settlement, if they become disgruntled.

With these common laws, unions are not essential to protect worker rights, although I fully expect to see at least a few unionized space settlements, and perhaps most commonly those devoted to tourism with large support staffs that are relatively unskilled. A more common structure may be the worker owned space settlement. Among the Artemis Accord members, such rules deem doable. Getting the "authoritarian" settlements to follow along seems fanciful, but then they offer no such rights to their Earthly citizens currently.

Additionally, as has been pointed out by Cockrell, "freedom engineering" of space settlements must be built in from the start. Highly robust, decentralized settlements by their nature have no single points of failure where a tyrant, terrorist, or mentally ill person might cause mass casualties. It should be kept in mind that our support infrastructure on the Earth is more vulnerable to a dedicated saboteur than many imagine, so we don't need to exceed the safety of Earthly homes and buildings. If you fly a spaceship into a settlement, vast damage will result, just as if you flew a jet into a skyscraper.

Discussion of Chapter 18: "How Big is Big: Plan B Settlements Without Genetic or Economic Calamities"

My Opening Comment

This chapter focuses on the space settlement population size needed to maintain an economically prosperous and genetically healthy population without any contact with the Earth. The Weinersmiths suggest that answer is that you will need "*a lot*." Given that all humans appear to have descended from a bottlenecked breeding population that may have been as small as 1,000 individuals[28], the answer to the genetic question is only "a lot" compared to the crew of the ISS. The authors appear to be on stronger ground with their concerns from an economic viewpoint, but we need to keep in mind that this is a long-term issue only, and in the long run most humans will not live on the Earth, making the question being asked essentially pointless. Of course, we need to keep in mind that it will take, in all probability,

centuries for space settlements to grow to a size sufficient to support true Earth independence from a techno-economic viewpoint. A mere million-person city on Mars probably will not do the job.

"How to Have Space Babies Without Marrying Your Space Cousin"

"*The Sustainable Growth Scenario: Lessons from Conservation Biology*"

In this section the Weinersmiths allow that as long as the space settlement population is reasonably large, has something like a 50/50 male/female balance, a good amount of genetic diversity, and at least some immigration, all will be well. With possible exception of the male/female balance, all of these elements are likely to be present in early cislunar space settlements. There may be some strain from a small initial population size on Mars or in the asteroids, but one would expect this to be counterbalanced by a high immigration rate.

The bottom line is that the only time any real issue arises is if civilization on the Earth is suddenly destroyed while the space settlements are in the early stages.

An issue the Weinersmiths don't discuss lies in how to avoid their lunar frat boy colony. Space settlement advocates tend to skew male, but a space settlement that is 90% male is unlikely to succeed. Although many early settlements skewed male historically, this is not a healthy long-term approach. While those who advocate space settlement and those who settle space may not overlap that much, when space settlement advocates envision a frat house in space, or a little boy's space cadet vision, they are not doing the cause of space development and settlement any favors. There has been a tradition of strong female leaders in the space settlement movement (Lori Garver, Anita Gale, Michelle Hanlon), and this tradition should be nurtured and grown, including ensuring that women have prominent roles in space settlement design and construction.

None of the above should be read as excluding LGBTQ persons from our future in space. In fact, the LGBTQ population are exactly the sort of disaffected minority that may find the creation of their own vision of the human future a project worth pursuing via the construction of a society of their own design in a space settlement. I fully expect to see many variations on this theme, supported in reproduction by technical means or immigration.

"*A Plan B Population*"

The section reviews various attempts to specify the minimum viable population for long term genetic flourishing, and concludes that it is "thousands or tens of thousands," a number rather close to the 1,000 minimum mentioned earlier. But the point is that it is not a million, or 100 million. Except for very small initial settlements, technological sustainability rather than genetic viability remains the greater concern.

"*Tech Fixes*"

A variety of technological means have been suggested to allow smaller populations to be genetically sustainable, but this is only relevant for small-scale interstellar generation ships. Even without a Mars cyclers system described earlier, Martian surface settlements as well as orbital settlements in the asteroid belt are close enough in travel time from the Earth to not be genetically isolated. Was Australia genetically isolated from England in the days of sailing ships? Hence, the need for genetic diversity is at best a weak argument for their "wait-and-go-big" approach.

“Let’s Talk Autarkic Arks”

This section may be the most interesting part of the chapter. The authors review various estimates of the human population needed for “Autarky,” i.e. economic independence. They come up with numbers ranging from 100,000 to 1 billion, with Elon Musk’s number of 1 million being supported by a Casey Handmer analysis that reaches the same number – not that this should be viewed as an authoritative endorsement!

The most autarkic nations on the Earth are suggested to be North Korea (population 26M) and Cuba (population 11M), leading to the authors conclusion that the real number is more than this, given that living in these countries isn’t exactly lux. However, both Cuba and to an even greater degree North Korea are highly inefficient communist states run to large degree by brute force, suggesting that their degree of autarky may be mostly limited by their economic and political systems rather than their populations.

Before attempting a more in-depth analysis, I want to emphasize that it has only a very limited importance to the case for space settlement. If we pursue space settlement strongly for a few centuries, there can be little doubt that the off-Earth population will become large enough to maintain an autarkic existence. We can debate endlessly exactly when this will occur, but it only matters if we are concerned with a near term disaster destroying the Earth. A reason to push space settlement as hard as possible is to narrow the window of danger, but there will always be a window of danger.

A more sophisticated analysis would start with these questions:

- What technological level are we seeking to maintain? There often is a hidden assumption that the highest possible technology will be needed, but that is just an assumption. It is true that a state-of-the-art chip factory costs billions, but building an integrated circuit using 1970s technology can be done on a small scale[29]. The question of relevance lies in the level of tech really needed to sustain our space settlement. And there is good reason to suspect that a truly robust space settlement may rely heavily on older, simpler, and more maintainable technologies. The need for the space settlement to be resilient to large coronal mass ejections suggest a reliance on mechanical over electronic technologies for vital systems.
- What emerging technologies might make it easier to sustain a high-tech civilization? 3D printer, robotics, and artificial intelligence technologies are growing by leaps and bounds. It is not that far-fetched to imagine a mass of equipment that is not that large but, especially with some human help, totally self-sustaining at a relatively high level. To quantify the AI growing by leaps and bounds thing – between when I first started on my project to respond to the Weinersmith’s book at length, AI evolved from being able to perform about as well as the average math Olympiad competitor on geometry proofs to being better than 95% of math Olympiad competitors.[30]

“Whither Plan B”

There can be little doubt that the Weinersmiths are correct that there is no “short-term Plan B” in space for some small values of “short-term.” Even Musk knows that his numbers for setting up an autarkic civilization on Mars loom as overly optimistic, and perhaps wildly optimistic. But he also knows that if we don’t start on the Plan B path now, we won’t get there 100 or 200 years from now. The authors retort that if we are so good with technology that we can settle Mars then “…surely we can clean some

carbon dioxide out the air on Earth." No doubt this is true, but surviving a climate disaster represents only one of many scenarios that the advocates of space settlement worry about.

At least some space settlement advocates believe that the problems with resolving many of our "big issues" including climate change lie not so much in a lack of technology as in a lack of will to apply the solutions we have. For example, large-scale construction of nuclear power plants and space solar power satellites would massively reduce carbon production, but are ideologically opposed by those seeking to use the climate crisis as a tool to attack capitalism rather than working to reduce carbon emissions. From this viewpoint, the "disaster" Plan B seeks to protect against is the social and political unwillingness to use the tools we have now to make our lives better.

How Big Is Big? My Own Conclusion

In terms of making the case against space settlement, this chapter seems a "nothingburger." In fact, the more we examine the minimum viable settlement sizes, the more it becomes obvious that we need to move forward with space settlement to achieve them as rapidly as possible rather than waiting for some future time to "go big."

Given the weakness of the arguments in this chapter, we should not be surprised to see the shadow of Daniel Deudney lurking as the authors conclude, "…having a multiplanetary species may not actually render humanity's existence more secure," when introducing the topic of the next chapter.

Discussion of Chapter 19: "Space Politics by Other Means: On the Possibility of Space War"

My Opening Comment

This chapter looks at whether developing and settling space makes large-scale war more likely. From previous hints, the reader by now has the impression that the Weinersmiths answer the question with a resounding YES! Let's see what develops.

"War in Space in the Near Term"

"*The Peace so Far*"

In this section the Weinersmiths explain, notwithstanding the fears expressed by the Bulletin of the Atomic Scientists famous count-down clock, why there has been no war in space so far, and isn't likely to be one in the near future. It boils down to self-interest. The major space powers have so much invested in space, and the "space stuff" is so fragile, that war in space seems a really bad idea to everyone who thinks about it for a few nanoseconds. Even for asymmetric rogue nations that have no space assets, the prospect of a devastating response from a major power has so far held them in check.

"*On the General Suckiness of Space Guns*"

Here the authors review why "space guns" pointing toward the Earth so far have not amounted to much. Their analysis, while solid, rather breezily dismisses the thought of a large network of kinetic weapons in orbit about the Earth. Such a network is surely becoming more feasible as launch costs drop, but might be the most useful to a space-based player that manufactures the systems in space rather than launches them from the ground. Having raised some fear here, the main weakness with such plans lies in the long period it would take to deploy them, and the likelihood of a response during deployment.

“War in Space in the Medium Term”

The Weinersmiths correctly point out that even in a future with large-scale cislunar development and modest settlements on Mars, there is something approaching zero chance of an Earth-space war, mainly because the Earth would crush the spacers. Putting this quantitatively, we can look forward to at least a century, and possibly two centuries of peace in space with high confidence.

The authors don’t mention this because it throws shade on their overall thesis, but the greatest medium-term risk is that the USA and associates just decide space development and settlement are too far out, will increase inequality, and aren’t green enough. The Chinese ignore all these considerations and develop a large-scale cislunar infrastructure. At some point the combination of the Chinese ground assets and space assets are sufficient that they start to think they can win a war to totally dominate cislunar space. They may be right or wrong, but either way this is a disaster.

Far better that both the Artemis Accord signatories and the Chinese Alliance both move in tandem in the development of space resources, creating a balance of cislunar power. Note that this will not prevent all wars (wars are going on right now) but it seems the best path to prevent a major war. Also, not that I am any special friend of the Chinese, but unrestrained Western power might not be the best possible path either. So, both groups moving forward in tandem with space development and settlement suggests itself as the best realistic option, as opposed to a fanciful new set of international treaties or a sudden outbreak of world peace.

“War in Space in the Long Term”

The Weinersmiths return to their previous arguments that space will not end war by removing scarcity, since war is never mostly about scarcity. They fall back to the idea that the causes of war are complex, but offer two scenarios for long-term space war they feel likely.

Before going there, consider the Skran rationale for why in the long term there will not be a war between the Earth and the spacers. This is like asking why there is no war between the rest of the world and Luxembourg. Luxembourg is rich, and seems like it might be worth conquering. But a better future lies with a Solar Federation that is more like the European Union (not economically, politically, or socially, but in terms of mutual respect) than the current world situation. There is virtually no chance that Spain will invade Luxembourg, and in the distant future, virtually no chance that Titan will attack the Earth. Eventually I will come back to how we can work to ensure this kind of future in space. Hint – it starts out with not demonizing or exploiting space settlements.

“*Scenario 1: Commitment Problems and the Thucydides Trap*”

The Weinersmiths envision a case where two rival settlements on the Moon are drawn toward war by the potential for one of them to suddenly gain a large advantage over the other, leading the “losing side” to start a war while they are still strong relative to their rival. Certainly, this could happen in space, and the rapid discovery of new resources and technologies might make it more likely.

Several points:

- This scenario isn’t very likely on the Moon, which is almost certain to remain firmly under the control of the Earth far into the future.

- Even if it did happen, so what? Two settlements on the Moon start a war. This is bit like the current conflict between Venezuela and Guyana[31]. It may lead to many deaths, and is surely not a good thing, but it does not remotely threaten the whole of humanity.
- This "trap" would be a bigger deal if the rival groups were large alliances of space settlements, say the Mars Alliance vs the Outer Planet League.

But the Weinersmiths fail to mention the greatest "trap" and the most difficult to avoid – the Earth attacking space settlements as they begin to become more powerful economically in order to maintain dominance over them. This is where the Earth needs to make the same choice that England did with regard to the USA – rather than try to impose its will on the now more successful colonies, instead work to support them as a junior partner.

"*Scenario 2: Leader-Nation Alignment, or Space Bastards in Charge*"

Herein the authors make the case that wars are (usually) not about anything that will change dramatically as we develop and settle space. They make some good points, so let's concede that living in space is not going to end war. Wars will happen in space. Wars will happen in the future. Wars are going on right now as I write this – in the Ukraine, in Gaza, in the various areas around Yemen, and in lots of other places. As Jerry Pournelle implied by creating a series of SF volumes titled "*There Will be War*," well, ya, there will be war.

The question is whether developing and settling space will make things materially more dangerous than they are on the Earth right now. It is worth keeping in mind at this point in the discussion that the main reason we are not holding a massive no-hold bars world war right now (instead of conducting what amounts to a slow-motion, limited theater world war as we are) is that our weapons are so powerful that using them is suicidal. And even the leaders of Russia and Iran want to keep living. Not to belabor the point, but it is not the UN or international treaties holding back the apocalypse; it is brute reality. So, the question of importance lies in the unvarnished truth about war in space.

"*Interplanetary War: Probably not Super-Great*"

The Weinersmiths make the argument that space war "…could be a uniquely awful event in human history. They suggest that because locations in space are not ecologically connected it will become much more feasible to use nuclear, biological, and chemical weapons without the large risk of blowback that exists when such weapons are used on the Earth.

Let's examine each class of weapons in turn. Perhaps chemical warheads might be useful in attacking a rotating space settlement as opposed to a battlefield formation on the ground fully equipped with gas masks and nerve gas antidotes. But wait – one suspects that pretty much all space settlers will keep a breathing apparatus that would function as a gas mask nearby all the time. Additionally, the air filtration systems of space settlements must be designed to deal with accidental fires and releases of industrial chemicals, which should cover a wide range of chemical attacks. Add some emergency reserves of nerve gas antidote at regular intervals inside, and a chemical attack on a space settlement becomes about as useful as a chemical attack on a well-equipped military formation on the Earth. Given this, why even bother with chemical weapons that create contamination that must be cleaned up later? And you will have to clean up the settlement to use it. Scratch chemical weapons off the parade of horribles – they are no more likely to be used in space than on the Earth.

Biological weapons might be the weapon of choice for space warfare, especially for a terrorist-suicide attack using sleeper agents. But wait – space settlements are going to be on constant alert for the infiltration of new diseases from the Earth. At least three mitigations appear essential:

- Space settlements will be constructed with fully independent sections.
- Newcomers will be quarantined for significant periods of time either in designated quarantine settlements, or in designated quarantine sections of a larger settlement.
- Every settler will be under a medical microscope to make sure that they aren't bringing in any new diseases.

Of course, no mitigation is fool-proof – think super AIDS – long incubation time, high infectivity, and high fatality rate. But even here, spreading humanity though the solar system will make any such attack much harder to execute than you might think. And the longer the attack takes to execute, the more likely retaliation becomes. If you are worried about a death-cult trying to kill everyone, I bet on humanity spread over the solar system vs humanity confined to the Earth every time.

What about nuclear weapons? The dirty secret here is that it is only a big nuclear war that puts the attacker at risk. As we have seen in World War II, if one side has three bombs, and the other side none, nuclear weapons are very useful. So yes, there will be no fallout on the Earth if the UN nukes an orbital around Mars. Or in Muskovia if Muskovia nukes Bezonia. But the real restraint on nuclear weapons is the fear of retaliation, and the fear of retaliation will loom just as large in space as on the Earth

There are several reasons to think that space wars will be less rather than more destructive than on the Earth. Space settlements are often viewed as fragile things, and no doubt some will be. But given the strong need to create radiation-safe habitats, many settlements will be buried deep in the regolith or in a hollowed-out asteroid. Such targets appear significantly more robust to a wide range of attacks than equivalent elements on the Earth's surface. To put this more colorfully, few people on Earth not named Mark Zuckerberg have access to a well-stocked, commodious super-bunker. A significant fraction of space settlers will spend their entire lives in such a bunker.

Perhaps more significantly, spreading humanity over the solar system (and far beyond cislunar space) returns us to a world where every human cannot be killed using nuclear missiles in under 30 minutes, which is how we currently live today. Given the vast size of the solar system, an attempt by the inner planet alliance to destroy the outer planet alliance will take a long time – weeks, months, even years. And all this time allows for escape, defense, and retaliation. Right now, here on the Earth, we will be lucky to have time to say good-by to our families and mutter a prayer.

Finally, space is great for "dead hand" retaliation. You set up your "dead hand" out in the Kuiper Belt, and when the keep-alive with your habitat stops, the retaliation commences. It will be slow, but potentially massive. Just the thought of such retaliation should give would-be conquerors pause.

"Make Star Peace, not Star Wars!"

Here we find a somewhat confusing conclusion from the Weinermiths. It appears to call for us to "constrain human nature and shape the future in space." Precisely what this might entail is left unstated, but when folks start talking about constraining human nature, they are usually talking about constraining someone they personally do not like rather than limiting their own freedom of action.

Space Politics by Other Means: My Own Conclusion

My impression is that the authors believe that in this chapter they have struck a mighty blow against near term space settlement. A closer examination suggests that although space development and settlement will not eliminate or prevent war, it will make long term human survival of future wars more probable.

The Weinersmiths have previously mentioned how space settlers might come to view the constant inspections and the lack of private property called for by the outer space treaty as oppressive. The greatest risk of a war resulting from space settlement may come from the Earth declaring the universe the common property of everyone on the Earth, and setting up an international authority to tax and control everyone living in space, distributing the resulting wealth back on the Earth with total equity – toward those living on the Earth! Over time, such policies seem certain to stoke a burning hatred among spacers, perhaps mocked on the Earth as lazy billionaires while working 16-hour days, sleeping on bunk beds, and consuming a diet consisting mainly of beans and shrimp. Eventually, the space settlements will grow economically, and begin to demand better treatment. This will be the point of maximum danger. The now-united Earth will realize they have one chance to maintain the upper hand – a massive surprise attack on the settlements, and new, more harsh policies of solar-system wide oppression.

How can we avoid this scenario? We can start by planning for a future in which space settlements ultimately become the bulk of humanity right now. And this starts with establishing the right to private property in space now. We need to advocate for policies with regard to space settlements that do not amount to new kind of exploitative colonialism, and then work towards a future in which all benefits flowing back to the Earth are from normal trade, not some kind of tax. Rather than a cumbersome international bureaucracy, we should to establish a Solar Federation which governs as lightly as possible, with the Earth one voice among many, and in time not the dominant one.

Discussion of Chapter 20: "A Brief Coda on a Rarely Considered Alternative: Wait-and-Go-Nowhere"

My Opening Comment

After quite a few hints and oblique references, the Weinersmiths finally get around to expounding on the anti-space expansionist arguments of Daniel Duedney in *Dark Skies*. Just a note here – much as I reject Duedney's thinking, I applaud his use the term "space expansionist." It is accurate and respectful. The Weinersmiths use, at various times "space geeks," "space nerds," "space enthusiasts," and "space fans." Hint – when referring to your debate opponents by humorous names is a significant part of your approach, this is not a good sign.

Discussion

This chapter is so short there are no sections.

The first part of the text describes a debate hosted by the NSS between Daniel Duedney and Mark Hopkins (NSS CEO Emeritus, now deceased), which was followed by a panel discussion, where, according to the authors, "…a panelist basically called him stupid." Full disclosure – I organized this debate. It is unclear to me why the Weinersmiths would expect an NSS panel discussing Duedney's work would contain a pro and con on space settlement. After all, the NSS is one of a really small list of organizations

that support space settlement. We honored him by inviting him to a debate and listening to what he has to say. Part of the reason for this is that Duedney is among the more rational of the anti-space settlement types. Contrary to whatever the authors interpreted from one panelist, Duedney is not stupid. Wrong, but not stupid. That's why it is important to respectfully examine and engage with his ideas. Sadly, this is not true about certain other anti-space settlement voices. For this reason, the NSS often chooses to simply ignore anti-settlement voices since engaging with them would only be further calling attention to what amounts to disinformation.

Next the authors then bring up the Carl Sagan fears about moving asteroids around that are expressed in *Pale Blue Dot* (and other papers by Sagan). My suggestion is to read all of the *Pale Blue Dot*. This is a strongly pro-space settlement book overall, marred by an exaggerated fear of asteroids as weapons.

Duedney's big idea is that space settlers will diversify into xenophobic tribes that ultimately engage in existential warfare with each other and with whoever is left back on the Earth. There is a lot to be said in response to his ideas, so I have included as Section 2 my previously unpublished response to *Dark Skies.* Let's assume you find my arguments convincing and then return to what the Weinersmiths are saying.

They refer to "…the concerns we've expressed about creating an immoral society, especially in the context of human reproduction and economics." But what exactly are those concerns? We are now delving into the hidden subtext of their arguments. They clearly are very worried that something bad will happen in space related to reproduction, but which is not put fully on stage. Hence, anything I say might be off-base. Are they just worried that randy over-eager "Muskies" will get pregnant on Mars without proper advance research, endangering their children? If so, their concerns are legitimate. But they seem to also be concerned that spacers will engage in culling of fetuses and perhaps children that are not adapting to different environments. Or just that "defective" fetuses will be frequently aborted in space, or perhaps more frequently than on the Earth? They further appear to fear that these attitudes will migrate back to the Earth, and be adopted here. This sounds like the authors are some flavor of anti-abortion/anti-eugenics advocates but don't want to come right out and say so. Duedney puts his arguments fully on stage where they can be engaged with, which is admirable. If someone wants to oppose space settlement because they are anti-abortion/anti-eugenics, please have the courage of your convictions.

As stated earlier, space settlement is not going to resolve the abortion debate. All the transhumanist evolution Duedney fears can happen just as easily on the Earth as in space. If there is going to be a civil war over abortion, settling space is not going to make things much worse. They will already be really bad. In a similar fashion, we don't need space settlements to fear lone crazy folks with powerful weapons doing great damage. We have that right now on the Earth, and it will only get worse. Space settlement at least gives us the time, and the space, to respond to these kinds of threats.

With regard to economics, the Weinersmiths are even more vague. Given that space law is already radically socialist, many space advocates are trying to create a space for the kind of economic life that has been proven to be beneficial on the Earth. We are not seeking to impose libertarian capitalism on the solar system – just allow it to exist somewhere. We are seeking the same kind of basic human freedoms that are common in many places – the right to own a home or business, the right to profit from your own labor, the right to own intellectual property, and the right to inherit property. The Weinersmiths are welcome to oppose these things on the Earth, but in doing so would reveal themselves as being far outside the mainstream of most societies.

It is easy to speculate that what the Weinersmiths suffer from is some variety of Musk Derangement Syndrome, or Bezos-Induced Paranoia. Their true view may be that contrary to all the FUD they produce, space settlement will in fact happen very rapidly, but that Musk and Bezos will end up owning space. These fears are hyperbolic, but if they think that way, join with space advocates in ensuring that space is a true free market, not a monopoly dominated by two very rich men.

The comments related to Larry Niven, dinosaurs, and having a space program are rhetorically cute, but don't constitute a real argument. Asteroids are only one of many existential risks that concern space settlement advocates. Even Duedney acknowledges the human race is doomed if we are still confined to the Earth in 800 million years or so. Hence, all we are arguing about is the timing of space settlement, not whether it is ultimately necessary.

The authors conclude "…we do believe the naysayers should get a little more room to say nay." This is really weird as a conclusion since the naysayers are firmly in control. They have the inside track everywhere, except maybe within the USSF. Contrary to any delusions of space advocates, NASA has no program to settle space, and is institutionally mostly hostile to the idea (this was not true in the 70s and 80s). There are no centers of support for space settlement in Congress or any administration, Democratic or Republican. What we have are a few tiny underfunded groups like NSS, the SFF, SEDS, and the Mars Society, and two driven billionaires. People like Linda Billings (mentioned in the Chapter as having the view of waiting until everything is fixed on Earth before we go into space), not space settlement advocates, have the inside track at NASA and appear at NASA organized conferences.

When the authors say "Things are now moving very quickly…" they are telling the Big Lie. In reality, progress in space essentially halted after the end of Apollo, and only restarted with the rise of SpaceX. But compared to other economic areas, space is a very small sector. 2023 was a record year for orbital launches – 210 in total. This is not brisk activity. 210 launches per hour would be significant. To put this more colorfully, if we had made progress in space at the same rate as progress in my field, computers/telecom, I would be writing this essay from my mansion in an orbital settlement around Ceres.

Wait-and-Go-Nowhere: My Own Conclusion

The NSS is not a forum for debate on the pros and cons of space settlement, the Deudney/Hopkins debate notwithstanding. We are an advocate, and our mission is to advocate – for space exploration, development, and settlement. For what Deudney calls "space expansionism." We really believe that humanity will be better off developing the resources of space, and developing them right now. There will be, realistically, a long period of mostly space development, and modest steps toward space settlement, before anything like O'Neill's vision is realized.

Discussion of "Conclusion: Of Hot Tubs and Human Destiny"

My Opening Comment

The authors offer this short summary, "Our original assumption was that space settlement was coming soon and that a question of governance was looming. We now believe the timeline is substantially longer and the project wildly more difficult and that the governance work to do is more about regulating the behavior of Earthlings than designing a Martian democracy."

The first part is easy to unpack. Depending on how you define soon, space settlement in a big way is not coming "soon." The Weinersmiths may be guilty of taking Elon's declarations about when he will build a city on Mars at face value, but as those of us who have been working on this project since the 1980s or longer know we are not now nor ever have been, realistically, going to be building autarkic space settlements "soon." Even if we had achieved "L5 in 95" (an old L5 Society slogan referring to 1995, not 2095), this would still be a long way from independent, autarkic space settlements, just a toe in the pond, so to speak. Precisely because the road to settling space is so long, we need to start vigorously now to work on this project to have any chance of there being a real space settlement 100 or 200 years from now. I am not sure that I am typical of space settlement advocates, but nothing in *A City on Mars* was surprising to me. There were no revelations about problems that are not currently receiving attention in the space settlement community. The Weinersmiths certainly have concerns, but they are mostly political. And as with most political issues, opinion varies substantially on the merits of their ideas.

A question of governance is not "looming" because the advent of sovereign space settlements lies at least 100 or more years in the future. Any base, outpost, orbital cruise ship, or proto-settlement built in the next 100 years will operate under the law of an Earth nation, and will follow Earth laws. The authors agree that for this reason there is no short to medium term issue with how to govern a space settlement any more than if Musk established a new town near Boca Chica, Texas, there would be no question about what law holds there.

It may be true that the space settlement project is "wildly more difficult" than the Weinersmiths thought it was, but, again, that is just them learning what we space settlement advocates have known all along.

What I find concerning is the idea that the governance work is "…about regulating the behavior of Earthlings." This is a euphemistic way of describing their aspirational and entirely unrealistic notions about political changes they believe need to happen on the Earth before we settle space. They appear to support a version of the Moon Agreement that has been modified to be "acceptable" to the major spacefaring powers, and lavish praise on the chaotic and unproductive sea bed mining authority. To put a finer point on things, I agree with the Weinersmiths that there are some things in space that need to be managed as a "commons" (though not always by the UN), but the disagreement lies in how many things in space are best suited for this approach. They appear to believe the entire solar system needs to be managed as a commons, while I suggest that the number of places appropriate for this treatment remain small. Additionally, the authors only thoughts about how their modified Moon Agreement will ever allow sovereign space settlements to come into being, is via universal agreement of all Earthly nations, a situation so unlikely it must be viewed as disingenuous.

"Argument 1: The Survival Cathedral"

Responding to this section was a challenge, since virtually every line provides a misleading or factually incorrect statement, unlike most parts of *A City on Mars* where the great bulk of the text is accurate.

The Weinersmiths write: "If humanity were governed so well that war and terrorism hadn't existed for ages, then we should build the cathedral."

Given that the Weinersmiths do not remotely provide a plan to end war and terrorism, adducing an argument like this is just saying that space settlement is not worth doing at all for any reason, since the

likelihood of a sudden outbreak of permanent world peace appears infinitesimal. Even if the authors put forward a 500-year plan to end war and terrorism, doing this first and then settling space significantly increases the risk of human extinction. If the all-source chance of human extinction each year is 1/1000 (which seems optimistic), the chance of humanity becoming extinct in the 500 years we wait to start settling space is 50%. Call me crazy, but waiting 500 years to settle space seems like a terrible bet. And waiting until war and terrorism ends seems to mostly be a suicide pact.

They go on to write: "If humanity has some kind of Star Wars force-field…that allowed us to…control what objects fall through our atmosphere, then we should build the cathedral."

Setting aside the fact that such technology lies firmly in the realm of fantasy, if it did exist it would imply the existence of a wide range of additional super-weapons, the usage of which would alter the balance between attack and defense in unpredictable ways. Waiting for a magical defense weapon before settling space seems to be on the order of waiting to find unicorns in the flame ducts before settling space.

They further write: "If we could build a settlement on a faraway star, making interplanetary conflict all but impossible, then we should build the cathedral."

First, if we have interstellar settlements, that is the survival cathedral, so there would be no further need for action. We do need to spread them over several hundred lights years to cope with certain categories of extinction events, but we would certainly be safe from a wide range of risks with just a few interstellar colonies. Secondly, if you can build interstellar settlements, you can conduct interstellar war. That are lots of ways of doing so, but I mention two: Von Neuman machines and relativistic weapons. Arguably, some of the risks Deudney fears are much more manageable in the solar system than on an interstellar scale. I am not saying they are unmanageable, but just that it requires a different approach than what will work in the solar system.

The Weinersmiths go on to write: "Our ability to harm ourselves vastly outweighs our ability to protect ourselves. Settling the solar system will likely increase the danger."

As previously argued settling the solar system is pretty much the only thing we can to that will materially increase our ability to protect ourselves. Perhaps I should say – the only practical thing we can do. Even if the Weinersmiths had a miraculous plan for world peace, this would only address one extinction risk.

They also state: "Without the confidence that space expansion produces net benefits for humanity on a short or long time scale, the creation of the survival cathedral becomes…an act of faith."

Space expansion has two components – space development and space settlement. There have already been enormous positive impacts from space development, and as shown in the NSS position paper on *How Space Technology Benefits the Earth*.[32] Continuing to develop the resources of space to benefit humanity will increase these benefits manyfold. To turn away from every good thing that can come from developing space out of a misguided fear of the long-term consequences of space settlement would be a tragedy of monumental proportions. If space settlement is truly dangerous, we can build the cislunar economy (Deudney's Orbita) and not settle the rest of the solar system. I do not advocate this course, but stopping after developing the Moon and the NEOs without large-scale space settlement is an option.

In the long run, we can say with absolute confidence that if humanity does not settle space, we will go extinct. It is just a question of when.

"Argument 2: The Hot Tub"

Now the authors argue that settling space is not like buying a hot tub, but more akin to purchasing a nuclear weapon. They expound that even libertarians don't want folks buying their own nukes, so we all ought to agree that space settlement should be a prohibited activity until some future time when the world's problems are solved.

While it is certainly true that settling space beckons as a far more significant activity than purchasing a hot tub, and certainly requires some degree of regulation, it seems far-fetched that it is on the same level as purchasing a nuclear missile. This is especially true since the kind of longer-term dangers related to xenophobic spacers and Earth-vs-space wars surely lie centuries in the future, while many of the benefits of space development and settlement can be obtained by full-throttle cislunar space development now, but with little risk of crazed two-headed transhumanist spacers attacking the Earth.

A City on Mars focuses heavily on space settlement while being rather dismissive of any kind of space development, whether space solar power, asteroid mining, or anything else. As a result, the authors conclude that there is little of economic value to do in space, and hence no real need except for the "survival cathedral" for anyone to live in space. We space expansionists believe that they are wrong, and not just wrong, but terribly and dangerously wrong. The Weinersmiths are setting aside every possible benefit from space development on the grounds that engaging in such activities increases the risk of successful space settlements, and successful space settlements are dangerous. This attitude suggests an indifference to human needs and suffering that could be addressed by large-scale space development, or a foolish certainty that we don't need no stinking space resources. The authors speak highly of the book *Asteroids* by Martin Elvis, but clearly do not agree with his strong support for asteroid mining.

The Weinersmiths think space settlement will be hard, but lacking in economic benefits. This may be 100% true in a literal sense. Space settlement surely will be hard – if it was easy and certain to happen quickly why would space advocates devote so much effort trying to make it a reality? And building a space settlement per se may not have significant short-term economic benefits, especially the Weinersmiths' distant Mars version. The economic case for cislunar orbital settlements is far closer to closing than that for living on Mars, but the authors dismiss these ideas, possibly because they lack the professional background to evaluate how realistic the construction of orbital settlements might be. But the economic benefits we can derive from large scale development of space resources, initially mainly via automated means, are the short-term carrot. Only over time will space development lead to economically viable space settlements.

The authors have convinced themselves that movement toward space development and settlement now increases the risk of war in both the short and long term. The long-term risks appear speculative, and more likely empty paranoia. The greatest real short-term risk lies in the Artemis Accord nations holding back on space development while the China Alliance rushes forward, although this is not acknowledged by the authors. One thing we can be absolutely certain of is that although the Weinersmiths have some chance of convincing the West to give up on space development, there is zero chance the Chinese government will listen to them.

The Weinersmiths' fears that the Artemis Accords will lead to a lunar land rush, followed by warfare on the Moon, seem especially off-base. They persist in looking at the glass and seeing that it is half-empty. Yes, there may be a conflict over the peaks of eternal light or some attractive lava tube, but no nation or company can claim all of the Moon or large parts of the Moon under the Outer Space Treaty. But it is possible to set up lunar bases and mines protected by non-interference zones, which is the minimum needed for robust space development. All that remains is to negotiate how we access the small number of areas on the Moon that logically constitute a "commons." This is a topic beyond the scope of this paper, but such areas most likely are particular lunar orbits rather than locations on the Moon. We do this for geosynchronous orbital slots now, so surely we can divide up the Earth-Moon L-points in the same fashion. Of course, if the West gives up on the Moon, and stays on the Earth while China sets up 100s of lunar mines, yes, bad things will eventually happen.

The authors trot out the old trope that space settlement is just an "escape fantasy" and that we are never going to settle space fast enough to escape anything. This is both true and false. It is true that those of us who advocate for space settlement are not personally going to escape some Earthly disaster or oppressive culture. We are working to create a future in which our grandchildren and beyond have this option. Even Musk knows this in this heart. But having real space settlements 200 years from now requires the most intense effort right now, because the Weinersmiths are right about space settlement being difficult. And there will be a thousand increasingly bold steps along this path, not just 200 years of research followed by the construction of a giant city on Mars. And building a giant city on Mars is just a small step toward species survival. For that we need humanity spread over the solar system in thousands of space settlements supporting a thriving economy.

The Weinersmiths appear to have encountered some highly negative reactions to their views from "space nerds." Part of the reason for this is that in spite of the authors' fears, the deck is stack heavily against space settlement advocates. New books appear all the time declaring that space settlement is a variously impossible, impractical, immoral, colonialist, exploitative, and so on enterprise that will lead us to our doom (*Aurora* [2015]*, Dark Skies* [2020], *Star Settlers* [2020]*, Space Forces* [2021]*, Astrotopia* [2022]*, Reclaiming Space* [2023], and *Ground Control* [2024]). The authors of these books often delight in mocking space settlement advocates. So yes, the "space nerds" are tired of being derided as naïve waifs whose idealism is manipulated by Musk and Bezos to further their financial empires. The nay sayers are everywhere, and hold the ramparts of government, academia, and media (a recent *Scientific American* article was titled "*Why We Will Never Settle Space*"[33]). This highly inaccurate and misleading *Scientific American* article is best ignored, but for those who are interested, I have included a detailed analysis as Section 3. Further, the anti-settlement forces are extreme in their positions, often calling for large scale relinquishment of all advanced technologies (the degrowth movement, *Enough* by McKibben). Serious space advocates are eager to engage with thoughtful critics such as Erica Nesbitt, but far too often anti-space settlement thinkers are take-no-prisoners' extremists whose agenda calls for the elimination of capitalism, free markets, and a return to a more primitive existence in the context of a vast decrease in the human population of Earth.

But I am disappointed that the Weinersmiths, as far as I know, did not engage with any NSS leader[34] that I know of with regard to any of their concerns about space settlement. Perhaps they had already made up their minds that space settlement was a bad idea when they attended the NSS Space Settlement Workshop which they describe as applauding them for writing a book on space settlement (full disclosure – I organized this workshop). But with regard to the applause, I was there applauding, mainly

because I cannot recall the last time anyone anywhere wrote a serious book supporting space settlement as a general theme. Yes, there are a lot of pro-Mars books, including a number by Zubrin, but none that I am aware of to compare to classics like *The High Frontier* or *Colonies in Space*. So yes, I was disappointed. I hoped for the first general pro-space settlement book in decades, and instead got smacked upside the head with *A City on Mars*.

"OKAY OKAY, BUT … or a Moderately Hopeful Coda"

In this section, perhaps the most important part of the book, the authors imagine that space expansion is inevitable, and they are put in charge of a space settlement research effort. This is a welcome direction, but the Weinersmiths seem to believe that "space agencies" are actively focused on space settlement, while in reality nothing could be further from the truth. Yes, in the distant past – the 1970s – NASA was supportive of space settlement summer studies, but that was a long time ago.

"Track 1: Biology, Reproduction, and Ecology"

For the most part, the authors are on-target with their clarion call for research into variable gravity biology and closed cycle life support systems. One can debate the details and timing of their program, but it is all in the right direction. Certainly, if I was running their imagined Space Settlement Agency, I would put down a huge marker on this kind of research, which for the most part space agencies neglect.

However, one corrective. The Weinersmiths appear to believe that an extremely reliable closed cycle ecology needs to be well developed before we construct any space settlements at all. This sort of siloed thinking puts all the emphasis on areas of research they are the most familiar with, while neglecting everything else. This derives in part from an over focus on settling distant Mars. Instead, we will construct at least dozens of proto-space settlements in cislunar space before we get to something that works smoothly. We need to get the kinks out of all the technologies, not just the biological ones.

Additionally, proto-space settlements located in cislunar space can be readily resupplied, and just don't need the super-closed cycle, highly-reliable systems that eventually will be developed. Their vision of a perfectly functioning space settlement that is "massive" and built during a "very brief period" ignores the reality of engineering experience. It is not just that step B depends on step A, but that unless step A is brought fully to reality, not just a lab experiment, we will never gain the real-world experience that converts a complex development system into a reliable operating reality. We will probably construct dozens of increasingly larger and more complex settlements in cislunar space, including on the lunar surface, before fully closed ecosystems are developed. And people with families will live in at least the last six of the dozen settlements constructed. Optimistically, VAST will start operation of the first rotating station within ten years.[35]

"Track 2: International Law"

The Weinersmiths are certainly correct that work in the area of international law provides the foundation of our future in space. However, their support of UNCLOS or Moon Agreement lite would, if successful, ensure that space development and settlement most probably will never occur. The important, truly vital task is to create laws that allow for corporations to operate profitably in space, leading rapidly to the vast space infrastructure that Deudney fears. The Artemis Accords are a major advance with the formal endorsement of resource extraction in space. Additionally, the U.S. work in building up customary law support for the purchase of lunar resources looms as the next major

milestone. Finally, we need to mine lunar resources, and use them not just for rocket fuel, but as a part of the Lunar Gateway or other space infrastructure that is under the sovereign power and ownership of an Earthly state. With all these milestones in place the stage will be set to mine the Moon and the asteroids, and use the extracted materials to construct space solar power satellites and orbiting space settlements that are accepted as being the property of nation-states on the Earth, not part of some nebulous "common heritage" of mankind.

Work is also needed to extend the International Telecommunications Union – Radio (ITU-R) geosynchronous slot management to a similar regime for lunar orbits and Lagrange points, to reserve frequencies for space solar power to be beamed back to the Earth, and a host of other tasks. The greatest challenge may be dealing with lunar south pole resources. And finally, we need a scheme for benefit sharing for latecomers, a major current NSS project, in such a fashion as to encourage rather the discourage space development.

The time is not yet ripe to tackle sovereignty in space. All the above is based on the OST prohibition on claiming any part of a celestial body. In the medium term, as more orbital settlements appear, a path to sovereignty described above appears far easier than for Earthly nations. Also as described above, similar scenarios might also be applied on celestial bodies. This may be as far as it goes, with the OST fading into the background over the centuries, but never being amended or repealed, until one day the Earth has the economic significance in the Solar Federation that Luxembourg has in the UN, after which the OST will be replaced by unanimous consent (or perhaps a 1,793 to 1 vote) with something rather different.

"Track 3: Geopolitics, Sociology, and Economics"

Here the authors reference the work of Dr. Charles Cockell, who has coined the term "freedom engineering" with regard to how we might best design a space settlement to avoid tyrannical governments easily establishing themselves. Fortunately, in practice "freedom engineering" calls for space settlements with internal segmentation, featuring vast redundancy and no bottlenecks that can be easily choked by saboteurs or tyrants. It also seeks to put the resources needed for survival under the direct control of individuals, families, or small groups, rather than an easily corrupted central authority. I heartily endorse this research direction, and believe that it is vital to the long-term success of space settlements. In addition to mitigating tyranny, "freedom engineering" holds out the promise of safer and more livable space settlements.

Although academic work on the governance and sociology of future space settlements surely has value, and again Cockell's paper on Shetland Islands governance has special merit, in the end people living in space are going to decide these matters, either when they first establish the space settlement, or over time as they live there. Although constitutional experts may indeed be rarely consulted by "space geeks," those experts are not going to be the ones living in space. A little humility is called for here, and some respect for the idea that different groups will seek to operate space settlements under different economic or governance systems. The idea of some central commission of experts dictating how people will live in space may appeal to someone, but, not, I suspect, to anyone living in space.

There are two areas that need attention beyond the generalities propounded by the Weinersmiths.

First, we need to examine the set of laws that might apply to all space settlements throughout the solar system, including the Earth. To be broadly supported and enforced, they need to be narrow in scope, limited only to address those things that would motivate a space settler to join a settlement militia and engage in a dangerous attack on another settlement. Some suggestions:

- Unconstrained AI ("the paper clip apocalypse")
- Unconstrained nanotech ("gray goo")
- Any form of totalizing death cult (ISIS, the Aum Cult, etc.)
- Creating a new species of humans that cannot interbreed with "norms"

But when you think about this list, please limit it to things that you personally are willing to die to stop. Personally, I am all in on the first three, but not totally convinced on the fourth. Your mileage may vary.

It might actually work best if all space settlements were recognized as sovereign from the start, constrained only by the above laws, and fully accepted with one vote in the "Solar Federation" (it has to be the "Federation" for obvious reasons. Live long and prosper!).

Secondly, there exists another class of laws needed to ensure that a minimal set of human rights can exist in space settlements. Two suggestions:

- All settlers have a right of self-exile. To make this work, the builders of the settlement must provide a bond to pay for each person to return to the Earth, or travel to another settlement.
- All settlers have a right to access the Solar Federation communications network directly, without eavesdropping from the local government. Without this, those being denied the right of self-exile will have no means to complain if it is not being granted.

Such laws might readily be agreed to by signatories of the Artemis Accords, but as the Chinese don't provide any such rights today to their own citizens, they are not likely to provide such rights to future space settlers. Given this reality, adoption of the above "solar laws" by Artemis Accord settlements seems important, and over the long run may influence the behavior the China Alliance, just as the Cold War over time altered the behavior of the USSR.

"The Good News for Nerds"

Here the Weinersmiths call for more academics to pay attention to space settlement since the field appears to provide many diverse and interesting avenues for research. Surely this is correct, but so far most of the academics looking at space settlement appear to be non-technical critics firing all their guns at an imaginary space settlement behemoth monster ridden by the devils Musk and Bezos. And yes, we will need to be wise to settle space, not in the sense that we will have magically solved the problem of the human condition, but to prevent the vast army of nay-sayers from imprisoning us on the Earth until we are all dead.

My Own Conclusion regarding the Weinersmiths' Conclusion

It is becoming increasingly clear to me that space settlement offers to some a second chance, or perhaps a new chance, to advance a political agenda which has failed on Earth. Specifically, the story of the 20th century is that of conflict between free markets and communism, and there can be little doubt that free markets won. But the core ideas behind the communist vision are endlessly seductive, and space settlement offers the opportunity to create a new future based only on socialist/communist ideals. For

this reason, the rise of the "Space Barons" Musk and Bezos terrifies these thinkers with the prospect of unfettered capitalism and exploitative company towns bursting out from the Earth and "infecting" the solar system. The Outer Space Treaty remains far more supportive of a socialist/communist future in space than one of free markets and capitalism.

From the opposite viewpoint, if free markets/capitalism are not extended into space settlements, the possibility exists that when the solar system is fully developed, the "enlightened" spacers will expunge free markets, capitalism, and private property from the Earth itself. Hence, a lot is on the table as we contemplate developing the resources of the solar system and settling space.

When the Weinersmiths argue for some variation of UNCLOS or the Moon Agreement in space, they are falling much more on the socialist/communist side than the free markets/capitalist side, since those treaties exclude even the concept of private property.

It behooves the NSS to take a different course – perhaps the most difficult course – that of allowing both socialist/communist and free market/capitalist space settlements to come into being. For this to happen, the ideas of UNCLOS and the Moon Agreement are entirely unhelpful since they presuppose the superiority of the universal "commons" over private property. What is needed instead is a way to split celestial bodies into three "zones" (which may be non-contiguous):

1. A zone where free markets reign
2. A zone where communist ideals reign
3. Limited numbers of special areas that are considered "common" to both zones, and are managed like geosynchronous orbital slots are today

At the same time, the Weinersmiths call to somehow resolve Earthly conflicts before building space settlements verges on the delusional, and creates enormous existential risk. If we believe that building space settlements is important, and indeed inevitable, holding them back while waiting for a magical outbreak of world peace seems more like Russian Roulette than anything else. Far better to, again, work to create a future in space that is open to most – ISIS and the Aum Cult excluded! – of the human family, and operates on the ancient principles of balance of power. It is time to grow up – living in space will not change human nature – there will be war, struggle, and death. There always has been, and there always will be. We just need to muddle through.

What does this mean in practice? It means reaching some agreement between the China Alliance and the Artemis Accord nations on how to manage access to resources in space. This could be as simple as splitting the Moon in half, and allowing dispute resolution of each half to be assigned to one of the two alliances. No one is excluded under the OST, but a balance of power is maintained, and a land rush avoided. The other area where agreement is needed lies in the size of a non-interference zone, which may vary on the Moon, Mars, and asteroids. In practice, an entire small asteroid will be within one non-interference zone. Finally, agreement is needed on what level of activity establishes a non-interference zone. Both groups have an incentive to agree so as to avoid their own "areas" being infiltrated by states outside either alliance, and their own non-interference zones being challenged. No one is saying any of this will be easy, but it at least appears far more possible than getting spacefaring nations to agree on a new version of the Moon Agreement.

Most importantly, some variation of the above ideas holds out the promise of rapid, or at least as rapid as technologically possible, development of space resources and space settlements without imposing a "universal" economic or political system on all future space settlements. Such a system, no matter the good intentions of its instigators, would be tyrannical in practice – both in space and on the Earth.

Part 2: DARK SKIES Examined

Daniel Deudney, an Associate Professor of political science at Johns Hopkins University, has written a massive challenge to "space expansionists" as he dubs them. Although much of the book is taken up with a historical tour of pro-space advocacy, eventually *Dark Skies* (2021) gets to the good stuff: an elaborate argument that space development/settlement will lead inevitably to "Astrocide" – the extinction of humanity by future space colonists.

For Deudney the ultimate danger to humanity is successful independent space settlements. He explains that this danger exists for six reasons (Table 10.2):

1. Geopolitically Malefic tendencies
2. Natural threat amplification
3. Restraint reversal
4. Hierarchy establishment
5. Alien generation
6. Monster multiplication

Geopolitically Malefic Tendencies

Deudney coins the term "globally malefic" to describe the geopolitical nature of the space environment, which Deudney believes will create a highly dangerous tendency toward constant warfare. He lists in Table 10.2 "Solar space Geopolitics: Main propositions" those factors which he believes will propel the settled solar system into being a hellscape of violence. To refute his arguments, it is necessary to examine each in some detail.

1. "Colonies large enough to provide catastrophic risk insurance are likely to be politically independent, producing an anarchic system structure, reinforced by fragmented topography, large distances, and great differences of circumstances."
    a. As is typical with Deudney, this proposition contains a large number of purely speculative and dubious notions. Although large space settlements will in time become politically independent, they will remain connected economically to each other, and to Earth for a very long time to come. Resources in the Solar System are not evenly distributed, making trade a necessity, which in turn will reduce the feasibility of warfare. The idea that the political system will be anarchic is purely speculative; distant colonies will have a common interest in restraining rogue AI, stopping the production of Gray Goo, and preventing species divergence. Additionally, the energy distance between settlements is just as important or more important than the time distance, and many space settlements will be close together energetically even if travel times are large. Although settlements on Mars will be quite distinct from those in free space, the most likely outcome is that free space settlements everywhere will be more common in structure and circumstance than towns/countries on the Earth. There is probably no planetary surface where we are likely to see self-sustaining settlements other than Mars and Earth, and more remotely Titan. Venusian cloud cities will be a great tourist destination but it is hard to see them being self-sustaining. A terraformed Venus is a good candidate, but far outside our planning horizon.

2. Deudney forsees a high level of violence interdependence due to the usage of asteroids as weapons.
    a. Like a house built on sand, this idea collapse once it is fully understood how limited asteroids will really be as weapons. This is explored in detail under "Natural Threat Amplification" below.
    b. In fact, violence interdependence on a solar system scale will be much less than on Earth today, leading to decreased, not increased tensions.
    c. When the population of Earth is a minor fraction of the Solar System population, it is inevitable that Earth's political role will decline, perhaps reaching the level of Luxembourg on the Earth today. In such a situation, there will be no need to use asteroids to attack Earth; the power imbalance will be so great as to make conflict unlikely. What is the motive of China to nuke Luxembourg?
3. "Differences of circumstances will make units very different, further exacerbated by species radiation (directed or undirected)"
    a. As noted above, there are likely to be three major "circumstances": living on the Earth, living on Mars, and living in free space settlements spread over the entire rest of the Solar System. If humans can thrive in lunar gravity, we can add the Moon, but the Moon is so close to the Earth that it will remain politically connected to the Earth for the foreseeable future. This three-part structure of the Solar System is similar to that envisioned in the SF series *The Expanse*.
    b. As noted below under "Restraint Reversal," space settlers will have a common interest with Earthers in avoiding a radical transhumanist explosion into wildly different species, in the context of managed species evolution.
4. "civil-military distinctiveness" will be low on space settlements because moving planetoids will be a standard industrial technique.
    a. This might be true if moving asteroids resulted in something of great military utility, but this is not the case as is covered in detail under "Natural Threat Amplification" below.
    b. Additionally, moving asteroids is not likely to be how asteroid mining is conducted. Most probably, a factory/processing plant will move from asteroid to asteroid, and only refined material will be transported to other locations.
    c. It should be noted that during most of human history, e.g., the diaspora out of Africa, military-civilian distinctiveness was very low. When the entire adult population is the military, there are constraints on violence which are not present when a professional military can be deployed at low risk to the settlement.
    d. With the growing use of AI in weapons, the size of the military may be minimal, with the result that civil-military distinctiveness among space settlers is in fact very high.
5. "The system will have full open frontiers prone to violence and producing perpetual shifts in power distribution."
    a. On Earth "frontier" warfare has often occurred as expanding powers crush "native" civilizations; this will not occur in space
    b. Although over time trade routes and economic strength will certainly evolve in a complex and difficult to predict pattern, the existence of new frontiers for "losers" to migrate to should substantially ameliorate conflicts.

c. There are certain fixed resources in space, starting with geosynchronous orbital slots, that will need some means of equitable distribution. This is an issue that is on a good course to being resolved in geosynchronous orbit, with the same methods (non-interference, resource reservation for latecomers) having great potential for extension to lunar mining and Mars. These issues need to be resolved immediately, and once resolved will set a pattern for peaceful expansion into the solar system.

6. Deundeny's 6th point is simply that points 1-5 will lead to a violent solar system, but of course if points 1-5 are wrong or weak, the conclusion does not follow.
7. "Because of intense violence interdependence and high vulnerabilities, exiting anarchy and establishing mutually restraining government will be necessary for security but nearly impossible to achieve due to extreme unit-level differences, large distances, and difficulties in surveillance."
    a. As explained above, the supposed high-level of violence interdependence is based on the purported ease of using planetoids as weapons, which is not actually the case.
    b. The supposed high level of vulnerably is not factual either. Space settlements will be significantly less vulnerable than states on the Earth relative to potential weapons. The fundamental realities of space settlement geography are:
        i. Settlements are far apart – really far. Imagine Mars launching a fleet of missiles to attack Bernel spheres orbiting Saturn. The attack will take a long time – months at a minimum for missiles, and asteroids will be far slower. There will be lots of time to spot the attack, prepare a defense, or move the settlement.
        ii. Settlements on Mars or large moons will almost certainly be deep underground, and relatively less vulnerable to attack than a free-space colony.
        iii. The locations of all settlements will be well known, allowing for at least the possibility of a MAD (Mutually Assured Destruction) balance of power.
        iv. Free space settlements inside asteroids (i.e. a rotating cylinder inside a tube drilled in an asteroid) are going to be even harder to attack
        v. Beamed power weapons on solar system wide scale are not especially useful due to the physics of beam divergence on the scale of the solar system, and the difficulty of doing damage to underground or shielded targets. Additionally, beamed power weapons will not be small, will require vast amounts of power, and can be counter-attacked while under construction.
        vi. Missiles can be stealthy, but all settlements will be on constant alert for incoming asteroids and space debris of varying sizes, which are also dark.
        vii. The question is not whether some particular strong point can be destroyed – anything can be overwhelmed with a strong enough attack. The question is whether it is possible to execute a time-on-target (TOT) totally destructive attack that allows for no retaliation. For a couple of settlements, of course it will be quite possible to attack and destroy them. When there are 1,000s of settlements spread over much of the Solar System, this kind of attack strains credulity. Such attacks are far more plausible as long as humanity remains confined to Earth.
        viii. It should be noted that space makes nuclear weapons less deadly, not more. There is no "blast wave" in space since there is no atmosphere. There is no wind to blow around fallout. Human settlements already have to be designed to be air-tight and heavily radiation shielded to protect against Coronal Mass Ejections

(CMEs) and Galactic Cosmic Radiation (GCR). Nuclear bombs only add so much to the other radiation hazards of space. And there is no such thing as a "nuclear winter" in space. The most destructive aspect of nuclear weapons in space is probably EMP effects, but even here a rotating cylinder space settlement inside an asteroid should have a high degree of protection. Additionally, space settlements must be designed to survive large coronal mass eruptions, and this hardening will carry over to EMP attacks.

   c. The major flaw in point seven lies in the apparent assumption that first space will be settled in a highly-divided anarchic fashion, and THEN someone will try to put in place restraints. Far better, and much more likely, that the restraints will grow organically as the settlements grow, starting from a reasonable set of restraints on the Earth. In this vision, no "anarchic" set of space settlements will ever exist since a condition of their initiation will be agreeing to the "Solar Accords" which ban rogue AIs, gray goo, and species divergence. The key to making such restraints work is to focus on a small set of seriously enforced restrictions that truly are in the common interest of all.

8. "Totalistic hierarchical government in space settlements"
   a. Because of the almost certainly initially fragile nature of space settlements, this will be an issue especially when settlements are small. There will need to be an empowered "captain and crew" that make sure the gears are turning properly. Some freedoms are going to be highly restricted. I would not expect to see any orbital settlement with a right to gun ownership, for example.
   b. We are also likely to see "kibbutz style" settlements, which may or may not prove to be successful, but which are almost certainly going to be highly collectivist with little of what we might think of as personal economic freedom.
   c. We are also likely to see "stock company" settlements where shares determine voting rights, which could certainly result in something other than democratic decision making.
   d. To counteract the pressures toward totalistic settlements, especially in the early days, the "Solar Accords" need to provide for a single right that is absolute: self-exile. In other words, no one can be forced to stay in a settlement who wants to leave, and they must be afforded passage elsewhere. Perhaps the main function of Solar System government would be facilitating these transfers. Without this right, some settlements might be little more than slave colonies.
9. "Island Earth in the Solar Archipelago will face strong pressures toward highly hierarchical political consolidation"
   a. There can be little doubt that as space settlements grow in size and number, nations on Earth may be drawn toward closer cooperation on security matters. The question is what kind of unified Earth government will emerge?
   b. To answer this question, we need to consider how Earth would move from its current vast array of sovereign states, with a limited set of nuclear powers who in practice hold veto power over major decisions, to some kind of "one world" government. Deudney proposes that as we develop infrastructure in space (which he calls "Orbita" but others might refer to as "cis-lunar development"), some power will use that infrastructure to gain control over the Earth.

c. This “control from space” model has no credibility; it could only occur if all Earth powers but one “stood down” from space and allowed, say, China or Jeff Bezos to build a huge space infrastructure of mines, solar power satellites, and so on, while all other potential players sit on their hands and watched.
d. A far more likely scenario is that cis-lunar space will be developed by a variety of powers, in some cases cooperatively, and in others competitively, but without any one group or company gaining absolute control. Seriously – is Elon Musk going to retire just because Jeff Bezos wants to do big stuff in space? Will the US sit idly by while the Chinese develop the Moon?

Natural Threat Amplification

By “Natural threat amplification” Deudney refers to his belief that the temptation to use asteroids as weapons against Earth will be added to the natural risk of asteroids hitting the Earth. Deudney, similarly to Sagan in *Pale Blue Dot*, greatly exaggerates the usefulness of asteroids as weapons. An asteroid large enough to be more than atomic destructive would be hard to move, hard to aim, and easy to see coming toward Earth. Aimed the other way, all the same issues arise, with the added complication that free-space colonies have maneuvering capability. Add to this the fact that both Earth and space settlers will have active defenses against asteroids, and the overall usefulness of these kinds of attacks seems minimal. These and many other aspects of using asteroids as weapons are discussed in Appendix C of “Space Weapons Earth Wars” by Preston, Johnson, et. al. (2002, RAND) which comes to the conclusion that asteroids are not particularly useful as weapons compared to the alternatives.

The use of asteroids as weapons both between space settlements and Earth, and between space settlements, looms large in Deudney’s claim that a settled solar system will, in spite of the vast distances, have a high level of what he calls “violence interdependence.” This is just the ease with which one actor can attack another. A person on one island 100s of miles from another person on another island has a low level of violence interdependence. Two people locked in a single room have a high level of violence interdependence. If you provide the island dwellers with nuclear missiles, they have a much higher level of violence interdependence. If it is, in fact, easy to use asteroids on a solar system scale to stage massive attacks, then the level of violence interdependence will be high, and the solar system will be a dangerous place. The supposition is not well established in DARK SKIES. There appears to be an unstated assumption that distant space settlements can surreptitiously launch asteroids accurately to arbitrary locations in the solar system. In reality, both Earth and space settlements would constantly be on the alert for both natural and human instigated asteroid dangers using advanced versions of satellites like the planned NEOSM. No doubt efforts would be made to “stealth” the asteroids, but the journey would be long, with extensive close-in defenses coming into play near targets.

The question isn’t whether it is possible to conduct a war in space – of course it is – but whether we will be safer spread over the solar system or stuck on Earth with nuclear missiles. I submit that whatever the exact level of violence interdependence might be in a fully settled solar system, it will be significantly less than on the Earth today, in which global destruction is only 20 minutes away every day of every month of every year. Deudney would like to change that picture by convincing the world powers to give up nuclear weapons, but good luck with that. Additionally, since the Earth is a single connected biosphere, it will always be far more vulnerable to a biological attack than thousands of space settlements separated by vast distances of vacuum.

Restraint Reversal

Here Deudney speculates that whatever restraints on weapons and advanced technology (AI, genetic engineering, Nanotech) might be established on Earth, on the scale of a settled solar system, those restraints will slip away. Deudney is well aware of the views of various space advocates, especially those of a libertarian bent, who in fact work toward space settlement precisely to seek the freedom in space to pursue technology that may be too dangerous to develop on Earth. Deudney also believes, probably correctly, that independent space settlers facing harsh conditions in space will reach out to whatever technology they can to make their lives better.

With regard to new technologies – AI, nanotech, and genetic engineering – it will take at least several centuries before we optimistically can establish even the first truly independent space settlement. During this period humanity will almost certainly achieve some balance with regard to all three of these technologies, or succumb to the disaster each may create.

Consider the case of AI. There are enormous efforts being made to develop it currently, and a vast array of applications and benefits potentially achievable. At the same time, anyone who thinks about AI for long will realize that an unconstrained general-purpose AI is a terrible idea. If we survive the "Paper Clip Apocalypse[36]" humanity will have found some approach to limiting AIs. Once this restraint is established, it is hard to understand why space settlers would undo it. No matter how post-human they are, the colonists will have no desire to be made into paperclips by a rogue AI. One can easily imagine a "Solar Patrol" crewed by Terrans and space settlers enforcing restrictions on AI development, supported by a solar system wide intelligence network uniting humans and post-humans in a common goal – survival.

A similar logic applies to restraints on nanotechnology. Post-humans will have no interest in becoming "gray goo". There may be rogue elements either on Earth or in distant settlements, but there will also be countervailing forces working diligently to ensure the survival of all.

Issues around genetic engineering will be considered below.

Hierarchy Establishment

Deudney fears that space settlement will lead to a hierarchical/totalitarian one-world government on Earth as a response to the growing power of independent space settlements, or that it might be facilitated by a single Earth power controlling a large in-space infrastructure, i.e. SPS satellites.

There can be little doubt that during some intermediate period – after what Deudney calls "Orbita" (full cis-lunar economic development) – and before space settlements are so widespread and populous that Earth is a backwater, there will be strong political forces pushing Earthly nations toward greater cooperation of all kinds, including defense. The question is whether this will be a Terran Federation or a one-world dictatorship? The only way the current diversity of Earthly powers could wind up as a one world dictatorship is if a single nation dominated cis-lunar space in a context where competing powers allow them to do so. As long as current major powers – included corporations of great capability - develop space resources in parallel, we need not fear Bezos owning the Moon or the Chinese controlling Earth via owning all the Solar power satellites. No – the only scenario we need fear is one in which many Earthly nations give up on space, while one – say, China – continues to develop cis-lunar and asteroid resources and uses them ultimately to dominate the Earth from space.

Hence, the greatest risk is that most – but not all - world leaders listen to Deudney and relinquish space development.

It is vital that space resources be developed in such a fashion that no nations – or groups – are arbitrarily excluded the benefits of space. This means that developing cis-lunar resources must be both international, and allow all interested groups and companies to participate. The joint operating agreement for the ISS is an excellent start. NASA's gateway plans could be an outstanding second step. The Artemis Accords proposal holds promise. We can reach out to include India and China in appropriate ways. The development of cis-lunar space will be highly competitive, but neither war nor one-world dictatorship is a foreordained outcome.

Alien Generation

Genetic engineering may be the tougher problem. The kind of total relinquishment Deudney envisions on a closed Earth is more likely to lead to global war than the peace he hopes for. If the neo-Luddites insist on complete relinquishment, they will come into conflict with those who see value in using germline techniques to prevent disease, extend life, and enhance the human condition. Any realistic restraint system must achieve for humanity the broad promise of genetic engineering – cures for disease, and longer, healthier lives. Not just somatic cell engineering, but germ cell engineering, both with appropriate limitations, will need to be part of the management agreement. Contrary to the "parade of horribles" laid out by germ-line engineering opponents like Kass and McKibben, humans have developed a political and legal system able to make fine distinctions between genetic technologies that ought to be allowed and that which should not.

The challenge will come as we spread out into space. There will undoubtedly be genetic changes – radiation resistance, for example, that will help more in space than on the Earth. The challenge will be to find a management structure that allows for the greatest part of the value of genetic engineering to be realized for all of humanity without allowing fractionalization into competing species. Although Deudney thinks this diversification is inevitable, nothing requires that it must be so. Perhaps the greatest risk is a scenario where Deudney and his ilk convince Earth governments to cruelly suppress all the good that might come from genetic technologies, inspiring growing numbers to leave Earth to pursue their many benefits in space. If post-human clades exist equally on Earth and in space, whatever conflicts exist between Terrans and spacers will not be fundamentally related to genetic differences.

The question we need to ask is what stage we want debate – or battle – over AI, nanotech, and genetic engineering – to take place on? A closed Earth or an open solar system? The probability of disaster seems greater on tiny earth, while on a solar system level that is more room for errors to be recovered from. Deudney is limited by the fallacy of the excluded middle – he imagines that the choice we face is between essentially complete relinquishment of AI, nanotech, and genetic engineering and an unconstrained transhumanist libertarian explosion of rapidly diverging species. There is a path in the middle that captures long life, excellent heath, and growing human capabilities while relinquishing only the "atomic bomb" of diverging species.

It is impossible to separate the above technologies from the "cyborgization" of humanity, which is already well advanced. Tens of thousands benefit from implants ranging from heart valves to cochlear implants to artificial limbs. Somehow the world has not been convulsed by "cyborg vs human" battles, perhaps because it is obvious to most people that "cyborgization" has many upsides, and few of the

types of risks envisioned by Luddites. As we move into space, we can expect “cyborgization” will continue, but there is little reason to suppose it will lead to the kind of violent conflict Deudney envisions.

Monster Multiplication

Deudney, much like McKibben, is terrified that technology will ultimately bring about some kind of unforeseen disaster. Because every single interaction between all possible science and technology is not foreseeable, even in principle due to chaotic effects, the only solution Deudney/McKibben can envision is “Enough” [McKibbin is the author of a 2003 book with the title “*Enough – Staying Human in an Engineered Age*] – an end to science and technology before the potential of AI, nanotech, and genetic engineering are realized.

The main problem lies in where they draw the line – right now, with humanity confined to the Earth – subject to the slings and arrows of vicious nature? Or should we hold back on the “big no” at least until we are spread safely through the solar system?

Unfortunately, Deudney has reversed the facts. By significantly understating the risks of staying contained on Earth, while making worst case assumptions related to space settlement, Deudney tips the scales in his preferred direction. In reality, if humanity stays locked in the cradle of Earth, our extinction is inevitable, and on a much shorter timeframe than Deudney seems to realize, since his understanding of extinction risks appears limited to the heat death of the Sun in 800 million years. If we spread over the solar system there are real risks. The Solar Patrol may fail to control AI, and the universe ends up getting converted to paperclips. Lots of bad things could happen, but they also might be avoided. Our doom on Earth is far less avoidable.

There are other relinquishment points than right now. We can choose to develop much of the potential of AI, but stop short of an unconstrained paper-clip factory destroying the galaxy or converting all matter into computronium. We can choose to develop nanotech, but manage it like other potentially dangerous technologies. We can say no to the curious notion than insane individuals should have easy access to weapons of mass destruction, starting with bump stocks. We can organize our society to be resilient rather than fragile. And perhaps most importantly, we can, collectively, choose to gradually gain the powers granted by human genetic engineering without dividing into competing species. This is a relinquishment (what Kurzweil calls “fine-grained relinquishment”), but potentially a golden one, full of potential.

Conclusion

Deudney is right about one thing - space advocates usually avoid talking about solar system governance. When they do talk about it, we often see a gauzy projection of a libertarian paradise without any consideration of possible risks. To make space settlement a reality, space advocates are going to have to make the case that there is a way to govern the solar system that does not involve unlimited techno-libertarianism/transhumanism. Whether humanity remains stuck on Earth facing eventual extinction, or expands into the solar system to improve the odds of human survival, there are going to be some limits of some kind. Even the most extreme libertarian must admit that there must be some common law for Solar System humanity. Build no rogue AIs. Build no Grey Goo. Make no new human species that diverge

into xenophobic differences. But above all, don't end the project of technic civilization now, when we are still at the beginning, as Deudney and McKibben demand.

Let us build a golden age today as we expand into space, where everyone is rich by the standards of today, but rewarded according to their efforts and talents. Where everyone has an equal political voice, and an ability to choose their lifestyle on a scale that we can only dream of. Let us adopt the powers of genetic engineering in measured fashion, with each generation exceeding the last in health, longevity, and capability, but not at such a speed that society is ripped asunder. Let us have some limits on human action, but no more than are needed to protect us all. Ad Astra!

Part 3: Interrogating "Why We'll Never Live in Space" by Sarah Scholes, Scientific American, October 2023

From the deceptive bait and switch between the cover title: "*Will Humans Ever Live in Space?*" and the real title, "*Why We'll Never Live in Space*" to the mocking usage of the term "space enthusiast," Scientific American has served up a hit-piece dressed as a science article. Ostensibly based on interviews with experts and book ended with quotes from less-than-expert "analog astronauts" attending a conference at Biosphere 2, this article is a sad excuse for responsible journalism.

Perhaps the greatest confusion Scholes perpetuates lies in equating traveling in space with living in space, and especially with living in a space settlement. For example, the impact of microgravity is very important when traveling in space, and the jury is in – microgravity is terrible for the human body. This is exacerbated by NASA doing everything it can to avoid the use of artificial gravity to address this issue. Yet no serious advocate of settling space thinks humans will thrive in microgravity. The entire focus of the space settlement movement lies in the creation of artificial gravity via centrifugal force. Scholes devotes most of a page on this problem without ever mentioning that it is one technological exercise from being solved – we know how to create artificial gravity.

Extended transit through space can also be enabled by artificial gravity. One approach, much favored by NSS Board of Governors member and the second man to land on the Moon, Buzz Aldrin, is called a Cycler. A Cycler is a large spaceship that orbits regularly between, for example, the Earth and Mars. Small, fast rockets ferry passengers and cargo to and from the Cycler as it swings past Earth and Mars on its continuous voyage. The Cycler is gigantic by spacecraft standards, supporting both artificial gravity and extensive radiation shielding.

Scholes then discusses her next demon, space radiation. We are told that although a shield of water can protect against solar radiation, astronauts wandering on the lunar surface might get caught in a solar storm and be harmed by the high radiation count, which is true. It should be noted, however, that NASA is generally able to provide ample warning of such events with plenty of time to seek shelter, even on the Moon or Mars.

Next in this parade of space terrors are Galactic Cosmic Rays (GCRs). In this case, a little bit of metallic shielding is worse than no shield at all since the GCR interacts with the shield to produce secondary radiation. But NASA and others have researched simple, workable solutions for GCRs as well – minimum shielding combined with a "storm shelter" that provides much stronger protection from space radiation. This solution works well for traveling in space, but not so much for living in space – for the latter, you need a significant amount of shielding to reduce the radiation count to Earth-like levels. The good news is that regolith (lunar, Martian, or asteroid soil) or water works just fine as a shield, and both are widely available in asteroids, on Mars, and on the Moon. There is an additional implication that most of the time, if you live in space, you will be "indoors." In orbital space settlements of any significant size, the "inside" that is shielded will be sufficiently large that claustrophobia will not be an issue.

Onward to the next warning in the article: mental health. By focusing only on "a tin can with a small crew" this might seem to be a major issue, but it is one that has been already been solved right here on Earth. One hundred day plus submerged voyages are routinely undertaken by nuclear submarines,

including claustrophobic submarine trips under the Arctic ice cap. Additionally, the problem of a small crew in a cramped capsule is a *traveling* in space issue, not a *living* in space issue. Although the very first habitats in space are likely be cramped, these will probably be research stations, and the first priority of the settlers will be rapid expansion of living space, that soon becomes a town, and then a city. At some point it will be no more claustrophobic than living in Tokyo or New York.

Next Scholes turns to the lack of a clear economic justification for living in space, and this will in fact be a challenge. Part of the problem lies in that although there are a significant number of plausible rationales for developing space resources, such ideas will remain speculative until the business is in operation and prospering. But the economic rationale for GPS and geosynchronous comsats was once questionable but is now well established, and have turned into highly profitable ventures. Similarly, we are close to seeing orbital tourism and mega-constellations of orbiting data communication satellites becoming viable businesses. But these baby steps are just the start. The business case must be made every step of the way.

Scholes provides a good bit of discussion on the topic that the government is not going to pay for settling space, and space settlement advocates agree. Instead, they want the government to support the space economy in the same way that the Earth economy is supported – by the development and demonstration of new technology, and by providing the legal framework that allows people to live and work in space as free economic beings, not employees of the government.

Next up, Scholes pits "practical" uses of space and Earthly needs – such as affordable housing – against "… money is going to the moon or Mars or Alpha Centauri." Setting aside the obvious rejoinder that all the money is spent on the Earth, not in space, this simple-minded critique ignores that fact that essentially zero dollars of the NASA budget goes toward settling space –most of that money goes toward robotic and human exploration and supporting the aerospace industry.

Next it is suggested that since the lives of people living in space will be most likely be difficult, it is unethical to allow anyone to attempt to settle space. If this "principle" had been followed throughout human history, we would all be living in a small settlement alongside the Olduvai Gorge.

Now comes the unanswerable question of whether we have the right to live on and contaminate the Moon and Mars. Although there are issues regarding whether a low-level life Martian form is worth protecting, what is being proposed is that for "ethical" reasons no human should ever be allowed to "contaminate" the Moon or asteroids in pursuit of the need to settle space. There is room for a rational discussion on resource reservation and benefit sharing, but the extreme form of his view would make the entire universe a park while ensuring eventual human extinction confined to the Earth.

We are finally led to Gary Westfahl's essay "The Case Against Space," which claims that the main argument for going into space can be reduced to "space travel represents humanity's destiny." This sort of nebulous pitch makes a poor case for space settlement and will not convince those who envision different human destinies, or reject the notion that humanity does have a single destiny. Thus, in destroying this argument for space exploration, Westfahl scores a point, but it is a very small point indeed. For more about Westfahl, see Annex A below.

Ultimately, the problem with Scholes' assertions lies not in the analog astronaut frame, but in her one-sided and even disingenuous treatment of the challenges, and rewards, of expanding the human domain into space.

Part 4: A Response to Gary Westfahl's "The Case against Space" (1997)

In *The Case against Space* (1997), an essay in *Science Fiction Studies*[37], Gary Westfahl argued from his perspective as scholar studying science fiction that science fiction failed to make the case for space exploration, and in particular for humans in space. It seems a bit unfair debating him from the perspective of 2024, since like some time-traveler I have the advantage of knowing what really did happen in the years following 1997, and those events in many cases contradict some of Westfahl's arguments. Sadly, bad ideas never die, and Westfahl was generously quoted in the 2023 anti-space settlement article in *Scientific American*. It is worth noting that in 1997 Westfahl argued against humans in space in general, while the Scientific American article Iimited itself to opposing space settlement rather than space exploration or development. This is progress of a sort.

Westfahl argues that there were three epochs in space advocacy. In the 50s and 60s there was an emphasis on philosophical arguments, in particular "…humanity must venture into and occupy outer space to fulfill an inherent human drive to explore and inhabit unknown realms." Overall, he provides a thoughtful rebuttal to this idea, which is quite popular among space advocates. Notably, Sagan's *Pale Blue Dot* echoes the idea in the quote, and the very short film *Wanderers*[38] – created by Erik Wernquist and written and narrated by Carl Sagan – amounts to a visualization of it. Although the video's 1.3 million views are impressive for a space video, Jenna Ortega (with 38 million followers on Instagram) has nothing to worry about.

Eventually Westfahl concludes, "…the history of our species powerfully suggests that progress will come from continued stable life on Earth, and that a vast new program of travel into space will lead to a new period of human stagnation." In saying this, he is describing the bulk of human history as hunters and gatherers as a period of stagnation, and suggesting that essentially all progress has come only after the stability made possible by the agricultural revolution. There are at least two difficulties with this line of reasoning. First, although progress was not rapid during our hunter-gatherer phase, an enormous amount of knowledge was collectively acquired with regard to everything about living on the Earth. Additionally, as the sophisticated gear carried by the "Iceman" found in a glacier in Switzerland suggests, living as a hunter-gatherer should not be understood as a "primitive" existence.

Second, Westfahl confuses the fact that while science fiction writers often describe life on space colonies with a nostalgic tone, looking back to an imagined past period of glory, this should not be understood as reflecting the likely outcome of humans actually settling space, for several reasons. It is just not very likely that humans living with advanced technology in a future interstellar settlement will behave like characters in a Jerry Pournelle story. Science fiction writers, including Pournelle, often insert a "dark age" to allow for a future society to resemble the present day or a past human society. This "trick" makes a story easier to write and for present day readers to understand, but should not be confused with a probable future.

Additionally, Westfahl understands that a political element exists in much science fiction, which reacts to unhappiness with 20th century civilization, and seeks to return to "…some idealized past existence before the bureaucrats, internationalists, politically correct professors, and other villains started to destroy civilization." Westfahl knows that not all cultures share the Western mania for exploration, travel, and progress, noting "…many impressive civilizations, like that of China, were founded on the notion that staying where you are is the best policy." One wonders what he thinks of China in 2024. He would possibly be pleased to note that after a last-ditch battle, the heirs of Jerry Pournelle have been

run out of the science fiction community on a rail (the "Sad Puppies" incident[39]), such that it is impossible to characterize today's culturally diverse science fiction community as opposing "politically correct professors."

Westfahl seems on weak ground indeed when he declares, "…it is disheartening to see the basic argument for colonialism warmed over and advanced as a basic argument for space travel." In his essay it remains unclear exactly what he thinks the basic motivation for colonialism was – "fame and glory"? If all we were doing in space was exploring, he might have a point, although a weak one that ignores the scientific and cultural value of exploration.

In the 1970s Westfahl characterizes space advocates as turning from philosophy to a new idea, "…outer space can solve many problems now confronting humanity on Earth; and the people who step forward to solve those problems are going to make an awful lot of money." He is not impressed with this idea, and considering the "false boom" of 1990s space activity, his feelings are perhaps understandable. What a difference a few decades makes. More or less everything that was not happening in space in 1997 is happening for real right now. We have a space station. We have a new generation of rockets that are fulfilling the low-cost promise of the shuttle. We have the first commercial landing on the Moon. We have suborbital tourism. We have orbital tourism. We have LEO megaconstellations providing global internet, an internet with capabilities beyond the imagination of science fiction writers in 1997. And it did turn out that not everything you can do in space can be simulated on the Earth, which is why we have just made the first kilometer long ZBLAN fibers on the ISS, and why the cold-atom lab is on the ISS, and not on the ground. And most importantly, billions and billions of private monies are flowing into space ventures. Even more unexpectedly, the two richest men in the world are locked in a race to do business in space and settle Mars. We recently saw the 6th test flight of the SpaceX Starship/Superheavy, a fully reusable vehicle designed to be capable of lofting 150MT to LEO. And so on and so on …

After the space benefits arguments failed, Westfahl says that space advocates are turning to concerns about asteroid impacts to advance their arguments. He is surely correct that although it may be a good idea to detect and deflect incoming asteroids, this does not in some larger sense justify space exploration, development, and settlement, mainly because we can detect and deflect asteroids with robots just fine. Although correct on this point, Westfahl expressed two common confusions about asteroid impacts. First, he thinks that if there is a low probability of a big asteroid impact, such an impact will be a long time in the future. This is not how probability works. The statistical distribution of an event over time is just that – statistical – and says nothing about when the event will actually happen. It could be very unlikely, and still happen next week. Second, he seems to feel that even an asteroid strike that causes 100s of millions of human causalities would not result in our extinction. This is a rather cavalier attitude toward human life, but also ignores the possibility of a double disaster, where the asteroid strike initiates a nuclear war or triggers a volcanic eruption.

Westfahl then considers alternative pro-space arguments that he finds more convincing, but dismisses them all as being long term prospects at best, or not being strong justifications in and of themselves. He then puts it forward that "What I would argue in contrast is that we should not go into space today precisely because the human race faces no major problems." Oh, what a difference the years make. 1997 was just before a long series of highly dangerous events, starting with the 9/11 attacks, and continuing with the war against first Al Quada and then ISIS, followed briskly by the covid pandemic (1M deaths in the USA alone), and now drone wars in the Ukraine and Gaza. Also, climate change. The pending appearance of true artificial general intelligence. And so on and so on ….

But Westfahl is certainly correct that science fiction as a genre oversold space travel, while mostly missing the vast progress that would occur with electronics, computers, and communication, as well in biology. He should have remembered that science fiction is always really about the present, not the future. And a fiction is not a fact.

Endnotes

[1] See: https://www.vastspace.com/roadmap
[2] See: https://en.wikipedia.org/wiki/Degrowth
[3] See: https://en.wikipedia.org/wiki/The_Limits_to_Growth
[4] See "The Settlement of Space: Economical and Logistical Drivers and Constraints," Journal of the British interplanetary Society, Volume 76, 2023.
[5] David G. Schrunk, Burton L. Sharpe, et al., *The Moon: Resources, Future Development and Settlement*, Springer Praxis Books, by, Oct. 4, 2007
[6] See: https://spacenews.com/varda-capsule-lands-in-utah/
[7] See: https://space.nss.org/space-solar-power-may-not-be-a-thing-for-casey-handmer-but-he-has-not-made-his-case/
[8] See "The Settlement of Space: Economical and Logistical Drivers and Constraints," Journal of the British interplanetary Society, Volume 76, 2023.
[9] This section is substantially based on a private conversation with Frank White and an associated email exchange with White that took place in November 2024. All quotes were directly provided by Frank White.
[10] Some people advocate spreading not just humanity but the entire ecosystem of the Earth throughout space. This is not a human centric ideology, but clearly if we are exporting all the lifeforms of Earth to the galaxy, that will include humans.
[11] Charles S. Cockell, *Extra-Terrestrial Liberty an Enquiry Into the Nature and Causes of Tyrannical Government Beyond the Earth*, June 13, 2013
[12] https://nss.org/l5-news-opinion-the-case-against-mars/
[13] https://nss.org/wp-content/uploads/NSS-JOURNAL-Nuclear-Fuel-Resources-of-the-Moon-2021-June-1.pdf
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[18] *The High Frontier: An Easier Way* (July 20, 2018) by Tom Marotta and Al Globus
[19] https://en.wikipedia.org/wiki/Lunar_cycler
[20] https://www.businessinsider.com/residential-cruise-startup-condos-at-sea-photos-2023-10
[21] https://www.frontiersin.org/articles/10.3389/fspas.2021.645363/full
[22] https://nss.org/settlement/nasa/spaceres/index.html (*Space Resources and Space Settlements*, NASA SP-428)
[23] *Colonization of Venus* by Geoffrey Landis, 2003, NASA Glenn Research Center, https://ntrs.nasa.gov/api/citations/20030022668/downloads/20030022668.pdf
[24] *Beyond Earth: Our Path to a New Home in the Planets*, Charles Wohlforth and Amanda R. Hendrix, Ph.D. (2016)
[25] The Weinersmiths later in this chapter do point out an area where the definition of space might matter, as they postulate a SpaceX Starship overflying Russia on a ballistic trajectory. However, the right of overflight is so well established that at this point as long as the Starship was really "in space" beyond any doubt, it would probably not be an issue. Unless the Russians make it an issue, but the Russians have a vast array of excuses for starting wars, one more or less hardly matters.
[26] https://nss.org/wp-content/uploads/NSS-benefit-sharing-terms-of-reference-2023-1.pdf
[27] https://spacenews.com/nasa-offers-to-buy-lunar-samples-to-set-space-resources-precedent/
[28] https://www.science.org/doi/10.1126/science.abq7487
[29] https://www.youtube.com/watch?v=IS5ycm7VfXg
[30] https://deepmind.google/discover/blog/alphageometry-an-olympiad-level-ai-system-for-geometry/https://deepmind.google/discover/blog/alphageometry-an-olympiad-level-ai-system-for-geometry/
[31] https://www.pbs.org/newshour/show/what-to-know-about-escalations-in-venezuela-and-guyanas-territorial-dispute
[32] https://nss.org/wp-content/uploads/2019/07/NSS-Position-Paper-How-Space-Technology-Benefits-the-Earth.pdf
[33] https://www.scientificamerican.com/article/why-well-never-live-in-space/
[34] They did interview Rod Pyle, Editor in Chief of the NSS flagship publication, *Ad Astra*, with regard to various books he has written about Mars.

[35] https://www.vastspace.com/roadmap
[36] The “paper clip apocalypse” refers to what may happen if an unconstrained general purpose AI is given a command like “Build the most efficient and highest volume paper clip factory possible,” with the result that first the Earth, then the Solar System and finally the entire universe is converted to paper clips, along with the human race. See “*Superintelligence: Paths, Dangers, Strategies*” by Nick Bostrom.
[37] https://www.depauw.edu/sfs/essays/westfahl%20case.html
[38] https://www.youtube.com/watch?v=YH3c1QZzRK4
[39] https://en.wikipedia.org/wiki/Sad_Puppies