# Framework

**The standard is maximizing societal welfare.**

**Utilitarianism respects the moral equality of individuals.**

Philosopher Eric Rakowski explains. “Taking and Saving Lives.” Columbia Law Review. June 1993.

On one side**, it presses toward the consequentialist view that** **individuals' status as moral equals requires that the number of people kept alive be maximized.** Only in this way, the thought runs, can we give due weight to the fundamental equality of persons; **to allow more deaths when we can ensure fewer** is to **treat[s] some** people **as less valuable[.]** than others. Further,killing some to save others, or letting some die for that purpose**,** **does not entail that those who are killed** or left to their fate **are being used** merely **as means to** the well-being of **others, as would be true if they were slain** or left to drown merely **to please [other] people[.]** who would live anyway. They do, of course, in some cases serve as means. But they do not act merely as means. Those who die are no less ends than those who live**. It is because they are also no more ends than others whose lives are in the balance that an impartial decision-maker must choose to save the more numerous group[.], even if she must kill to do so.**

**This means that whoever maximizes societal well-being wins the round.**

# Contention 1: Asteroid Mining

How is this relevant to appropriation?

Is there space mining happening now?

\*\*You might want to start with the problem, not the solution – this means say “We are running out of precious metals now” and then “Space mining solves these concerns” rather than the other way around

#### Mining Industry destroying itself.

David Oni, Space analyst at Space in Africa, writes in 2019:

David Oni 19 (David Oni, Space industry and technology analyst at Space in Africa, Graduate of Mining Engineering from the Federal University of Technology Akure.) The Effect of Asteroid Mining On Mining Activities in Africa 9-24-2019 Space in Africa https://africanews.space/the-effect-of-asteroid-mining-on-mining-activities-in-africa/ //DebateDrills TJ

The earth, as we have come to know, is enriched with a vast array of mineral resources. But these resources are nonrenewable and hence, constant growing consumption in developing and developed countries, with the rising need for more resources to keep driving the fourth industrial revolution, will ultimately lead to a depletion in a couple of years to come. Experts say that elements needed for modern industry and food production could be exhausted on Earth within 50–60 years.

In terms of mineral resources, Africa has the most abundant of reserves. Currently, Africa hosts 30% of the world’s mineral reserve, 55% of the world’s diamond comes from Botswana and Congo, 60% of the mining in Africa is gold mining but to mention a few.

Given that the mining industry is consistently rising across sub-Saharan Africa, it is good news for the African mining sector as mining companies are beginning to expand operations, countries are already looking into improving regulatory frameworks that will enhance activities and also attract more investors.

But recent breakthroughs in space technology have led to many space scientists and engineers looking to explore alternatives to sustaining the earth while generating massive revenue and improving life generally. Currently, there are various comprehensive research documents on the Space Mining market, with detailed insights on growth factors and strategies. With the current advances and cutting edge technologies developed in preparation for the first stages of asteroid mining, one might want to ask if it is indeed good news for the African continent.

Apart from the environmental impacts, major mining activities are largely hindered in Africa by a handful of other factors such as access to energy, health and safety volatility of commodity prices, etc. Other issues such as political uncertainty, economic instability, religious and tribal wars, industrial unrest, and the fickle nature of regulatory bodies have also rendered foreign direct investment increasingly unattractive to global investors. Furthermore, most African countries have a relatively undeveloped infrastructure for exploiting resources effectively.

At the moment, Asteroid mining poses no threat to terrestrial mining; however, this will not hold for long. The space industry is progressing at such a rapid pace, and the prospects are unequivocally mouth-watering. The big question is, will asteroid mining lure away investors in Africa? The planetary resources company estimates that a single 30-m asteroid may contain 30 billion dollars in platinum alone and a 500m rock could contain half the entire world resources of PGM. Considering the abundance of minerals in asteroids, once asteroid mining materialises, it will severely affect the precious metals market, usurp the prices of rare earth minerals, and a whole lot more because minerals that are usually somewhat scarce on earth will be easily accessible on asteroids.

While foreign investors run the majority of the large-scale mining activities in the region, reports say that many African countries are dangerously dependent on mining activities. For some African countries, despite massive mineral wealth, their mining sectors are underdeveloped, and this is as a result of much focus on oil resources and a couple of other challenges. The million-dollar question is, what will become of the mining activities in Africa?

#### Dwindling precious metals are key to innovation.

Jeremy Hsu, Author in Popular Science and Scientific American mind, writes in 2012:

Jeremy Hsu 12 (Jeremy Hsu, Masters in Science Journalism from NYU, written in publications such as Popular Science, Scientific American Mind and Reader's Digest Asia.) Shortage of Rare Metals Could Threaten High-Tech Innovation 1-30-2012 livescience https://www.livescience.com/18167-shortage-rare-metals-threaten-high-tech-innovation-hitchhiker-metals-clean-technologies.html //DebateDrills TJ

A world in need of faster computers, smarter phones and more energy-efficient light bulbs threatens to strain the small supply of rare metals used by the global electronics industry. But limits on the production of such rare metals mean the supply can't easily expand to meet the demand for innovation in both consumer electronics and clean technologies.

Scarce metals such as gallium, indium and selenium — known as "hitchhiker" metals — come only as byproducts of mining major industrial metals such as aluminum, copper and zinc. That makes it hard to simply boost production of hitchhiker metals whenever industries face a shortage, even if the metals have become critical components of everything from high-performance computers to solar panels.

"With respect to metals that are hitchhikers, a higher price isn't going to lead to much more production," said Robert Ayres, a physicist and economist based at the international business school INSEAD in France. "And therefore it's much more important to think in terms of conservation, recycling and substitution."

That sobering message was delivered by Ayres at a Royal Society discussion meeting held in London Jan. 30. He wants both governments and industries to come up with a standard recycling process that could reuse rare metals.

"You produce something, you use it, but you don't just toss it in a landfill; it goes to another stage and another, and eventually the rare materials are recovered," Ayres told InnovationNewsDaily. "At present, hardly any are recovered."

Take gallium as an example. Gallium is a small byproduct of mining bauxite and zinc, but it has become a critical component for technologies such as lasers, energy-efficient LED lighting and solar panels. The metal has also become a replacement for silicon in faster microchips powering the latest generation of smartphones.

U.S. demand for gallium relied upon $66 million of overseas imports in 2011, according to the U.S. Geological Survey. And just one company, in Utah, recovered and refined gallium from scrap metal and impure gallium metal.

Indium has become a crucial ingredient in the liquid crystal displays for smartphones and in some types of solar panels. A third hitchhiker metal, selenium, also forms part of the solar panels containing both gallium and indium.

Ayres worries in particular about rare metal shortages crippling innovation in clean energy technologies such as solar power.

"Tellurium, part of the lowest-cost photovoltaic material, is only available from copper refineries," Ayres pointed out. "And so the quantity available in the world isn't anywhere near enough to satisfy the potential demand for thin-film photovoltaic surfaces (solar panels)."

#### Asteroid mining provides the necessary precious metals for innovation.

Matthew Williams, Journalist with articles in Universe Today and Business Insider, writes in 2020:

Matthew S. Williams 20 (Matthew S. Williams, writer for Universe Today, and the curator of their Guide to Space section, Articles have been featured in Phys.org, HeroX, Popular Mechanics, Business Insider, Gizmodo, and IO9, ScienceAlert, Knowridge Science Report, and Real Clear Science,) Asteroid Mining to Shape the Future of Our Wealth 11-6-2020 No Publication https://interestingengineering.com/asteroid-mining-to-shape-the-future-of-our-wealth //DebateDrills TJ

The argument in favor of asteroid mining is simple: within the Solar System, there are countless bodies that could contain a wealth of minerals, ores, and volatile elements that are essential to Earth's economy.

Asteroids, as we saw above, are believed to be the material left over from the formation of the Solar System. As such, many asteroids are thought to have compositions that are similar to that of Earth and the other rocky planets (Mercury, Venus, and Mars).

All told, there are thought to be more than 150 million asteroids in the inner Solar System alone, and that's only the ones that measure 100 meters (330 ft) or more in diameter.

These can be divided into three main groups: C-type, S-type, and M-type, which correspond to asteroids composed, respectively, largely of clay and silicates, silicates and nickel-iron, and metals. About 75% fall into the category of C-type; S-types account for 17%; while M-type and other types make up the remainder.

These latter two groups are thought to contain abundant minerals, including gold, platinum, cobalt, zinc, tin, lead, indium, silver, copper, iron, and various rare-Earth metals. For millennia, these metals have been mined from the Earth's crust and have been essential to economic and technological progress.

In addition, there are thought to be many asteroids and comets that contain water ice and other volatiles (ammonia, methane, etc.). Water ice could be harvested to satisfy a growing demand for freshwater on Earth, for everything from drinking to irrigation and sanitation.

Volatile materials could also be used as a source of chemical propellant like hydrazine, thus facilitating further exploration and mining ventures. In fact, Planetary Resources indicates that there are roughly 2.2 trillion US tons (2 trillion metric tons) of water ice in the Solar System.

Of course, this raises the obvious question: wouldn't it be really expensive to do all this mining? Why not simply continue to rely on Earth for sources of precious metals and resources and simply learn to use them better?

To put it simply, we are running out of resources. To be clear, learning to use our resources better and more sustainably is always the most important idea. And while it is certainly true that Earth-based mining is far cheaper than going to space would be, that may not be the case indefinitely.

#### Space Research is key to solving climate change.

Greg Autry, Professor of Space Leadership at Thunderbird School of Global Management, writes in 2019:

Greg Autry 19 (Greg Autry, Clinical Professor of Space Leadership, Policy and Business at Thunderbird School of Global Management, Tech startup founder, Researcher on entrepreneurship, commercial space and economics. Former NASA Presidential Appointee. Writer & regular Forbes contributor, 2021 Space Advocate of the Year.) Space Research Can Save the Planet—Again 7-20-2019 Foreign Policy https://foreignpolicy.com/2019/07/20/space-research-can-save-the-planet-again-climate-change-environment/ //DebateDrills TJ

Indeed, understanding the evolution of other planets’ climates is essential for modeling possible outcomes on Earth. NASA probes revealed how, roughly 4 billion years ago, a runaway greenhouse gas syndrome turned Venus into a hot, hellish, and uninhabitable planet of acid rain. Orbiters, landers, and rovers continue to unravel the processes that transformed a once warm and wet Mars into a frigid, dry dust ball—and scientists even to conceive of future scenarios that might terraform it back into a livable planet. Discovering other worlds’ history and imagining their future offers important visions for climate change mitigation strategies on Earth, such as mining helium from the moon itself for future clean energy.

Spinoff technologies from space research, from GPS to semiconductor solar cells, are already helping to reduce emissions; the efficiency gains of GPS-guided navigation shrink fuel expenditures on sea, land, and air by between 15 and 21 percent—a greater reduction than better engines or fuel changes have so far provided. Modern solar photovoltaic power also owes its existence to space. The first real customer for solar energy was the U.S. space program; applications such as the giant solar wings that power the International Space Station have continually driven improvements in solar cell performance, and NASA first demonstrated the value of the sun for powering communities on Earth by using solar in its own facilities.

Promisingly, space-based solar power stations could overcome the inconvenient truth that wind and solar will never get us anywhere near zero emissions because their output is inherently intermittent and there is, so far, no environmentally acceptable way to store their power at a global scale, even for one night. Orbital solar power stations, on the other hand, would continually face the sun, beaming clean power back through targeted radiation to Earth day or night, regardless of weather. They would also be free from clouds and atmospheric interference and therefore operate with many times the efficiency of current solar technology. Moving solar power generation away from Earth—already possible but held back by the current steep costs of lifting the materials into space—would preserve land and cultural resources from the blight of huge panel farms and save landfills from the growing problem of discarded old solar panels.

Sustainable energy advocates in the U.S. military and the Chinese government are actively pursuing space-based solar power, but just making solar cells damages the environment due to the caustic chemicals employed. Space technology offers the possibility of freeing the Earth’s fragile biosphere and culturally important sites from the otherwise unavoidable damage caused by manufacturing and mining.

The U.S. start-up Made in Space is currently taking the first steps toward manufacturing in orbit. The company’s fiber-optic cable, produced by machinery on the International Space Station, is orders of magnitude more efficient than anything made on Earth, where the heavy gravity creates tiny flaws in the material. Made in Space and others are eventually planning to build large structures, such as solar power stations, in space. As these technologies develop, they will augment each other, bringing costs down dramatically; space manufacturing, for instance, slashes the cost of solar installations in space.

# Contention 2: Safety Zones

What is a keep out zone?

What is a space war? Why is it likely? Who would fight a space war? Why are satellites valuable?

#### Keep-out zones are crucial to preventing space wars

James Acton, Co-director of the Nuclear Policy Program at the Carnegie Endowment for International Peace, writes in 2021:

James M. Acton et al. 21 (James M. Acton, Thomas Macdonald, Pranay Vaddi, Acton holds the Jessica T. Mathews Chair and is co-director of the Nuclear Policy Program at the Carnegie Endowment for International Peace.) Reimagining Nuclear Arms Control: A Comprehensive Approach 12-16-2021 Carnegie Endowment for International Peace https://carnegieendowment.org/2021/12/16/reimagining-nuclear-arms-control-comprehensive-approach-pub-85938 //DebateDrills TJ

Establishing keep-out zones around high-altitude satellites could help reduce the vulnerability of key nuclear C3I capabilities. Specifically, China, Russia, and the United States should commit not to maneuver their satellites within an agreed minimum distance—700 kilometers (430 miles) in any direction—of another participant’s high-altitude satellites (with the exception of repositioning maneuvers conducted one at a time and declared in advance). This agreement would apply only to satellites nationally owned by China, Russia, and the United States and not to privately owned satellites or to satellites owned by other states (so would not contravene the 1967 Outer Space Treaty’s prohibition on “national appropriation”).

Currently, the regulation of high-altitude satellite orbits is minimal. The International Telecommunication Union (ITU), a United Nations agency, allocates slots to geostationary broadcast and communication satellites in order to prevent interference—though these slots can overlap if satellites operate on different frequencies or broadcast to non-contiguous regions on the ground. Participation in the ITU is voluntary and is designed only to minimize broadcast interference.

Establishing keep-out zones would go further than the ITU rules by applying to all Chinese, Russian, and U.S. satellites in both geostationary and Molniya orbits—not just geostationary satellites broadcasting at a particular frequency band—without permitting any overlap. It would begin to establish rules of the road for good behavior in space and help break the deadlock in improving space governance. Even recognizing that keep-out zones could not physically prevent one participant state from attacking another’s satellites in conflict—although the proposed agreement would still apply then—they would still help to reduce escalation risks in three ways.

First, keep-out zones would mitigate the danger that repositioning operations could lead one state to wrongly conclude that one or more of its satellites were under attack—that is, the zones would help to define the difference between innocuous and aggressive actions in space. Even (or perhaps especially) in a conflict, a state that did not intend to attack a nuclear C3I satellite belonging to its adversary would have a clear incentive to abide by rules designed to prevent such threats from arising inadvertently.

Second, even if one participant decided to attack another’s satellites—for whatever reason—keep-out zones could buy time. An attacking satellite would typically have to close in on a target before launching an attack (how close it would need to come would depend on its capabilities).14 This process would not be instantaneous. If the target state detected a violation of its keep-out zones before the attacking satellites were able to execute the attack, it could take preventative action (by, for example, maneuvering its satellites away from the attacking ones). Increasing the warning time of an intentional attack would also reduce the likelihood of escalation resulting from time pressure.

The margin of warning afforded by keep-out zones would depend, in part, on their size. Fuel-efficient maneuvers in geostationary orbit to cross from the edge to the center of a 700-kilometer keep-out zone would require about one day (see appendix B for more details). Faster crossing would be possible by using larger amounts of fuel. For example, the same keep-out zone could be crossed in six hours by expending the same amount of fuel that a communication satellite typically uses each year for station keeping (that is, making minor adjustments so the satellite remains in its correct orbit during day-to-day operations). Larger keep-out zones would buy more warning time and further complicate attacks—but they would be more disruptive to satellite operations. The keep-out distance of 700 kilometers proposed here aims to strike a balance between increasing warning and reducing disruption.

Third, each state could use negotiations to underscore to the others the dangers of attacking its high-altitude satellites. Such messaging could reduce the likelihood of one participant’s deliberately attacking another’s dual-use satellites in an effort to win (or at least not lose) a conventional war because it had underestimated the consequent risk of nuclear escalation.

#### Space wars destroys satellites which hinders innovation and deters private companies.

Thomas Roberts, space security researcher at the Center for Strategic and International Studies, writes in 2017:

Thomas GonzáLez Roberts 17 (Thomas GonzáLez Roberts, Space security researcher at the Center for Strategic and International Studies) Why We Should Be Worried about a War in Space 12-15-2017 Atlantic https://www.theatlantic.com/science/archive/2017/12/why-we-should-be-worried-about-a-war-in-space/548507/ //DebateDrills TJ

One hundred miles above the Earth’s surface, orbiting the planet at thousands of miles per hour, the six people aboard the International Space Station enjoy a perfect isolation from the chaos of earthly conflict. Outer space has never been a military battleground. But that may not last forever. The debate in Congress over whether to create a Space Corps comes at a time when governments around the world are engaged in a bigger international struggle over how militaries should operate in space. Fundamental changes are already underway. No longer confined to the fiction shelf, space warfare is likely on the horizon.

While agreements for how to operate in other international domains, like the open sea, airspace, and even cyberspace, have already been established, the major space powers—the United States, Russia, and China—have not agreed upon a rulebook outlining what constitutes bad behavior in space. It’s presumed that International Humanitarian Law would apply in outer space—protecting the civilian astronauts aboard the International Space Station—but it’s unclear whether damaging civilian satellites or the space environment itself is covered under the agreement. With only a limited history of dangerous behavior to study, and few, outdated guidelines in place, a war in space would be a war with potentially more consequences, but far fewer rules, than one on Earth.

Although there has never been a military conflict in space, the history of human activity above our atmosphere is not entirely benign. In 1962, the United States detonated a 1.4 megaton nuclear weapon 250 miles above the Earth’s surface. The blast destroyed approximately one third of satellites in orbit and poisoned the most used region of space with radiation that lasted for years. Although the United States, Russia, and others soon agreed to a treaty to prevent another nuclear test in space, China and North Korea never signed it. In 2007, China tested an anti-satellite weapon, a conventionally-armed missile designed to target and destroy a satellite in orbit. In the process, it annihilated an old Chinese weather satellite and created high-velocity shrapnel that still threatens other satellites. Even though demonstrations like this have consequences for everyone, countries are free to carry them out as they see fit. No treaties address this kind of test, the creation of space debris, or the endangerment of other satellites.

The U.S. has the most to lose in a space-based conflict

With by far the most satellites in orbit, the U.S. has the most to gain by establishing norms, but also the most to lose. Almost half of all operational satellites are owned and operated by the United States government or American commercial companies. That’s twice as many as Russia and China, combined. Space may seem distant, but what happens there affects our everyday lives on the ground. When we use our phones to plan a trip, we depend on American GPS satellites to guide us. When the U.S. military deploys troops overseas, satellite communications connect forces on the ground to control centers. When North Korea launches an intercontinental ballistic missile, the U.S. and its allies depend on early-warning satellites to detect it.

#### **Recall the Greg Autry Evidence. It explains that space research solves climate change because it allows for efficient solar panels in space and spinoff technologies that reduce fuel emissions.**

# Case

#### Asteroid Mining betters quality of life and the economy.

Daniel Sutter, Professor of Economics at Troy University, writes in 2020:

Dr. Daniel Sutter 20 (Dr. Daniel Sutter, Charles G. Koch Professor of Economics with the Manuel H. Johnson Center for Political Economy at Troy University) Could an asteroid destroy our economy? 1-26-2020 Yellowhammer News https://yellowhammernews.com/could-an-asteroid-destroy-our-economy/ //DebateDrills TJ

An asteroid could wipe out all life on Earth, so yes. But what if we mined and brought an asteroid’s valuable metals to Earth? NASA’s plan to send a probe to an asteroid generated some out-of-this-world economic claims.

The asteroid belt between Mars and Jupiter may be the remnants of a proto-planet that broke up long ago. NASA plans to visit 16 Psyche, a heavy metal asteroid, which astronomers believe is mostly nickel and iron, but may contain precious metals like gold and platinum. The reported $10 quintillion (a 1 with eighteen zeros behind it) market value for Psyche’s metals seems to have been pulled out of thin air, or the vacuum of space.

Would the metals in 16 Psyche make everyone on Earth become a billionaire? Or would metals markets crash and somehow destroy the world economy? Economics suggests neither extreme.

We live in a world of scarcity, meaning that our desire for goods and services exceeds our ability to produce them. Production requires raw materials and, more importantly, know-how. Knowledge lies behind technology, from agriculture to supercomputers; discovering productive uses for nature’s bounty creates natural resources. The heavy metal asteroids have existed since before the first humans but will only become resources if we learn how to make space mining a reality.

Resource availability frequently constrains production. We cannot make metals or petroleum out of nothing. The harder we must toil to acquire resources, the greater their cost because everyone must be compensated for their hard work.

If technologically and economically feasible, space mining will increase the supply of metals and lower their prices. This will enable production of more goods at lower prices. Our standard of living will unambiguously rise.

But might a collapse of gold and precious metals prices bankrupt investors and cause a depression? Gold prices would likely tank, making investors holding gold suffer losses. At a price of $1,500 an ounce, all of the gold ever been mined is worth about $10 trillion. This is a lot of money, but Credit Suisse Research Institute estimates total world wealth at $360 trillion. Even a 90% drop in gold prices will not impoverish investors as a group.

The minerals from 16 Psyche would make some people wealthy, particularly the owners of Psyche’s minerals. Lower prices for cars, buildings, spaceships and other goods will increase investors’ effective wealth. The world’s economy will be more productive and investors (overall) more prosperous.

Furthermore, a decline in gold prices should not surprise investors. Expectations about demand and supply in the future influence commodity prices today. Market prices would fall as space mining becomes a reality.

Resource price adjustments also explain why 16 Psyche will not make everyone a billionaire. The news stories have a sliver of truth: $10 quintillion is over $1 billion for each of the world’s 7.5 billion persons. Yet if 16 Psyche has ten times more gold than currently in the world, gold’s price will be far below $1500 per ounce. As another way of considering this, no one has $10 quintillion to pay for Psyche’s resources.

Will space mining prove feasible? The scientific and engineering questions are well beyond my expertise. Two recently founded space mining companies, Planetary Resources and Deep Space Industries, have some highly respected scientists and smart investors involved. If Google’s Larry Page and Erich Schmidt are investing in a venture, it probably has some chance of success.

Perhaps space mining’s biggest contribution is illustrating the innumerable possibilities of the future. The potential that we will run out of resources remains highly persuasive, even though objective measures like the Cato Institute’s Simon Abundance Index demonstrate otherwise. Ultimately knowledge and discovery create the resources we use and new inventions which improve our lives. Undiscovered discoveries, however, are inherently hard to foresee. To envision the enormous potential for future innovation, just remember asteroids and space mining.

#### Space Launches will increase in both worlds.

Mike Safyan 20 (Mike Safyan, VP of Launch at Planet, International Space University) Rocket Launch Trends Roaring into the 2020s 1-30-2020 No Publication https://www.planet.com/pulse/rocket-launch-trends-roaring-into-the-2020s/ //DebateDrills TJ

It’s never been easier to launch satellites into space, and things are only getting better for satellite operators. A multitude of launch vehicles and orbits are available to satellite missions ranging from Kickstarter-funded garage efforts to serious commercial endeavours. Today, we’re recapping some of the most important launch trends of the last decade and reflecting on how they’ll evolve in the 2020s.

The International Space Station (ISS) is one of the most steady and reliable launch destinations in Low Earth Orbit. Over the last decade, there was an average of almost nine cargo flights per year to the ISS, mostly on U.S. and Russian launch vehicles. Those cargo flights carry science equipment and supplies for astronauts, but there is often additional capacity to squeeze in a handful of small satellites as well.

Between 2014 and 2016, Planet alone launched over 150 Dove satellites to the ISS across nine separate flights. While there are some drawbacks to launching via the ISS, including a low drop-off altitude of about 400 kilometers—translating to shorter orbital lifetimes for the satellites, there are still many satellite missions like university projects and commercial research and development missions that are well matched to those orbital conditions. The ISS will continue to be an important launch platform in the coming decade, especially with the soon-to-be-installed commercial airlock called Caber (designed by NanoRacks) that should further ease the process.

Another major trend of the last decade that shows few signs of slowing down is the development of nano-launchers—launch vehicles sized to serve the needs of the small satellite market. As 2019 came to a close, the vast majority of nano-launchers had still yet to get off the ground despite earlier projections. Carlos Neiderstrasser of Northrop Grumman, an aerospace and defense technology company, keeps a list of over 100 efforts from all around the world, including several projects that have already had to close shop; but there is a clear market consensus that there is a need for such launch capacity. What is less clear is exactly which efforts will ultimately be successful and how many nano-launchers the market has room for.

Rocket Lab, based in the U.S. and New Zealand, is the market leader with nine consecutive, successful launches under their belt at present, but there are a handful of nano-launchers set to debut in 2020. These range from private efforts such as Richard Branson’s Virgin Orbit, to the Indian Space Agency’s Small Satellite Launch Vehicle (SSLV), which will add even more tailor-made options for satellite operators to get into space in the coming years.

On the opposite side of the size spectrum, we’re seeing an increase in medium-lift and heavy-lift launch vehicles offering piggyback launch opportunities for small satellites. The Indian PSLV and Russian Soyuz are much too large and expensive for most small satellite companies to purchase the full capacity of the rocket. Though much like the ISS cargo flights, there’s usually several hundreds of spare kilograms available on each flight—and Planet has already launched over 200 of its satellites as hitchhikers on bigger rockets.

The real industry shaking news, however, came in 2019—when SpaceX announced its smallsat rideshare program offering launch capacity as low as $5,000 per kilogram, which is 4-8x cheaper than most options currently available. With launch typically being one of the most expensive aspects of a space mission, 4x-8x cheaper really makes a big difference!

The main drawback in such an arrangement is that the launch provider or the primary satellite sets the schedule and orbit. If your satellite mission requires very specific orbital parameters, a dedicated nano-launcher like Rocket Lab may be the only way to get there. But there is no doubt that SpaceX has yet again single-handedly set a new baseline in the launch market—and the other launch providers are being forced to respond.

#### Asteroid Mining solves for climate. Benefit outweighs the greenhouse gases released during launch.

Emerging Technology 18 (Emerging Technology, Emerging Technology from the arXiv covers the latest ideas and technologies that appear on the Physics arXiv preprint server.) Asteroid mining might actually be better for the environment 10-19-2018 MIT Technology Review https://www.technologyreview.com/2018/10/19/139664/asteroid-mining-might-actually-be-better-for-the-environment/ //DebateDrills TJ

For a certain kind of investor, asteroid mining is a path to untold riches. Astronomers have long known that asteroids are rich in otherwise scarce resources such as platinum and water. So an obvious idea is to mine this stuff and return it to Earth—or, in the case of water, to a moon base or Earth-orbiting space station.

There is no shortage of interest in these ventures. In the last decade, investors have funded half a dozen companies that have set their sights on various nearby rocks. To many observers, it’s only a matter of time before such a mission gets the green light.

But profit margins are only part of the picture. A potentially more significant aspect of these missions is the impact they will have on Earth’s environment. But nobody has assessed this environmental impact in detail.

Today, that changes thanks to the work of Andreas Hein and colleagues at the University of Paris-Saclay in France. These guys have calculated the greenhouse-gas emissions from asteroid-mining operations and compared them with the emissions from similar Earth-based activities. Their results provide some eyebrow-raising insights into the benefits that asteroid mining might provide.

The calculations are relatively straightforward. Rocket launches release significant amounts of greenhouse gases into the atmosphere. The fuel on board the first stage of a rocket burns in Earth’s atmosphere to form carbon dioxide. For kerosene-burning rockets, one kilogram of fuel creates three kilograms of CO2. (The second and third stages operate outside the Earth’s atmosphere and so can be ignored.)

Reentries are just as damaging. That’s because a significant mass of a re-entering vehicle ablates in the upper atmosphere, producing NOx such as nitrous oxide (N2O), a greenhouse gas that is about 300 times more potent than CO2. By one estimate, the space shuttle released about 20% of its mass in the form of N2O every time it returned to Earth.

Hein and co use these numbers to calculate that a kilogram of platinum mined from an asteroid would release some 150 kilograms of CO2 into Earth’s atmosphere. However, economies of scale from large asteroid-mining operations could lower this to about 60 kilograms of CO2 per kilogram of platinum.

That needs to be compared with the emission from Earth-based mining. Here, platinum mining generates significant greenhouse gases, mostly from the energy it takes to remove this stuff from the ground.

Indeed, the numbers are huge. The mining industry estimates that producing one kilogram of platinum on Earth releases around 40,000 kilograms of carbon dioxide. “The global warming effect of Earth-based mining is several orders of magnitude larger,” say Hein and co.

The figures for water are also encouraging. In this case, the authors calculate the greenhouse-gas emissions from an asteroid-mining operation that returns water to anywhere within the moon’s orbit, a so-called cis-lunar orbit. They compare this to the emissions from sending the same volume of water from Earth into orbit.

The big difference is that a water-carrying vehicle from Earth can haul only a small percentage of its mass as water. But an asteroid-mining spacecraft can transport a significant multiple of its mass as water to cis-lunar orbit. “Substantial savings in greenhouse gas emissions can be achieved,” say Hein and co.

This interesting work should help to focus minds on the environmental impacts of mining, which are rapidly increasing in profile. But it is only a first step. There is significant uncertainty in the numbers here, so these will need to be better understood.

Other factors will also eventually need to be taken into account. The Earth-bound mining industry could become more environmentally friendly by using renewable energy rather than burning coal to generate power (as it does in South Africa). Rocket launching could also become greener if more eco-friendly fuels are developed. Both these things would change the numbers.

There are also emissions that this analysis does not take into account. For example, it does not include the emissions from mission control on Earth or from launch-pad construction. Then there are the ongoing effects of rocket launches on the ozone layer, which also need to be considered.

So there is more work to be done. But Hein and co have taken a significant first step toward realistic environmental life-cycle assessments for asteroid mining, a task that will surely become more pressing as this industry matures.