# First off - Asteroid Mining

**Commercial asteroid mining is coming now – lower costs and improving tech make it economically viable – and the legal basis is already in place**

**Gilbert 21** alex gilbert, is a complex systems researcher and a PhD student in space resources at the Colorado School of Mines. "Mining in Space Is Coming." Milken Institute Review, April 26, 2021, [www.milkenreview.org/articles/mining-in-space-is-coming](http://www.milkenreview.org/articles/mining-in-space-is-coming). [Quality Control]

**Space exploration is back**. after decades of disappointment, a combination of better technology, falling costs and a rush of competitive energy from the private sector has put space travel **front and center**. indeed, many analysts (even some with their feet on the ground) believe that commercial developments in the space industry may be on the cusp of starting the largest resource rush in history: **mining on the Moon**, Mars and **asteroids**.

While this may sound fantastical, some baby steps toward the goal have already been taken. Last year, NASA awarded contracts to four companies to extract small amounts of lunar regolith by 2024, effectively **beginning the era of commercial space mining**. Whether this proves to be the dawn of a gigantic adjunct to mining on earth — and more immediately, a key to unlocking cost-effective space travel — will turn on the answers to a host of questions ranging from what resources can be efficiently.

As every fan of science fiction knows, the resources of the solar system appear **virtually unlimite**d compared to those on Earth. There are whole other planets, dozens of moons, thousands of massive asteroids and millions of small ones that doubtless contain humungous quantities of materials that are scarce and very valuable (back on Earth). Visionaries including Jeff Bezos imagine heavy industry moving to space and Earth becoming a residential area. However, as entrepreneurs look to harness the riches beyond the atmosphere, access to space resources remains tangled in the realities of economics and governance.

Start with the fact that space belongs to no country, complicating traditional methods of resource allocation, property rights and trade. With limited demand for materials in space itself and the need for huge amounts of energy to return materials to Earth, creating a viable industry will turn on major advances in technology, finance and business models.

That said, there’s no grass growing under potential pioneers’ feet. Potential economic, scientific and even security benefits underlie an emerging geopolitical competition to pursue space mining. The United States is rapidly emerging as a front-runner, in part due to its ambitious Artemis Program to lead a multinational consortium back to the Moon. But it is also a leader in **creating a legal infrastructure for mineral exploitation**. The United States has adopted the world’s first spaceresources law, recognizing the property rights of private companies and individuals to materials gathered in space.

However, the United States is hardly alone. Luxembourg and the United Arab Emirates (you read those right) are racing to codify space-resources laws of their own, hoping to attract investment to their entrepot nations with business-friendly legal frameworks. China reportedly views space-resource development as a national priority, part of a strategy to challenge U.S. economic and security primacy in space. Meanwhile, Russia, Japan, India and the European Space Agency all harbor space-mining ambitions of their own. Governing these emerging interests is an outdated treaty framework from the Cold War. Sooner rather than later, we’ll need new agreements to facilitate private investment and ensure international cooperation.

What’s Out There

Back up for a moment. For the record, space is already being heavily exploited, because space resources include non-material assets such as orbital locations and abundant sunlight that enable satellites to provide services to Earth. Indeed, satellite-based telecommunications and global positioning systems have become indispensable infrastructure underpinning the modern economy. Mining space for materials, of course, is another matter.

In the past several decades, planetary science has confirmed what has long been suspected: celestial bodies are potential sources for dozens of natural materials that, in the right time and place, are **incredibly valuable**. Of these, water may be the most attractive in the near-term, because — with assistance from solar energy or nuclear fission — H2O can be split into hydrogen and oxygen to make **rocket propellant**, facilitating in-space refueling. So-called “**rare earth” metals** are also **potential targets** of asteroid miners intending to service Earth markets. Consisting of 17 elements, including lanthanum, neodymium, and yttrium, these critical materials (most of which are today mined in China at great environmental cost) **are required for electronic**s. **And they loom as bottlenecks in making the transition from fossil fuels to renewables backed up by battery storage.**

**Private companies are more efficient and are accomplishing more than NASA**

**Follett 21** [Andrew Follett, Andrew Follett previously worked as a space and science reporter for the Daily Caller News Foundation. He has also done research for the Congressional Committee on Science, Space and Technology, the National Aeronautics and Space Administration, the Cato Institute, and the Competitive Enterprise Institute. He currently conducts research analysis for a nonprofit in the Washington, D.C., area., “Private Firms Are the Key to Space Exploration”, 08/21/2021, The National Review, <https://www.nationalreview.com/2021/08/private-firms-are-the-key-to-space-exploration>] /Triumph Debate

But NASA’s troubles are, depressingly, likely to get even worse. In November the James Webb Space Telescope (JWST) will finally launch, after taxpayers have forked over $9.7 billion. It was originally supposed to launch in 2007 on a budget of $500 million. That means the project is over a decade behind schedule and costing almost 20 times its initial budget. Perhaps the telescope, meant to locate potentially habitable planets around other stars and perhaps even extraterrestrial life, could instead search for a calendar . . . or fiscal sanity . . . in the stars? JWST isn’t the first NASA space telescope to suffer cost overruns and setbacks. The Hubble Space Telescope (HST) was originally intended to launch in 1983, but technical issues delayed the launch until 1990 because the main mirror was incorrectly manufactured. JWST is very likely to fail because it is supposed to unfold itself “origami style” in space in an extremely technically complicated process. If difficulties arise, JWST lacks HST’s generous margin for error because of its location far beyond earth’s orbit at the Sun-Earth L2 LaGrange point. NASA currently lacks the capability to send a team of astronauts out that far to fix any problems. Even if NASA could get out to JWST, the telescope doesn’t have a grappling ring for an astronaut to grab onto and thus could potentially kill astronauts attempting to fix it. It is hard to imagine a better example of the private sector’s amazing ability to outcompete government bureaucracy and mismanagement than NASA’s planned Shuttle replacement, the Space Launch System. It is estimated to cost more than $2 billion per flight. That’s on top of the $20 billion and nine years the agency has already spent developing the vehicle. Contrast that with the comparatively inexpensive $300 million spent by SpaceX to develop the Falcon 9 in a little over four years, and the fact that each Falcon 9 costs around $62 million. One SLS launch could pay for over 32 SpaceX launches. Private ventures such as SpaceX are more efficient because they have a lot more incentive to avoid excessive costs and focus on solutions: Their own money is at stake, and people spend their own money more carefully than they spend taxpayer dollars collected from others. Multiple private American space firms are currently pursuing accomplishments beyond those of NASA, and they are more advanced and ambitious than the entire government space programs of China and the European Union combined. So one possible solution to NASA’s woes would be to greatly increase its reliance on commercial launch providers. And one way to do that would be to return to the system that made civil aviation great: prizes to reward private-sector innovation. Charles Lindbergh flew across the Atlantic Ocean in pursuit of the privately funded Orteig prize, valued at almost $395,000 in today’s money. Another famous example was the X Prize, which rewarded Burt Rutan’s company Scaled Composites with over $14 million in today’s money for becoming the first nongovernmental organization to launch a reusable and manned space vehicle, SpaceShipOne. The X Prize succeeded in creating over $100 million in investment by private corporations and individuals. Aerospace experts expect that establishing a $10 billion prize for successfully landing a crew on Mars and returning it safely to earth could very well lead to a successful landing. That’s a bargain compared with the $500 billion cost estimates NASA puts out for the same objective. And of course in the worst-case failure scenario for a prize program, taxpayers would pay nothing until the mission was complete. A system based on private enterprise incentivized by a fixed prize would end government cost overruns and waste. The cause of space exploration is simply too important to leave to the public sector.

**Asteroid mining offsets terrestrial growth that ruins the environment and enables solar power satellites – both solve climate change**

**Taylor 19** Chris Taylor is a veteran journalist. Previously senior news writer for Time.com a year later. In 2000, he was named San Francisco bureau chief for Time magazine. He has served as senior editor for Business 2.0, West Coast editor for Fortune Small Business and West Coast web editor for Fast Company. Chris is a graduate of Merton College, Oxford and the Columbia University Graduate School of Journalism. "How asteroid mining will save the Earth — and mint trillionaires." Mashable, 2019, mashable.com/feature/asteroid-mining-space-economy. [Quality Control]

The mission is essential, Joyce declares, to save Earth from its **major problems**. First of all, the fictional billionaire wheels in a fictional Nobel economist to demonstrate the actual truth that the entire global economy is sitting on a **mountain of debt**. It has to keep growing or it will **implode**, so we might as well take the majority of the **industrial growth off-world where it can’t do any more harm to the biosphere.**

Secondly, there’s the **climate change fix**. Suarez sees asteroid mining as the only way we’re going to build **solar power satellites.** Which, as you probably know, is a form of uninterrupted solar power collection that is theoretically more effective, inch for inch, than any solar panels on Earth at high noon, but operating 24/7. (In space, basically, **it’s always double high noon).**

The power collected is beamed back to large receptors on Earth with large, low-power microwaves, which researchers think will be harmless enough to let humans and animals pass through the beam. A space solar power array like the one China is said to be working on could reliably supply 2,000 gigawatts — or **over 1,000 times more power than the largest solar farm currently in existence.**

“We're looking at a 20-year window to **completely replace human civilization's power infrastructure,**” Suarez told me, citing the report of the Intergovernmental Panel on Climate Change on the coming catastrophe. Solar satellite technology “has existed since the 1970s. What we were missing is **millions of tons of construction materials** in orbit. **Asteroid mining can place it there.”**

The Earth-centric early 21st century can’t really wrap its brain around this, but the idea is not to bring all that building material and precious metals down into our gravity well. Far better to create a whole new commodities exchange in space. You mine the useful stuff of asteroids both near to Earth and far, thousands of them taking less energy to reach than the moon. That’s something else we’re still grasping, how relatively easy it is to ship stuff in zero-G environments.

**Asteroid mining solves rare earth metal depletion – prevents tech stagnation and unsustainable resource extraction**

**Mitchell 20** Robin Mitchell is an electronic engineer who has been involved in electronics since the age of 13. After completing a BEng at the University of Warwick, Robin moved into the field of online content creation developing articles. "How might asteroid mining be key to electronics future?" 28-09-2020, [www.electropages.com/blog/2020/09/how-might-asteroid-mining-be-key-electronics-future](http://www.electropages.com/blog/2020/09/how-might-asteroid-mining-be-key-electronics-future). [Quality Control]

As electronics continue to become increasingly more important in everyday life, so is the ability to **produce electronic components**. With the supply of minerals on Earth having a finite size, some are worried that Earth will soon run out of critical resources such as **platinum and lithium**. What are asteroids, what are they composed of, and could they be the key to providing humanity with a near-infinite source of minerals?

What minerals are commonly needed for electronics?

Since the introduction of the first commercial circuits, electronics have become incredibly advanced with silicon dies having billions of active components, resistors the size of dust specks, and capacitors that can hold obscene amounts of charge for their size. However, many of these components rely on minerals that most will never have heard of for them to be able to work. Basic components such as resistors and capacitors use common materials including iron, carbon, and aluminium, but components such as LEDs, silicon dies, and thin-film displays use lanthanum, cerium, neodymium, and europium. While many of these minerals **fall under the “rare-earth” category**, that does not necessarily mean that they are rare; but many are.

Why are these minerals running out?

Minerals that are rare by nature are uncommon in the crust, and mass industrialisation is quickly using up remaining reserves of these minerals. However, it is important to understand what reserve means and how reserves are calculated. Let’s take Uranium as an example to understand this concept better; as things currently stand, there are 80 years of Uranium reserves left. Now, this does not mean that all the uranium will be used up globally in 80 years, this means that at the current price of Uranium, proven sources will continue to supply Uranium at a profitable rate for 80 years. When all reserves are used up, the price for that mineral increases, and this makes areas that used to be unprofitable more profitable, thus generating new reserves.

However, there is another aspect to resources that need to be considered; **environmental damage**. A good example to demonstrate this is Lithium. While Lithium is rather abundant in the crust, it is spread very wide, making most crust uneconomical to mine. If all cars on earth went electric, the proven reserves of Lithium would run out in 3 years. Of course, new reserves would be made available, and this would extend the ability to use Lithium in industrial practices. However, mining Lithium has a massive environmental impact and sees vast amounts of land destroyed and made toxic due to by-products in the extraction process. The same applies to many rare minerals; many tons of earth is needed to get even the smallest quantity.

What are asteroids, and what are they made of?

Asteroids are small cosmic bodies that orbit a star and can range in size, density, and composition. One of the largest asteroids in the Solar System, Vesta, has a diameter approximately 330 miles, while some of the smallest can be just two meters across. Asteroids mostly consist of rock as well as minerals, but their exact composition greatly varies. For example, M-type asteroids are those that mostly consist of nickel-iron, while C-type asteroids consist of clay and silicate rocks. Other minerals that are often found in asteroids include gold, cobalt, palladium, platinum, and osmium.

Could asteroid mining be the key to ensuring limitless supplies?

While asteroids themselves may contain trace amounts of rare minerals, their size and lack of an ecosystem **would allow for a mining operation to destroy an entire asteroid with no repercussions.** Asteroids are also plentiful in the Solar System, and would most likely **provide humanities resource needs for millions of years.** For perspective, the total weight of the asteroid belt is only 3% that of the moon, but that is still 2.39×1021 kilograms. Even then, that is only the asteroid belt and does not consider stray asteroids that orbit the sun, planets, and rings around Saturn / Jupiter.

**Both of those cause extinction**

**Bell 19** Aidan Bell is the co-founder of EnviroBuild, a sustainable building materials company based in London. PhD from Manchester in Inorganic Chemistry. "The Conflict of Tech Innovation and Sustainability." TechNative, 22 Jan. 2019, technative.io/the-conflict-of-tech-innovation-and-sustainability. [Quality Control]

Technological advancement has existed throughout human history

Humans have walked the Earth for 200,000 years, inventing **countless new processes and systems along the way.** The somewhat gradual expansion of human knowledge exploded after the burgeoning of agriculture in the Middle Eastern region of the Levant around 12,000 years ago. Societies at this time manipulated their environment for food-crop cultivation for the first time, inventing sophisticated activities like irrigation and logging.

This nascent field of agriculture created more food and thereby lead to a rapid increase in population size. Yet human expansion also resulted in the increased degradation of the environment. Experts theorise that the mass extinction of megafauna across North America and Australasia was the result of humans rather than environmental factors, while the Mayans were also at fault for causing widespread deforestation and a severe drought through excessive logging, a mistake that brought their eventual demise.

The exploration and proliferation of new technologies is the **inevitable result of human intelligence**, and the consequences thereof have always been difficult to avoid. Yet our awareness of this damage places humanity in a position of knowledge outside the standard predator-prey relationship that otherwise dominates the world and results in starvation for animals that overeat their food sources.

The current technological dilemmas that we face today are similar to those of ancient time**.  Overuse of a resource for immediate human benefit risks longer-term negative influence**.  A report conducted by Greenpeace found that Internet data centres have incredibly large carbon footprints, accounting for 3% of global electricity use, much of it in locations that offer cheap, but dirty, electricity. Likewise, the minerals that are found in electronic devices like mobile phones, such as tantalum and gold, often originate from unregulated mining that releases harmful substances into the surrounding soil, air and water. Mining also contributes hugely to **deforestation**, which is responsible for 15% of global greenhouse gas emissions.

The negative impacts of technological innovation are increasing and action needs to be **taken soon to resolve this crisis for the sake of future generations.** The Intergovernmental Panel on Climate Change (IPCC) report last month warned that we have just 12 years to reduce the rate of global warming before widespread flooding and droughts become unavoidable. The demand for minerals and energy brought about by technological advancements shows no sign of slowing down, painting a worrying picture for the future of the planet.

Faced with the consequences of our intelligence, humanity now has to use its **incredible versatility** to overcome the challenges it has created for itself. For example, wind and solar power are increasingly becoming economically-viable sources of unlimited, free electricity and provide us with the opportunity to reduce our dependence on harmful fossil fuels. Bioengineering should help us protect surface soils and the ecosystems that depend on them by maintaining healthy levels of nutrients and soil salinity. **Technological advancements will even help us prevent species extinction events** that would **otherwise destroy our Earth altogethe**r, with NASA already developing spacecraft to push approaching asteroids out of our orbit.

# Case

#### 2] Companies key to solving debris.

**Gao 21** – [Reporter at Reuters Liangping, and Ryan Woo, "China launches robot prototype capable of catching space debris with net," Reuters, 4-27-21, https://www.reuters.com/lifestyle/science/china-launches-robot-prototype-capable-catching-space-debris-with-net-2021-04-27/, accessed 6-25-21]

BEIJING, April 27 (Reuters) - A Chinese space mining start-up launched into low Earth orbit on Tuesday a robot prototype that can scoop up debris left behind by other spacecraft with a big net. The NEO-01, which will also peer into deep space to observe small celestial bodies, was launched on the government's Long March 6 rocket along with a handful of satellites, state-run Xinhua news agency reported. The 30kg robot developed by Shenzhen-based Origin Space will pave the way for future technologies capable of mining on asteroids, according to the company. Since the establishment of the world's first asteroid mining company Planetary Resources in 2009, more than a dozen firms across the world have entered the fledging sector, including 3D Systems (DDD.N) of the United States and Japan's Astroscale. Unlike Astroscale's technology, which uses magnets to gather up space junk, NEO-01 will use a net to capture debris and then burn it with its electric propulsion system, according to a report on the company's website. Thousands of satellites have been launched globally. As they outlive their use, many end up as junk, posing danger to other operating satellites. Origin Space plans to launch dozens of space telescopes and more spacecraft to achieve the first commercial mining of asteroids by 2045, said the company's founder Su Meng in an interview with domestic media on April 6. Xinhua reported on Saturday that China was stepping up efforts to land a probe on a near-Earth asteroid to collect samples, and also expediting a plan to build a defence system against near-Earth asteroids.

**There is a credible asteroid threat – the private sector can develop planetary defense much more effectively than governments.**

**Nelson 20** [Don A. Nelson. Retired NASA mission planner. “More than government work”. 01-2020. Aerospace America. https://aerospaceamerica.aiaa.org/departments/more-than-government-work/]

Americans would rather stop asteroids from hitting Earth than go to the moon or Mars, according to a poll published last June by the Associated Press-NORC Center for Public Affairs Research at the University of Chicago. The potential for a cataclysmic asteroid impact on our home planet is so credible that NASA established a Planetary Defense Coordination Office in 2016 to coordinate efforts of U.S. agencies, international counterparts, and professional and amateur astronomers around the world. The European Space Agency also established a Near-Earth Object Coordination Centre that conducts searches for near-Earth asteroids.

To date, approximately 20,000 near-Earth asteroids have been discovered, of which 800 have been classified by NASA as possible impact risks, because they are greater than 500 feet (152 meters) in size and their orbits bring them within 4.7 million miles (7.6 million kilometers) of Earth’s orbit.

The trouble is, size alone doesn’t determine destructive power. The density and the angle of entry into the atmosphere determine how much kinetic energy is generated. It is these small asteroids that are the most concerning. They impact Earth at a greater frequency and far too often are not discovered until a few days before their impact.

The small undetected asteroid that broke up over Chelyabinsk, Russia, on Feb. 15, 2013, created a shock wave that shattered glass and injured about 1,200 people. It would have been far worse if it had been an iron core asteroid with a high entry angle into the atmosphere. Or consider Asteroid 2008TC3, estimated to be 4 meters and discovered the day before it broke up on Oct. 7, 2008, and scattered at least 600 extremely hot fragments over the Nubian Desert. Had this occurred over a dry forest region, the outcome would have been far different.

Or last March, BBC News reported that a “space rock” exploded in the atmosphere the previous December but that the event went largely unnoticed because the explosion was over the Bering Sea. Last July, our planet reportedly had a near miss with a city-killer asteroid.

And yet, on its Planetary Defense webpage, NASA says, “No known asteroid poses a significant risk of impact with Earth over the next 100 years.” The statement is true, but the key word is “known.” Surprises from smaller asteroids happen fairly regularly.

Consider these questions: Is there a credible asteroid threat that requires the immediate development of a planetary defense system? Can the requirements for the system be defined? Can this system be built and operated without significant government funding? This old retired NASA engineer believes the answer to each of these questions is yes.

The three requirements for the defense system are: rapid deployment, reliability and affordability. Such an asteroid defense system must be able to detect the threat, provide rapid access to inspect the object and categorize the degree of danger and the ability to neutralize it.

It would be cost prohibitive for the U.S. and partner governments to develop stand-alone launch vehicles and deflection devices for this purpose. Rather, the need for planetary defense must be a participating part of the developing 21st-century commercial space transportation system programs. For cost-effective and reliable commercial space operations, the private-sector transportation system must include reusable launchers and space tugs based in orbit. These vehicles will for that reason meet the defense system requirements for rapid launch and access to the threat. Future civil, military and commercial satellites in addition to their primary function could be equipped with sensors to identify asteroid threats. Since there are no new technology requirements demanded of the vehicles for planetary defense, they can be developed by the private sector with minimum or no government funding.

Rapid deployment can be achieved only with reusable launch vehicles. There may not be an inventory of expendable launchers available when an asteroid threat is discovered. Also, expendable launchers cannot achieve the required reliability because of undetected manufacturing errors on vehicles whose first flight is the only flight. Reusable launchers and space-based vehicles have the potential to achieve a failure rate equivalent to commercial aircraft.

Affordability is a function of flight rate and launch operations costs. Where operations cost will be a fixed value, flight rate will be a function of the economy and missions needed. To stay in business there must be significant flight rate to cover operations overhead. This may require a business model similar to the one considered by Lockheed Martin for its 1990s-era VentureStar reusable, commercial launch vehicle proposal. One cost estimate for the fleet was $8 billion in 2014 dollars. NASA and other U.S. government customers were expected to guarantee a specific number of payloads or launches. Unfortunately the VentureStar had unsolvable development problems. It remains true, however, that reusable launchers must be used to contain operations costs.