# Contention 1: 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

### A2: Emissions

#### 1] Emissions from launches are dwarfed by terrestrial mining’s impact – it’s 3 orders of magnitude lower

**ArXiv 18** Emerging Technology from the ArXiv. Emerging Technology from the arXiv covers the latest ideas and technologies that appear on the Physics arXiv preprint server. Team list found here: <https://www.technologyreview.com/author/emerging-technology-from-the-arxiv/>. "Asteroid mining might actually be better for the environment." MIT Technology Review, 2 Apr. 2020, [www.technologyreview.com/2018/10/19/139664/asteroid-mining-might-actually-be-better-for-the-environment](http://www.technologyreview.com/2018/10/19/139664/asteroid-mining-might-actually-be-better-for-the-environment). [Quality Control]

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.

**1.**      **Companies are already looking into ways to make space launches sustainable.**

**Verbeek and Fouquet 20**Verbeek, David, and Helene Fouquet. “Can We Get to Space without Damaging the Earth through Huge Carbon Emissions?” *Los Angeles Times*, Los Angeles Times, 30 Jan. 2020, [www.latimes.com/business/story/2020-01-30/space-launch-carbon-emissions](http://www.latimes.com/business/story/2020-01-30/space-launch-carbon-emissions).

Although there are no regulations on rocket emissions, **new space pioneers are taking it upon themselves to develop launchers that make leaving the atmosphere less damaging to the planet.** It’s less space cowboy and more space boy scout.

**“Climate change is real, and we don’t want to make it worse,” said Chris Larmour, chief executive of British rocket maker Orbex. The start-up, founded in 2015 and which has a contract with U.S. launch integrator TriSept Corp., uses bio-propane that it says can cut CO2 emissions by 90% compared with traditional launch fuel.**

Besides greenhouse gas pollution, kerosene-fueled rockets transport large amounts of black carbon, also known as soot, into the upper layers of the atmosphere. There, it remains for a long time, creating an umbrella that may add to global warming. The fuel is widely used because it’s easier to handle than fuels such as hydrogen.

“So far the only criteria for everyone to build rockets was performance and cost,” said Jean-Marc Astorg, director for launch vehicles at French space agency CNES. “Environment was not a priority at all. That’s changing.”

The urgency to clean up rocket emissions is intensifying. Last year, the space industry launched 443 satellites, more than three times as many as a decade earlier, according to the United Nations Office for Outer Space Affairs. Planned missions to the moon and Mars will increase the strain on the environment.

SpaceX alone is planning to launch 12,000 satellites in the next seven years for its Starlink internet constellation. The company is developing the methane-powered Raptor engine, burning the greenhouse gas with a view to refueling on Mars. Blue Origin’s strategy is potentially more environmentally friendly, with plans for liquid hydrogen to propel its reusable rockets.

**Virgin Galactic says its plans represent a “new age of clean and sustainable access to space.” The company relies on lightweight spaceships that can fly hundreds of times to mitigate its environmental effect and says its rockets burn for only 60 seconds. The carbon footprint for passengers will be in line with a transatlantic business-class seat, it says.**

**ArianeGroup is going a step further. Europe’s biggest launch company is working on a rocket that aims to be carbon-neutral by running on methane produced from biomass.** Dubbed Ariane Next, the heavy-launcher project targets liftoff in 2030.

[**https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions**](https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions)

* In 2019, U.S. greenhouse gas emissions totaled 6,558 million metric tons (14.5 trillion pounds) of carbon dioxide equivalents. This total represents a 2 percent increase since 1990 but a 12 percent decrease since 2005 (see Figure 1).

### A2: Debris

#### 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.

#### No debris collision

**Albrecht 16** [Mark Albrecht is chairman of the board of USSpace LLC. He was head of the White House National Space Council from 1989 to 1992. Paul Graziani is CEO and founder of Analytical Graphics, an Exton, Pennsylvania, company that develops software and provides mission assurance through the Commercial Space Operations Center (ComSpOC), “Op-ed | Congested space is a serious problem solved by hard work, not hysteria”, SpaceNews, May 9th 2016, <https://spacenews.com/op-ed-congested-space-is-a-serious-problem-solved-by-hard-work-not-hysteria/>] [modified for readability]

**Popular culture has embraced the risks of collisions** in space in films like **Gravity**. Some participants **have dramatized the issue** by producing **graphics of Earth and its satellites, which make our planet look like a fuzzy marble, almost obscured by a dense cloud of white pellets** meant to conceptualize space congestion. Unfortunately, **for the sake of a good visual, satellites are depicted as if they were hundreds of miles wide**, like the state of Pennsylvania (for the record, there are no space objects the size of Pennsylvania in orbit). **Unfortunately, this is the rule, not the exception, and almost all of these articles, movies, graphics, and simulations are exaggerated and misleading**. **Space debris and collision** risk is real, but it **certainly is not a crisis.** So what are the facts? On the positive side, **space is empty and** it is **vast**. At the altitude of the International Space Station, one half a degree of Earth longitude is almost 40 miles long. That same one half a degree at geostationary orbit, some 22,000 miles up is over 230 miles long. Generally, **we don’t** intentionally **put satellites closer together than one-half degree. That means** at geostationary orbit, **they are no closer than 11 times as far as the eye can see** on flat ground or on the sea: **That’s the horizon over the horizon 10 times over.** In addition, other than minute forces like solar winds and sparse bits of atmosphere that still exist 500 miles up, **nothing gets in the way of orbiting objects** **and they behave quite predictably.** The location of the smallest spacecraft can be predicated within a 1,000 feet, 24 hours in advance. **Since we first started placing objects into space there have been [eleven]** known low Earth orbit **collisions**, and three known collisions at geostationary orbit. **Think of it:** 135 space shuttle flights, all of the Apollo, Gemini and Mercury flights, hundreds of telecommunications satellites, **[thirteen hundred] functioning satellites on orbit today, half a million total objects** in space larger than a marble, **and fewer than 15** known **collisions. Why do people worry?**

#### Debris growth down

**Wall 19** [Mike Wall, Ph.D, Space.com Senior Space Writer, “Space Junk Menace: New Guidelines Urged to Help Fight Orbital Debris Threat”, Space.com, Oct 15th 2019, https://www.space.com/space-junk-threat-satellites-guidelines-reduce-orbital-debris.html]

But **we can stave off the Kessler syndrome** — or at least minimize the odds that it happens anytime soon — **if spacecraft builders** and operators **follow a few simple rules**, **according to the Space Safety Coalition (SSC). The SSC**, a newly established group of space-industry stakeholders, **laid out those proposed voluntary guidelines** last month in a document called "Best Practices for the Sustainability of Space Operations." There are **space-junk mitigation guidelines on the books** already, which were drawn up by the Inter-Agency Space Debris Coordination Committee and the United Nations Committee on the Peaceful Uses of Outer Space. But those guidelines **were last revised in 2007**, the SSC noted. "**Plans to increase our space population with more cubesats and other small satellites, as well as new, large constellations of satellites, were not envisioned when the above-mentioned guidelines** and standards **were established**," **the new "best practices" document states. "These new planned spacecraft and constellations**, coupled with improvements in space situational awareness, space operations and spacecraft design, **all provide an opportunity to expand upon established space operations and orbital debris mitigation guidelines and best practices**." One of **the key new recommendations is that all spacecraft that operate at an altitude above** 250 miles (**400 kilometers) should feature a propulsion system that allows them to maneuver their way out of potential collisions. That's a natural dividing line**, Scott said; the **I**nternational **S**pace **S**tation **circles at about that altitude**, **and nobody wants out-of-control satellites falling back to Earth** through the orbiting lab's path. Also, **below 250 miles, there's enough atmosphere to create significant drag on spacecraft**, **causing them to deorbit** relatively **quickly** when their operational lives are over. (The space community could designate the below-250-mile region an "experimental zone," Scott wrote in a recent blog post. Such a move would keep space "affordable for operators of the growing number of inexpensive, experimental or educational cubesats," he wrote.) The SSC also recommends that satellite designers consider building encryption into their command and control systems, so that spacecraft cannot be hijacked by hackers intent on causing havoc in orbit. **And the best practices include anti-littering guidelines**. For example, **the handlers of satellites that operate in low-Earth orbit should include in their launch contracts a requirement that rocket upper stages be disposed of promptly, via a controlled reentry into Earth's atmosphere**. As of today (Oct. 15), 31 **space-industry stakeholders** **have endorsed the new guidelines**. **And there are some big names in that group**, including Maxar (the parent company of satellite operator DigitalGlobe and the spacecraft manufacturer SSL, among other subsidiaries), OneWeb, Rocket Lab, Iridium, SES and Intelsat. "**You don't want to wait for a disaster before you take action**," Scott said. "**It really is time, and you're seeing operators** like Maxar and OneWeb **being proactive**."

**Burns Interviewing Kessler ’13** Corrinne Burns, interviewing Donald Kessler, who made up the concept. [Space junk apocalypse: just like Gravity? 11-15-2013, [https://www.theguardian.com/science/blog/2013/nov/15/space-junk-apocalypse-gravity]//BPS](https://www.theguardian.com/science/blog/2013/nov/15/space-junk-apocalypse-gravity%5D/BPS)

Now? Are we in trouble? Not yet. Kessler syndrome isn't **an acute phenomenon**, as depicted in the movie – it's **a slow, decades-long process**. "It'll happen throughout **the next 100 years** – we have time to deal with it," Kessler says. "The time between collisions will become shorter – it's around 10 years at the moment. In 20 years' time, the time between collisions could be reduced to five years." Fortunately, communications satellites are, in the main, situated high up in geosynchronous orbit (GEO), whereas the risk of collisions lies mainly in the much lower, and more crowded, low Earth orbit (LEO). But that doesn't mean we can relax. "We've got to get a handle on it – we need to prevent the cascade process from speeding up." And the only way to do that is, he says, to begin actively removing junk from space. Charlotte Bewick agrees. She's a mission concepts engineer with the German space technology company OHB System, with special expertise in space junk – specifically, how we can capture it and bring it back to Earth. While agreeing with Kessler that the movie scenario is exaggerated, she remains concerned. "Fragments of junk can naturally re-enter the atmosphere [and so be removed from orbit]. But we're at the stage where the rate of creation of new debris fragments is higher than the rate of natural removal. The orbits most at risk harbour important space assets – satellites for weather forecasting, oil spill and bush fire detection, and polar ice monitoring." Bewick highlights the case of Envisat, a defunct 8,000kg spacecraft circling Earth in an orbit that is very popular with space agencies and, hence, pretty crowded. "If Envisat collides with a piece of debris or a micrometeorite, the fragments could render the whole orbital region unusable." So can we get the junk down, I asked Massimiliano Vasile, part of the Mechanical & Aerospace Department at the University of Strathclyde and co-ordinator of the Stardust network. He told me defunct satellites in the high GEO region have, for some time, been shifted to higher "graveyard orbits" to keep them out of the way. But that's not an option for items in low Earth orbit. For this, he tells me, researchers are looking seriously into active debris removal – in-orbit capture techniques like harpooning, netting and tethering, the use of contactless systems like ion-beams or lasers, and even onboard robotics to position the junk away from high-risk orbital regions. As for middle Earth orbit – well, ideas are welcome, he says. We're in no **immediate danger** from Kessler syndrome – but it's not a problem that's going away. Despite Gravity's artistic license, Donald Kessler is pleased to see the phenomenon represented on the big screen. "It is **very improbable** that events would play out as they did in the film," he says. "But if it raises awareness, then that's great."

### A2: Space war

**Limited Accessibility**

**Pavur 19** [James, DPhil Researcher Cybersecurity Centre for Doctoral Training Oxford University, Ivan Martinovic, Professor of Computer Science Department of Computer Science “The Cyber-ASAT: On the Impact of Cyber Weapons in Outer Space” https://ccdcoe.org/uploads/2019/06/Art\_12\_The-Cyber-ASAT.pdf]

**Space is difficult**. Over 60 years have passed since the first Sputnik launch and **only nine countries** (ten including the EU) **have orbital launch capabilities**. Moreover, **a launch programme** alone **does not guarantee** the resources and precision required to operate a meaningful **ASAT capability**. Given this, one possible reason why **space wars have not broken out** is simply **because** **only** **the US has ever had the ability to fight one** [21, p. 402], [22, pp. 419–420].

**Although launch technology may become cheaper and easier**, **it is unclear** **to what extent** these **advances will be distributed** among presently non-spacefaring nations. **Limited access** to orbit **necessarily** **reduces** the **scenarios** **which** could plausibly **escalate** to ASAT usage. Only major conflicts between the handful of states with ‘space club’ membership could be considered possible flashpoints. Even then, the **fragility of an attacker’s own space assets** **creates** **de-escalatory** **pressures** **due to the deterrent effect** of retaliation. Since the earliest days of the space race, dominant powers have recognized this dynamic and demonstrated an inclination towards de-escalatory space strategies [23].