## 1

### 1NC

#### Text: The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)’s Legal Subcommittee ought to do (the aff)

#### Normal means for treaties involves solely the signatory countries

Berkeley Law Library 16

Berkeley Law (It’s the handbook from the Berkeley law library, just a basic definition), 2016-2-23 (date from source code), "Treaties and International Agreements," Berkeley Law Library, https://www.law.berkeley.edu/library/guide.php?id=65, // HW AW

Treaties can be referred to by a number of different names: international conventions, international agreements, covenants, final acts, charters, protocols, pacts, accords, and constitutions for international organizations. Usually these different names have no legal significance in international law. **Treaties may be bilateral (two parties) or multilateral (between several parties) and a treaty is usually only binding on the parties to the agreement.** An agreement "enters into force" when the terms for entry into force as specified in the agreement are met. Bilateral treaties usually enter into force when both parties agree to be bound as of a certain date.

#### The CP competes off of actor spec – they had complete control over how and who implements the aff, especially in this topic since the actor was not specified in the resolution. The actor is a key, debatable element and a change poses an opportunity cost, which is sufficient for competition.

#### COPUOS has jurisdiction and has passed treaties on similar topics in the past

UNOOSA

UNOOSA (united nations outer space committee), 2021 (no date but written about the 2021 conference), "COPUOS 2021 Session," UNOOSA, <https://www.unoosa.org/oosa/en/ourwork/copuos/index.html> // HW AW

The Committee on the Peaceful Uses of Outer Space (COPUOS) was set up by the General Assembly in 1959 to govern the exploration and use of space for the benefit of all humanity: for peace, security and development. The Committee was tasked with reviewing international cooperation in peaceful uses of outer space, studying space-related activities that could be undertaken by the United Nations, encouraging space research programmes, and **studying legal problems arising from the exploration of outer space**. The Committee was **instrumental in the creation of the five treaties and five principles of outer space**. International cooperation in space exploration and the use of space technology applications to meet global development goals are discussed in the Committee every year. Owing to rapid advances in space technology, the space agenda is constantly evolving. The Committee therefore provides a unique platform at the global level to monitor and discuss these developments. The Committee has two subsidiary bodies: the [Scientific and Technical Subcommittee](https://www.unoosa.org/oosa/en/ourwork/copuos/stsc/2020/index.html), and the [Legal Subcommittee](https://www.unoosa.org/oosa/en/ourwork/copuos/lsc/2019/index.html), both established in 1961. The Committee reports to the [Fourth Committee of the General Assembly](http://www.un.org/en/ga/fourth/), which adopts an annual resolution on international cooperation in the peaceful uses of outer space.

#### **COPUOS is losing legitimacy due to an inability to reach consensus and thereby pass policies – the plan restores faith, discourages weak agreements, solves space debris, sustainability, and security issues**

Masson-Zwaan 19

Tanja Masson-Zwaan (deputy director of institute of air and space at Leiden University), 2019, "SYNOPSIS ON THE NEW SPACE RACE: NEW STATES IN SPACE " Cambridge, https://www.cambridge.org/core/services/aop-cambridge-core/content/view/E68383DE71B60A711EE1E4578CA303A8/S2398772319000138a.pdf/new\_states\_in\_space.pdf, // HW AW

The “old” space race started in 1957 and involved mainly the United States and the Soviet Union. These states led the development of the initial international agreements adopted in the framework of the UN Committee on the Peaceful Uses of Outer Space (COPUOS).1 Within less than two decades, between 1967 and 1984, five international treaties were adopted and entered into force.2 At the time, COPUOS had less than twenty-five member states and agreement was reached relatively easily. Gradually, the group of space actors grew, but space activity remained state-centered and involved a relatively small number of states, while private-entity involvement was mostly limited to the telecommunication sector in the United States. Today, the landscape is entirely different. Not only are more and more states interested and involved in exploring and using outer space, but private entities also have entered the scene, and the trend of privatization and commercialization of space activities is expected to gain more speed in years to come. As the number of states active—or wishing to become active—in outer space has grown, so has the membership of COPUOS, which today counts nearly ninety states.3 It has thus **become more difficult to reach consensus, which has been the working method of COPUOS from the start**. As a consequence of the growing number and diversity of stakeholders, in recent decades the **agreements among states about the use and exploration of outer space have taken the form of principles and other UN resolutions, rather than legally binding treaties**. At the same time, a growing number of new topics require states’ attention. With constant advances in technology, new capacities and activities emerge at high speed, such as ever-smaller satellites, large constellations of hundreds or even thousands of satellites, the prospect of suborbital flights, reusable launch vehicles, on-orbit servicing, and the use of resources from asteroids or the Moon. These developments were not foreseen in the early days of space exploration. Although the UN space treaties and resolutions provide the basic legal framework, some form of further elaboration is now needed to provide clear and predictable standards to govern these new activities. Issues such as the continuing congestion of outer space, the problems related to the mitigation and remediation of space debris, the long-term sustainability of space activities, space traffic management, space situational awareness, and the security of critical space infrastructure will also increasingly require the attention of the international community of states. In this changed landscape with new states, private entities, new activities, and new concerns, it is useful to look at how emerging space nations view the rules that were laid down in the past, the issues that will require regulation in the future, and whether there are any special concerns that influence their positions.4 The main principles of international space law are embodied in the Outer Space Treaty of 1967 (OST). The treaty has been widely adopted and states have consistently acted in accordance with its principles.5 In addition, states have not publicly contested those principles, proposed amendments, or withdrawn from the treaty. Thus, at least parts of the treaty could be considered to have reached the status of customary international law, meaning that they are binding on all states, including nonparties. The following sections highlight principles that are not likely to be contentious for new space states and then identify current principles and future issues that may raise more concerns.

#### Revitalizing COPUOS solves great power space conflict – it is the single organization that has enough member states, legitimacy, and empirical success to ensure peace – it stopped the first space race, it can do it again

McMillan 7-14-21

Anne Mcmillan (journalist trained in law, chai tea enthusiast), 7-14-2021, "The final frontier – 21st century space race," International Bar Association, <https://www.ibanet.org/the-final-frontier> , // HW AW

As far as international oversight is concerned, the UN Committee on the Peaceful Uses of Outer Space (COPUOS) is the main forum governing the exploration and use of space. But it has failed to achieve an agreement on the interpretation of the broad concepts outlined in the OST, and legal developments since 1979 have been in the form of soft law guidelines and principles. Perhaps multinational initiatives led by individual states, such as the recent US-sponsored Artemis Accords, signal an alternative route. These envisage a series of bilateral agreements between the US and individual countries in the context of planned future exploration of the Moon, Mars, comets and asteroids. Nacimiento thinks such initiatives could help to develop space law. ‘There is some indication that international space law may develop in a different form, meaning not necessarily within the United Nations Committee on the Peaceful Uses of Outer Space and via multilateral international treaties. The Artemis Accords signed in October 2020 are one very recent example of how space law could develop in the future.’ However, not all states support the US-led initiative and so far the Artemis accords have only been signed by eight countries. Predictably China and Russia are prominent critics, objecting in particular to a suggestion in Artemis to create ‘safety zones’ around national lunar exploration sites, arguing that this amounts to a creeping claim of sovereignty. Nacimiento concedes that the provision for such zones under Artemis ‘could be in conflict with existing international law prohibiting any form of national appropriation of celestial bodies. It remains to be seen how these Accords work in practice and if they develop into generally recognized principles of cooperation.’ Although much of Artemis reflects existing international law, its future is likely to depend on as much as law itself. The mere fact that the process is led by the US seems to have stoked the fires of competing states, with the head of Russia’s space agency dubbing it ‘too US-centric’. Consequently, China and Russia signed an agreement this year to set up a rival system for exploration of the Moon, planning to establish a joint ‘International Lunar Research Station’. This, like the US-led effort, seeks to attract international partners. Monthly number of objects in Earth orbit by object type As China-Russia cooperation increases, Russia-US cooperation is waning. For many years the International Space Station has been a beacon for international cooperation in space, notably as a forum for detente between Russia and the US. However, it will eventually be de-orbited, possibly as soon as 2024, and with its demise will go a touchstone of cooperation between historical rivals. Clearly, events in space exploration have moved on since the 1967 OST which reduced tensions between Russia and the US. But now, with China as a significant new player, we seem to be witnessing a reignition of the space race. ‘The UN, notably its COPUOS, is still the best forum for all discussions on where the OST and the rest of the framework might need further elaboration, interpretation and implementation, comprising basically all the spacefaring nations,’ says von der Dunk. Based on experience, are international bodies helping to reduce friction in space?

## 2

### 1NC

#### CP –

#### [the aff] except for the development of single-use debris-limiting laser cannons and gossamer sails

#### the US and Japan ought to divert funds to build a laser cannon for the International Space Station and require gossamer sails on all future satellites

#### No laser cannon or gossamer sail r&d now due to cost, but it’s possible with the proper funding and the profit motive from private entities like RIKEN – solves extinction and future space junk permanently

Powell 15

Corey S Powell (science journalist and editor in chief at discover magazine, wrote 3 books with Bill Nye!!), May 20 2015, "Space Junk is a Problem. Is a Laser Cannon the Solution?," https://www.discovermagazine.com/the-sciences/space-junk-is-a-problem-is-a-laser-cannon-the-solution#.VV4ENGRViko, // HW AW, bracketed cause I don’t like reading big numbers

There’s a general rule in media reporting called Betteridge’s Law: Whenever a headline poses a question--especially a sensational one--the answer is “no.” I’m going to break the law this time. **An orbiting laser cannon is not only an intriguing technology but, yes, it’s one of the most promising ways to clean up the ever-thickening cloud of dangerous debris surrounding the Earth**. And just to be clear, space junk is a danger. There are about 25,000 human-made objects larger than your fist flying around in orbit, and about half a million pieces bigger than a dime. If you include millimeter-scale shrapnel, the number of rogue bits reaches deep into the millions. Typical speeds in low-Earth orbit are about 30,000 kilometers per hour (18,000 miles per hour), ten times the velocity of a rifle bullet. You see the problem: A little impact can pack a big wallop. So far, there have not been any space-junk catastrophes remotely resembling the sensationalized events in the movie Gravity, but the reality is still disconcerting. In 2009, a $50 million Iridium communications satellite was destroyed by a collision with a defunct Russian satellite. Three years later, the [Fermi space observatory](https://www.nasa.gov/mission_pages/GLAST/news/bullet-dodge.html) had a near miss with another Soviet-era satellite. NASA had to clad the International Space Station in shielding to protect it from repeated small impacts, and the agency sometimes moves the whole station to dodge larger pieces of junk. Orbiting debris adds cost and risk to the space business.The proposed space-station laser cannon (upper left) would work in conjunction with a telescope called EUSO to track and destroy space debris. (Credit: RIKEN) The amount of junk in orbit is increasing rapidly, meaning that those costs and risks are increasing, too. Once junk gets up there, it takes a long time to come back down: years to centuries in low orbits, and essentially forever in geosynchronous orbit (40,000 kilometers up, where many communications satellites are located). Most disconcerting, collisions in orbit create more junk, which leads to more collisions. Potentially this could lead to a runaway process called [Kessler Syndrome](http://en.wikipedia.org/wiki/Kessler_syndrome). **This is where the laser cannon comes in**. Toshikazu Ebisuzaki and a team of researchers at the RIKEN lab in Japan have [formulated a plan](http://www.riken.jp/en/pr/press/2015/20150421_2/) to clear out near-Earth space by zapping pieces of space junk with a high-power blast of focused radiation. The laser doesn’t need to be able to destroy the whole piece of debris. All it has to do is vaporize enough of the object to slow its orbit and send it spiraling into Earth’s atmosphere, **where it will burn up harmlessly before reaching the ground. It’s an ingenious solution**. Ebisuzaki’s concept was inspired by a science project called the Extreme Universe Space Observatory, currently under development for the International Space Station. [EUSO](http://jemeuso.riken.jp/en/), which will be installed on the station in 2017, is a fascinating instrument in its own right; it will study extremely high-cosmic rays by watching the light they create when they collide with air molecules. But EUSO’s sensitive, wide-field optics also make it well suited to spotting and tracking small bits of space debris, which are hard to locate from the ground. Finding targets is the crucial first step toward getting rid of them. The next step, of course, is the laser. RIKEN’s concept (which is not yet funded) would start with a 10-watt laser prototype, mounted on the International Space Station, capable of firing 100 laser pulses a second. That would pave the way for a larger system powerful enough to blast away any pieces of space junk within a 100-kilometer range, and eventually lead to a dedicated garbage-cleanup satellite equipped with a [five-hundred-thousand]500,000-watt laser that can fire [fifty-thousand]50,000 times per second. Such a satellite could remove 100,000 pieces of junk a year, the Japanese researchers claim, **fast enough to bring the whole orbital debris problem under control.** The fast-growing population of space debris. "LEO" refers to low-Earth orbit. (Credit: Surrey Space Centre) There are significant technical hurdles to overcome, including the data-processing capacity needed to spot the bits of debris and the considerable energy supply needed to keep such a powerful laser operating for years. Building a giant laser-cannon satellite would not be cheap, either. But this is exactly the kind of ambitious thinking needed to tackle the space-junk mess. Several additional cleanup technologies are also under development. A separate Japanese-led team has proposed trapping and eliminating space debris with a huge [electromagnetic tether](http://www.academia.edu/1265073/Space_Demonstration_of_Bare_Electrodynamic_Tape-Tether_Technology_on_the_Sounding_Rocket_S520-25http:/). A European project called [e.DeOrbit](http://www.esa.int/Our_Activities/Space_Engineering_Technology/Clean_Space/How_to_catch_a_satellite) would snare big pieces of space junk using a net or harpoon and dispatch them Earthward. Other concepts under study would use puffs of [pressurized gas](http://www.nasa.gov/directorates/spacetech/niac/gregory_space_debris_elimination.html), large [magnetized nets](http://www.spacesafetymagazine.com/space-debris/debris-removal/electrodynamic-debris-eliminator-receives-funding/), or a [slingshot-style satellite](http://aero.tamu.edu/news/removing-space-debris-tamu-sweeper-sling-sat). The laser cannon has some obvious advantages over all of these options, however. It could tackle the small fry, not just the big pieces, and it could deal with far more targets than would be possible for any spacecraft that is going after them one by one. If all of these ideas sound a little wacky, there's a good reason: Getting rid of space junk is a really, really hard problem. There is a lot of space to scour for debris. The individual pieces are mostly small and nearly invisible, and they each follow a unique orbit. Hard problems call for creative (and sometimes wacky) solutions. Further complicating things, nobody has devoted much money to cleanup, and any mission that can remove space junk could potentially remove active satellites as well--a delicate political issue. **If the RIKEN laser cannon never happens, it will more likely be due to budget** and political **obstacles than to technical ones**. In the long run, the best way to deal with space junk is never to create it in the first place. One of the most important principles here is what is called [design for demise](http://www.esa.int/Our_Activities/Space_Engineering_Technology/Clean_Space/Space_debris_mitigation)--that is, engineering satellites so that they will automatically de-orbit and remove themselves from the trash pile within, say, 25 years of the end of their mission. A simple way to do this is to equip a satellite with a small sail that would pop open when it is no longer needed. The so-called [gossamer sail](https://theconversation.com/cleaning-up-space-debris-with-sailing-satellites-20384) would act like a space parachute, using the pressure of sunlight and the extremely thin traces of atmosphere in orbit to create drag. The drag would then pull the satellite down to a fiery demise. Simulated view of Earth from the Planetary Society's new LightSail, launched on May 20. Space sails could be used to clear away satellite debris--or to take humanity on great ventures of exploration. (Credit: Josh Spradling/Planetary Society) A gossamer sail is very similar in function to a solar sail--like the prototype [LightSail](http://sail.planetary.org/) launched today by the Planetary Society. That creates a neat kind of symmetry to the story. Powerful space lasers may be useful for clearing debris, but they could also be used to launch high-speed spacecraft. Solar sails could be used to de-orbit satellites, but they could also provide new ways to navigate to new worlds. In short, the kinds of technological solutions needed to clear a path through our local garbage dump could be the exact same ones needed to blaze a path to the stars.

#### No laser cannon means nuclear war via the Kessler syndrome

Les Johnson 13, Deputy Manager for NASA's Advanced Concepts Office at the Marshall Space Flight Center, Co-Investigator for the JAXA T-Rex Space Tether Experiment and PI of NASA's ProSEDS Experiment, Master's Degree in Physics from Vanderbilt University, Popular Science Writer, and NASA Technologist, Frequent Contributor to the Journal of the British Interplanetary Sodety and Member of the American Institute of Aeronautics and Astronautics, National Space Society, the World Future Society, and MENSA, Sky Alert!: When Satellites Fail, p. 9-12 [language modified]

Whatever the initial cause, the result may be the same. A satellite destroyed in orbit will break apart into thousands of pieces, each traveling at over 8 km/sec. This virtual shotgun blast, with pellets traveling 20 times faster than a bullet, will quickly spread out, with each pellet now following its own orbit around the Earth. With over 300,000 other pieces of junk already there, the tipping point is crossed and a runaway series of collisions begins. A few orbits later, two of the new debris pieces strike other satellites, causing them to explode into thousands more pieces of debris. The rate of collisions increases, now with more spacecraft being destroyed. Called the "Kessler Effect", after the NASA scientist who first warned of its dangers, these debris objects, now numbering in the millions, cascade around the Earth, destroying every satellite in low Earth orbit. Without an atmosphere to slow them down, thus allowing debris pieces to bum up, most debris (perhaps numbering in the millions) will remain in space for hundreds or thousands of years. Any new satellite will be threatened by destruction as soon as it enters space, effectively rendering many Earth orbits unusable. But what about us on the ground? How will this affect us? Imagine a world that suddenly loses all of its space technology. If you are like most people, then you would probably have a few fleeting thoughts about the Apollo-era missions to the Moon, perhaps a vision of the Space Shuttle launching astronauts into space for a visit to the International Space Station (ISS), or you might fondly recall the "wow" images taken by the orbiting Hubble Space Telescope. In short, you would know that things important to science would be lost, but you would likely not assume that their loss would have any impact on your daily life. Now imagine a world that suddenly loses network and cable television, accurate weather forecasts, Global Positioning System (GPS) navigation, some cellular phone networks, on-time delivery of food and medical supplies via truck and train to stores and hospitals in virtually every community in America, as well as science useful in monitoring such things as climate change and agricultural sustainability. Add to this the [destruction] ~~crippling~~ of the US military who now depend upon spy satellites, space-based communications systems, and GPS to know where their troops and supplies are located at all times and anywhere in the world. The result is a nightmarish world, one step away from nuclear war, economic disaster, and potential mass starvation. This is the world in which we are now perilously close to living. Space satellites now touch our lives in many ways. And, unfortunately, these satellites are extremely vulnerable to risks arising from a half-century of carelessness regarding protecting the space environment around the Earth as well as from potential adversaries such as China, North Korea, and Iran. No government policy has put us at risk. It has not been the result of a conspiracy. No, we are dependent upon them simply because they offer capabilities that are simply unavailable any other way. Individuals, corporations, and governments found ways to use the unique environment of space to provide services, make money, and better defend the country. In fact, only a few space visionaries and futurists could have foreseen where the advent of rocketry and space technology would take us a mere 50 years since those first satellites orbited the Earth. It was the slow progression of capability followed by dependence that puts us at risk. The exploration and use of space began in 1957 with the launch of Sputnik 1 by the Soviet Union. The United States soon followed with Explorer 1. Since then, the nations of the world have launched over 8,000 spacecraft. Of these, several hundred are still providing information and services to the global economy and the world's governments. Over time, nations, corporations, and individuals have grown accustomed to the services these spacecraft provide and many are dependent upon them. Commercial aviation, shipping, emergency services, vehicle fleet tracking, financial transactions, and agriculture are areas of the economy that are increasingly reliant on space. Telestar 1, launched into space in the year of my birth, 1962, relayed the world's first live transatlantic news feed and showed that space satellites can be used to relay television signals, telephone calls, and data. The modern telecommunications age was born. We've come a long way since Telstar; most television networks now distribute most, if not ali, of their programming via satellite. Cable television signals are received by local providers from satellite relays before being sent to our homes and businesses using cables. With 65% of US households relying on cable television and a growing percentage using satellite dishes to receive signals from direct-to-home satellite television providers, a large number of people would be cut off from vital information in an emergency should these satellites be destroyed. And communications satellites relay more than television signals. They serve as hosts to corporate video conferences and convey business, banking, and other commercial information to and from all areas of the planet. The first successful weather satellite was TIROS. Launched in 1960, TIROS operated for only 78 days but it served as the precursor for today's much more long-lived weather satellites, which provide continuous monitoring of weather conditions around the world. Without them, providing accurate weather forecasts for virtually any place on the globe more than a day in advance would be nearly impossible. Figure !.1 shows a satellite image of Hurricane Ivan approaching the Alabama Gulf coast in 2004. Without this type of information, evacuation warnings would have to be given more generally, resulting in needless evacuations and lost economic activity (from areas that avoid landfall) and potentially increasing loss of life in areas that may be unexpectedly hit. The formerly top-secret Corona spy satellites began operation in 1959 and provided critical information about the Soviet Union's military and industrial capabilities to a nervous West in a time of unprecedented paranoia and nuclear risk. With these satellites, US military planners were able to understand and assess the real military threat posed by the Soviet Union. They used information provided by spy satellites to help avert potential military confrontations on numerous occasions. Conversely, the Soviet Union's spy satellites were able to observe the United States and its allies, with similar results. It is nearly impossible to move an army and hide it from multiple eyes in the sky. Satellite information is critical to all aspects of US intelligence and military planning. Spy satellites are used to monitor compliance with international arms treaties and to assess the military activities of countries such as China, Russia, Iran, and North Korea. Figure 1.2 shows the capability of modem unclassified space-based imaging. The capability of the classified systems is presumed to be significantly better, providing much more detail. Losing these satellites would place global militaries on high alert and have them operating, literally, in the blind. Our military would suddenly become vulnerable in other areas as well. GPS, a network of 24-32 satellites in medium-Earth orbit, was developed to provide precise position information to the military, and it is now in common use by individuals and industry. The network, which became fully operational in 1993, allows our armed forces to know their exact locations anywhere in the world. It is used to guide bombs to their targets with unprecedented accuracy, requiring that only one bomb be used to destroy a target that would have previously required perhaps hundreds of bombs to destroy in the pre-GPS world (which, incidentally, has resulted in us reducing our stockpile of non-GPS-guided munitions dramatically). It allows soldiers to navigate in the dark or in adverse weather or sandstorms. Without GPS, our military advantage over potential adversaries would be dramatically reduced or eliminated.

## 3

#### 1] Space innovation is high and on the rise- **but innovation could tank in the absence of private companies**

Peterson 21 Bob Peterson is based out of Colorado Springs, Colorado, United States and works at Lockheed Martin as VP Space Systems. Peterson, Bob. “Commercializing the Race to Space - Insigniam.” Insigniam, August 9, 2021. https://insigniam.com/private-space-exploration-innovating-future-space/.//WL

After publicly stalling out due to cost concerns circa 2011, America’s space race is quickly heating up again. Only instead of NASA, this time it’s being spearheaded through private space exploration by three billionaire investors and the companies that mirror these entrepreneurs’ out-of-this-world ambitions: Richard Branson (Virgin Galactic), Elon Musk (SpaceX) and Jeff Bezos (Blue Origin). Expected to be a $1.4 trillion market by 2030, according to analysts at Bank of America, private space exploration and tourism are already ushering in a host of new innovations outside of traditional aerospace and defense realms. For example: Morgan Stanley suggests that the business world’s growing rush to reach orbit may also help sate the world’s ever-growing appetite for high-speed satellite broadband technology and data, kick-start rocket-fueled delivery services and even enable asteroid mining in years to come. Here, we take a closer look at the field’s three front-runners, how each is pioneering new scientific advancements, and various trickle-down innovations that private space exploration may soon bring back to dozens of industries on planet Earth. Virgin Galactic On July 11—just 17 years after announcing the company—Virgin Group founder Richard Branson took his inaugural trip 53 miles above the Earth’s surface in Virgin Galactic’s suborbital, rocket-powered space plane VSS Unity. Capable of holding six passengers and two pilots, the craft isn’t likely to be earthbound for very long; the company has already sold around 600 tickets for flights at the princely sum of $200,000 to $250,000 apiece. As of early August, more tickets were available starting at $450,000 each. The increasing desire for private space exploration points to companies’ growing desire to more cost-efficiently use resources, leverage emerging or preexisting technology in new ways, optimize processes and workflows, and pioneer new markets by democratizing access to resources and equipment. The first of the billionaire space company founders to reach the edge of space (depending on the definition), Branson did so thanks to myriad scientific and business innovations made by his firm. Advancements not only include a new high-speed aircraft design that leverages modular technology to improve flight rate and maintenance access. They also incorporate a livery design built from a mirrorlike material that provides heightened thermal protection and color-changing potential, a spectacular display of the plane’s advanced capabilities in keeping with Branson’s notoriously flashy brand of showmanship. These upgrades have helped power Virgin Galactic’s ongoing push to capture public and media attention, enticing armchair astronauts to fulfill childhood dreams and fueling a booming business in space tourism. Moreover, unlike traditional crewed rockets, which launch from ground-based locales, Virgin’s ships lift off from bigger planes that drop them off in midair. It’s a highly efficient technique that consumes less fuel and reduces the need for custom launch pad infrastructure. Passengers, who can enjoy three to five minutes of weightlessness, will soon include scientists who can run experiments midflight, as opposed to primarily using traditional suborbital space testing methods—i.e., spacecraft without a crew. SpaceX Tesla founder Elon Musk’s SpaceX is an all-purpose space technology firm that designs and manufactures myriad cutting-edge rockets and spacecraft. Case in point: Its Dragon capsule has already proved it can cost-efficiently carry crew and cargo to the International Space Station. The company’s Starship large-scale rocket and spacecraft system is also designed to carry massive payloads into orbit—and, thanks to NASA’s support, is expected soon to land the first astronauts on the moon since the Apollo program. Not yet 20 years old, SpaceX is additionally focused on introducing more dependable equipment at a fraction of standard production and operating costs. Other innovations include the Falcon 9, a reusable two-stage rocket for repeatedly transporting people and equipment into space, and Falcon Heavy, the world’s most powerful rocket today, which can carry twice as much weight as its closest competitor. SpaceX’s ambitions even extend to commercial space flight and ride-sharing if you or your company’s inventory need to catch a quick lift into the atmosphere. Almost as curious as the company’s public-facing creations are those powering its operations behind the scenes, including a fleet of autonomous drone ships that catch rockets as they hurtle back to earth, landing in the ocean. SpaceX is also heavily investing in building out Starlink, a broadband internet service powered by thousands of satellites that has the potential to bring high-speed connectivity to remote and rural areas around the globe. In short, by leveraging a host of leading-edge technical advancements to power practical innovations in communications, transport and aerospace operations, SpaceX aims to privatize the field of space flight as a whole. No wonder NASA ranks among the company’s biggest customers. Blue Origin The brainchild of Amazon founder Jeff Bezos, Blue Origin was founded in 2000 with the mission of expanding humanity’s reach into space, fueling interstellar exploration, and powering the search for new material and energy resources. It hopes to do so by delivering low-cost, fully or partly reusable orbital launch vehicles that can serve the needs of businesses and individuals alike. One person recently paid an astounding $28 million for a ticket. Unlike Virgin Galactic, Blue Origin makes spacecraft that are able to cross the Kármán line—the 62-mile-high measurement that most countries consider to be the boundary of outer space. (The U.S. uses 50 miles as a benchmark instead.) The company’s mantra is “Launch, Land, Repeat,” a testimonial to its commitment to drastically lower expenses associated with space travel, and to the built-in vertical takeoff and landing technology that allows used vehicles to be quickly refurbished and once again take flight. Note that Blue Origin is also experimenting with oversized lunar landers designed to ferry astronauts and equipment affordably to and from the moon. Investment Opportunities and New Innovations The increasing desire for private space exploration points to companies’ growing desire to more cost-efficiently use resources, leverage emerging or preexisting technology in new ways, optimize processes and workflows, and pioneer new markets by democratizing access to resources and equipment. Each of the big three players has sought to tap into a mix of proprietary and community knowledge bases, leverage new high-tech and engineering advancements to lower overhead and operating costs, and boost the accessibility of space travel. Likewise, all have looked to raise public awareness, amortize their investments in new innovations and extend potential revenue streams by finding new business applications for their proprietary solutions at every turn. To read more about the commercialization of space, read “Commercial Space Is Becoming Big Business.” Virgin Galactic is publicly traded, Blue Origin and SpaceX are not. However, more than 10,000 companies (42% of which are American), worth upward of $4 trillion in total, are now pioneering space-based business solutions. In addition, many of these firms—which are looking to make plays in many fields, like telecom, tourism, artificial intelligence and robotics—are investor-friendly startups helping to further capitalize or expand upon the innovations that the big three players are ushering in. Key areas of growth going forward for space-based business are expected to include navigation and mapping, satellite communications, cloud-based applications, manufacturing, and health care/medicine. And that’s before you factor in potential research and scientific applications. Example: the University of Florida researching plants’ changing gene activity in weightless environments via experiments conducted in partnership with Virgin Galactic. It’s yet to be determined whether billionaire-funded private space exploration spaceflight firms will successfully deliver on their aim to democratize space travel, or such trips will remain a prohibitively pricey luxury for most aspiring voyagers. Regardless of whether casual flights into space and stargazing business or research contracts become more commonplace, it’s clear that this nascent field has a promising future. While a Jetsons-style culture of weekend jaunts into orbit is still the stuff of science fiction for now, don’t forget: Succeed or fail, to their credit, all of these firms are helping expand businesses’ ambitions to the stars and beyond and helping illustrate a multitude of potential new uses for aerospace solutions.

#### **2] Private space firms are key to promote competition and drive innovation**

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On 11 July UK billionaire businessman Richard Branson travelled to the edge of space in a spaceplane developed by his company, Virgin Galactic. On Tuesday this week, the billionaire founder of Amazon, Jeff Bezos, will take a similar trip to space aboard the New Shepherd rocket built by his Blue Origin company. Elon Musk’s SpaceX will soon begin sending paying civilians into Earth orbit with the company’s Falcon 9 rocket. The ability of such billionaires to afford private spaceflight trips or invest in heavy-lift rockets, while paying a smaller fraction of income in tax than the average American, reflects inequality in America. This inequality has been made especially stark during the COVID-19 pandemic with billionaires’ wealth increasing while many others experienced financial hardships. Increasing wealth and reaching for space has not purchased popularity for these billionaires. Ahead of Bezos’ upcoming suborbital flight, a petition to “not allow Bezos to return to Earth” gained more than 160,000 signatures. Richard Branson has been criticized for using his wealth to go to space rather than addressing more terrestrial problems like climate change. But after half a century of government-led exploration beyond earth, why are billionaires now at the forefront of our minds when we think about space travel, and what do they mean for how we go to space? The private sector has always had a close involvement with space Billionaire interest in space is not new. Historically, science research funding for observatories in the 19th and 20th centuries was typically provided through endowments from wealthy individuals. Institutions such as the Smithsonian and the Guggenheim family were the early donors of Robert Goddard’s ambitious projects to develop rockets and space technology. Following 1980s initiatives like MirCorp’s plan to provide privately owned space stations, the 1990s and 2000s saw commercial space efforts like Peter Diamandis’ introduction of the Ansari X Prize (1996), the US government’s Alternate Access to [the International Space] Station Program (2000-2002), and the founding of Mojave Aerospace Ventures (2004). Between 2001 and 2009 seven wealthy people went to space as paying customers on Russian Soyuz rockets including Dennis Tito, Iranian American businesswoman Anousheh Ansari and Cirque du Soleil founder Guy Laliberte. More recently, aside from Jeff Bezos and Richard Branson, other billionaires have also planned trips to space, including Jared Isaacman and Yusaku Maezawa. The wave of billionaires now seemingly interested in space exploration is a return to a past trend. Space exploration is expensive Private actors and the government think differently when it comes to what type of space programs to prioritize. The government prioritizes aspects of a space program that are in the public-interest such as national security and Earth sciences, while wealthy individuals that enter the space sector are interested in personal and financial endeavors that involve space exploration, such as making life multiplanetary for Elon Musk and space tourism for Richard Branson and Dennis Tito. The Apollo program which ultimately sent astronauts to the moon in 1969 is thought of as the height of US government leadership in space. But the massive investment which made the first moon landing possible was an anomaly that had been driven by political necessity given the climate of the Cold War. As Figures 1 and 2 show, by 1965, the US government had begun to cut NASA’s budget to the point that by the 1970s it made up only about 0.5-1 percent of the total federal budget. According to Dr. John Logsdon of George Washington University’s Space Policy Institute: “From 1970 onward, NASA has not had a budget adequate to support a robust program of human exploration.” Figure 1 – NASA’s budget from 1959 – 2025 Source: The Space Report Figure 2 – NASA’ share of US federal Budget 1959-2018 Source: The Space Report The lackluster interest in space exploration by the US government since the 1970s sits alongside with a similar lack of enthusiasm by the American public. In a 2018 survey conducted by Pew Research Center, a majority of American adults believed that that monitoring Earth’s climate system should be the highest priority and sending astronauts to Mars and the Moon the lowest (Figure 3). Figure 3 – Americans’ views on policy priorities Source: Pew Research Center, 2018 Re-emergence of commercial space At the same time, many wealthy individuals have been dissatisfied with the lack of public enthusiasm and the lack of progress in recent years due to the government’s traditional view of space operations, and failures of the Space Shuttle. Wealthy individuals like Musk believed that they could spur a robust marketplace for providing access to space which could work alongside and provide services for government space agencies by leveraging reusable technologies, lean manufacturing, and vertically integrated production to enable cheap space access. Because typical debt and equity investors are unwilling to finance the risks of space exploration and the government is unable or uninterested in large up-front investments, it is natural for private space exploration to be funded out of billionaire’s own wealth initially, with government support through development contracts. Government support and US Commercial Space Policy Without the government, the private sector cannot thrive in space. The government supports the private sector by adopting regulatory reforms or creating contracts and awards. Early attempts to invigorate the commercial space industry include the 1984 Commercial Space Launch Act, which was unsuccessful as US launch firms were unable to compete against NASA’s Space Shuttle. President Reagan’s 1986 US Space Launch Strategy reduced NASA’s ability to provide commercial launches, which led to the re-emergence of commercial space activities. The limitations provided by the 1986 policy led to the first commercial space launch by Space Services, Inc. in 1989. The US government under the Obama administration made policy reforms such as introducing fixed price contracting to support development of commercial services. An example of this was a request for over $6 billion to subsidize commercial crew vehicles to visit the International Space Station for the Commercial Crew Resupply (CRS) program. Congressional appropriators in the Senate created a “Dual-track” approach, exemplified by the 2010 NASA Authorization Act, which calls for commercial cargo development. The bill shows that policymakers were willing to compromise on certain aspects of the space program such as CRS to support private space launch companies. By 2010, commercialization was well underway with Obama’s National Space Policy that emphasized supporting a “competitive US commercial space sector.” As of 2011, NASA had paid SpaceX $181 million for 14 Commercial Resupply Missions and $298 million under the Commercial Orbital Transportation Services Demonstration Agreement. The Trump Administration increased public investment in private space actors further and established a series of Space Policy Directives that were meant to bolster the commercial sector. Government support to the private sector further comes in the form of NASA- approved loans, loan guarantees, and tax credits. Firms can also receive tax exemptions through facility constructions, discounted loans, and environmental credits. It is estimated that all of Musk’s ventures, not limited to SpaceX, received at least $4.9 billion in government support through tax breaks, factory construction, discounted loans, environmental credits, facility loans, and rebates to product buyers. Photo by SpaceX on Unsplash How billionaires support the space industry Private investment in space has created competition and reduced space launch costs. New space actors began to challenge the government-created monopoly, United Launch Alliance (ULA), for contracts, creating competition and introducing a market for small-medium class reusable launch. SpaceX’s Falcon 9’s average cost is $62 million, while ULA’s Atlas V starts at $110 million per launch. Commercial actors enable the government to have multiple competitive proposals to select from during project development. NASA would pay less money upfront for a service, while private companies can operate and have autonomy over their final product. The government can act as a buyer of commercial services, which allows NASA to be more efficient and cost-effective, as the agency can cut costs by only developing projects it has expertise and funding for. Such competition has dramatically changed space technology. New players that enter the space industry are able to embark on ambitious projects at a greater scale and faster pace. Innovative concepts such as reusable rocket stages has shifted the launch industry into integrating reusability into vehicle design and the proliferation of ridesharing missions has decreased the costs of space launch. This has lowered barriers to enter the space industry, making small satellites rideshare as low as $1 million per mission. Innovations in space launch have further changed the policy environment and streamlined launch and reentry regulations. Billionaires in space are here to stay Investment from wealthy individuals in recent decades have stimulated private markets and paved the way for many startups to enter the industry. As more new players join the commercial space industry, access to space becomes cheaper, resulting in an explosion of proposed satellite constellations and small launch vehicle concepts. Wealthy entrepreneurs have seen an opportunity to take advantage of a lack of government interest in space exploration funding. The high-risk nature of space exploration requires substantial upfront investment that only wealthy individuals can provide before any pay-off. Private investments in space promote competition and innovation. Billionaires providing upfront investments has stimulated the space market and made space more accessible – and profitable.

#### **3] Space innovation is key to colonizing outer space- scientific discovery promotes breakthroughs that benefit society**

Raghavan 21 Seetha Raghavan is a professor in UCF’s Department of Mechanical and Aerospace Engineering. “The Impact of Innovation in the New Era of Space Exploration | University of Central Florida News.” 2021. University of Central Florida News | UCF Today. August 5, 2021. https://www.ucf.edu/news/the-impact-of-innovation-in-the-new-era-of-space-exploration/.//WL

Every once in a while, a confluence of discoveries, events and initiatives results in a breakthrough so significant that it propels the entire world to a higher level, redefining what is possible in so many different fields. This breakthrough is taking centerstage now, as the new era of space exploration — catalyzed by increasing launch access — dawns upon us. The surge of innovation that comes with this will create new opportunities and inspire the next generation of doers. When this happens, boundaries between scientific and social impact are blurred. Innovation leading to scientific discovery can benefit society in the same way that social innovation can diversify and support scientific innovators, who can contribute to global progress. To ride this wave of progress, we must all participate and innovate in the new era of space exploration. The intersection of space exploration, innovation and impact isn’t a new phenomenon. In the past, technology developments and spin-offs from space research have consistently found their way into communities worldwide sometimes with lifesaving benefits. The International Space Station supports experiments that have led to discoveries and inventions in communication, water purification, and remote guidance for health procedures and robotic surgeries. Satellite-enabled Earth observation capabilities that monitor natural disasters, climate and crops often support early warnings for threats and mitigation strategies. Space exploration has always been relevant to everyone no matter the discipline or interest. Commercialization of space has been key in many ways to the current boost in “firsts” over the last few years. It has spurred innovation in launch vehicles and related technologies that led to firsts in vertical-takeoff-vertical landing rocket technology, reusability of rocket boosters and privately developed crewed missions to orbit. Concurrently, NASA has continued to captivate our imagination with the first flight of a helicopter in another world, a mission to return an asteroid sample to Earth and sending a probe to make the closest ever approach to the sun. While we celebrate the scientific progress, there is a vastly important question that we all need to focus on: How can we drive the surge in innovation offered by increased access to space, to benefit humankind? Access to low-Earth orbit, and eventually human exploration of space, is a portal to achieve many impactful outcomes. The numbers and completion rate of microgravity experiments conducted by scientists will be greatly increased as a range of offerings in suborbital flights provide more opportunities to advance critical research in health, agriculture, energy, and more. Lunar, planetary, and even asteroid exploration may lead to discoveries of new materials — busting the limitations now imposed on capabilities for energy, transportation, and infrastructure or creating new sensors and devices that enhance safety on Earth. Space tourism —one can hope — has the power to potentially create an awareness of our oneness that may lead to social change. But much like all scientific endeavors, we cannot ignore the importance of pre-emptively identifying and mitigating negative impacts of new ventures some of which may have already taken shape. We need to consider space debris that threatens the very access that facilitates it, safety and rescue readiness to support increased crewed missions and space tourism, national security, and effects of light pollution on astronomy. Much of these can be approached and mitigated with new concepts and ideas that have already been set in motion. One thing is for certain, space has always been the inspiration for the next generation of innovators and creative thinkers. Architects of new ideas in this era will inspire many more. Ingenuity must also come from academic and research institutions building a new space-ready generation through innovative curriculum, scholarships, and research opportunities for key fields at all levels. Most of all, engaging participation is a responsibility anyone can take by steering the conversation and gathering ideas on how we can make this era one of positive benefit for all, while making opportunities inclusive to all.

#### 4] Private space firms are on the verge of colonizing outer space- the plan stops them now by cutting competition

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Humans have long desired to explore the vast realms of space. Today, we are finally poised to send people out into the cosmos. Indeed, a number of private and public space companies are gearing up for Space Race 2.0 — a (very expensive) competition that inches us closer to uncovering answers about our universe and exploring new realms of our own humanity. Though they are still in the race, shifting priorities and limited budgets have undermined NASA’s lead in exploring the solar system and beyond. In the meantime, private entities like SpaceX and Virgin Galactic are flush with cash, and they are stepping up to try and engineer better, bigger, and faster rockets. And this is a good thing because, if humans are to find life on other planets, or perhaps a new planet for ourselves, more work needs to be done. Engineers and scientists need to develop life support systems, find reliable sources of water and fuel, overcome the negative effects living in space has on the body, and find a faster way to travel. There is still much to be done, but sending the average person to the Moon and beyond no longer seems so far out of reach. Yet, when will it finally happen? When will humans finally roam across an alien world? Here’s a comprehensive timeline of our future beyond Earth. Late 2017: Heavy Falcon Launch SpaceX plans to launch the Falcon Heavy for the first time before the end of 2017. Because the rocket can be reused, the Falcon Heavy rocket can deliver its payload into space at only a third of the cost of the next closest operational vehicle, the Delta IV Heavy. This lower upfront cost means that more organizations can carry out experiments in outer space. One of these experiments is the Planetary Society’s LightSail 2 solar sail that will launch on board a Heavy Falcon in early 2018. SpaceX’s Falcon Heavy rocket lives up to its name. 27 rocket engines weigh down the 70-meter (229-foot), 1.4-metric-ton (3.1-million-pound) rocket. That’s a lot of extra weight, but the payload makes it worthwhile — the rocket can launch 63,800 kg (140,660 lbs) of equipment, cargo, and passengers into orbit around Earth. That’s more than double the weight that the Space Shuttle can haul to the same altitude. 2018: Preparing For Space Tourism In 2018, SpaceX plans to launch more than ever before, sending 30 rockets into orbit (up from 20 in 2017). More attempts give the company more data to show how it can perfect its technology to launch rockets cheaply and securely. Eventually, this inexpensive and safe spaceflight will make space tourism finally viable. In fact, just this year, SpaceX announced that they would be sending two humans to orbit the Moon in 2018. Image Credit: Virgin Galactic Virgin Galactic is gearing up to launch its first astronauts into space before the end of February 2018. Before it launches with passengers on board, though, the spacecraft will have to undergo a series of test flights. The space plane, called the VSS Unity, completed its fifth ‘glide flight’ (distinct from the vertical trajectory of traditional space rockets) earlier in 2017. In the first months of 2018, it will be taking flights closer to the Karaman line, the official border between the Earth’s atmosphere and outer sp ace located 100 km (62 miles) above the Earth’s surface. Image Credit: Planetary Society Around that same time in early 2018, scientists will test the LightSail 2, a device that moves through space by harnessing the power of solar photons — no fuel tanks or thrusters required. The LightSail 2, a citizen-funded spacecraft and created by the Planetary Society (the largest nonprofit organization that promotes the exploration of outer space), would be a proof of concept that solar sailing could propel spacecraft deeper into space. The unmanned, light-propelled spacecraft will hitch a ride on SpaceX’s Falcon Heavy rocket before taking its test flight at an altitude of 720 km (447.4 miles). 2019: Space Tourism And Observation Image Credit: Blue Origin Blue Origin, the spaceflight services company started by Amazon founder Jeff Bezos, recently announced that it intends to take tourists to space before April 2019. In groups of six, passengers will board an 18-meter (60-foot) rocket to the edge of space, around 100 km (62 miles) from the Earth’s surface. Once there, they will experience zero-gravity flight. Three independent parachutes and a retro-thrust system ensure that passengers will gently sail back to Earth. This experience does not come cheap — a ticket to board the New Glenn to reach Earth orbit is rumored to cost anywhere between $150,000 and $250,000. And, yet, there’s little question that people will want to sign up — Virgin Galactic, a competing space tourism project, reportedly already has 700 people signed up. In 2019, Blue Origin plans to add two- and three-stage rockets to its arsenal. They are fully reusable, up to 99 meters (326 feet) tall, and can deliver payloads at a relatively low cost, competing with SpaceX’s Falcon Heavy rockets. Image Credit: NASA NASA also intends to launch its James Webb Telescope in the first quarter of 2019. The telescope will observe the solar system in the infrared to see every phase of the solar system’s maturation; it will ultimately be 100 times more powerful than the Hubble Space Telescope, thanks to its array of 18 hexagonal mirror segments. With a combined mirror diameter of 6.5 meters (the Hubble measures in at only 2.4), the James Webb Telescope will be able to detect events such as the formation of galaxies dating back to the time of the Big Bang. It will also have a special focus on discovering new planets that could be capable of supporting life. 2020-2025: “Earth Reliant” And Beyond From finding evidence of liquid water to detecting organic matter in the soil of the Red Planet’s surface, the Curiosity rover has answered some fundamental questions about what it’s like on Mars. However, that information has also sparked more questions about what other elements may be present. To this end, in an effort to establish whether oxygen is present in the Martian atmosphere, and at what concentration, Curiosity’s successor, the Mars 2020 rover, will be saddled with a host of sensors and instruments that will allow it to answer this question. Information about oxygen concentration will be important if humans are ever able to visit the Red Planet themselves, which could be possible as early as 2030. There are other things that need to happen if we’re going to colonize other planets. NASA has established three phases that we need to complete before this is possible. In the first, which NASA calls “Earth Reliant,” we continue to test the feasibility of living in space and conduct more research aboard the ISS. In the second (“Proving Ground”), operations around the Moon will be used to establish ways to return humans to the Earth safely. With those stages complete, we will finally reach the third stage (“Earth Independent”) in which humans establish a self-sufficient colony on Mars. Image Credit: NASA Just over 50 years after humans first touched the lunar surface, NASA is gearing up to launch another manned spacecraft to go beyond the Moon. The astronauts will be on board a ship called the Orion, which will lift off using NASA’s Space Launch System (SLS), a modular heavy launch vehicle. SLS is similar to SpaceX’s Heavy Falcon and has a maximum payload of 70 to 130 metric tons (150,000 to 290,000 lbs). First, though, the spacecraft will do a few test runs without any humans on board. The first mission, Exploration Mission-1, is slated for late 2018. The SLS will launch the unmanned craft, travel to the Moon, enter orbit about 100 km (62 miles) above the lunar surface, and use gravity to propel itself into deep, unexplored space. The goal of this mission is to see if the craft can help humans survive a trip to distant planets. The second mission (Exploration Mission-2), planned for August 2021, will be NASA’s first manned test flight beyond the Moon. “During this mission, we have a number of tests designed to demonstrate critical functions, including mission planning, system performance, crew interfaces, and navigation and guidance in deep space,” Bill Hill, the deputy associated administrator of Exploration Systems Development at NASA Headquarters said in a 2016 NASA blog. To gain enough momentum to make the trip around the Moon, the spacecraft will have to make multiple orbits around Earth, occasionally igniting its thrusters. During its stable orbit of the Moon, the Orion will gather data and test the spacecraft’s capabilities for interplanetary flight. 2022: Making Mars Habitable While NASA spends the 2020s exploring how to best keep humans healthy in space, SpaceX plans to start putting down the infrastructure for humans to colonize it. SpaceX anticipates completing its first 54.6-million-km (33.9-million-mile) trip to Mars in 2022. Image Credit: SpaceX In his update earlier this year, Elon Musk revealed plans for a rocket that is far bigger and more powerful than NASA’s Space Launch System and even his agency’s own Falcon Heavy — the BFR. A rocket that big would have enough space for fuel to take humans to Mars, or even allow for Earth-based city-to-city travel. With a maximum payload of 150 tons, the enormous 106-meter (347.7-feet) rocket would break the current record for biggest payload (including cargo, fuel, and passengers) launched into orbit, while providing the lowest cost for each additional launch. To reach the Moon, the BFR would launch from the Earth’s surface, transfer propellant from fuel depots previously stationed in Earth’s orbit, accelerate in orbit, pick up an injection of fuel for the remaining distance to the lunar surface on the way, and land. SpaceX plans to refuel the rocket once it is in orbit in order to extend its range and payload capacity so that it can return safely to Earth. Tests have already shown that it’s possible to refuel rockets in space. NASA conducted the Robotic Refueling Mission in 2011, and it successfully completed a robot-actuated propellant transfer on an exposed platform of the International Space Station. Image Credit: SpaceX By 2022, SpaceX expects to land at least two cargo ships on Mars in order to establish a habitat for humans. The primary goal of those initial missions is to find a reliable source of water on the Martian surface. 2024: Manned Missions On The BFR Image Credit: SpaceX Two years after those cargo ships establish an infrastructure, SpaceX plans to send humans to inhabit a colony on Mars. The passengers aboard the BFR’s 40-cabin Mars transit module will be the first to make the unprecedented trip. This is, Musk would probably admit, an aggressive timeline. And it may not work in SpaceX’s favor: Due to planetary alignments and other factors such as solar power requirements and fuel limitations, the launch window of Earth-Mars travel is only a few weeks, according to Wired. And that’s assuming that all the other pieces fall perfectly into place — neither the BFR nor its predecessor, the Falcon Heavy, has yet had a successful launch. Should the BFR mission make it to Mars, it will contain the materials to construct a propellant production plant as part of its Martian colony. The plan would suck carbon dioxide from the atmosphere and turn it into deep-cryo CO4 fuel using solar power. 2025-2030: A Year In Space Image Credit: NASA SpaceX might be ready to send humans to live in space by the early 2020s, but NASA is a little more cautious. The government space agency is planning to put astronauts into orbit for a year to find out if humans are indeed ready to live on a different planet. In March 2016, NASA astronaut Scott Kelly completed a similar year-long mission aboard the ISS to test the effects of zero gravity on the human body and what that will mean for future space travel to Mars. Unlike Kelly’s mission, however, NASA’s 2021 mission will put astronauts in orbit around the Moon. They’ll be in a “deep-space gateway” — a small ISS-like station that will serve as a testing ground for future deep space missions, including later missions to Mars. It will be built over five earlier missions, four of them with humans aboard. The effects of spending a year in lunar orbit on the human body, caused by factors such as different day-night cycles and solar radiation, are still unknown. 2030s: NASA Sends Humans To Mars Five years after SpaceX’s manned missions to Mars, NASA plans to send its own spacecraft to the Red Planet. Using data and samples from the Curiosity and Mars 2020 rovers, NASA will first establish how humans could sustain themselves on the Martian surface before sending manned spacecraft from its deep-space gateway to do so.

#### 5] Not colonizing space directly links to human and extraterrestrial extinction scenarios, which outweigh

Munevar, PhD, 19 [Gonzalo Munevar, Professor Emeritus at Lawrence Technological University, PhD Philosophy @ UC Berkeley. "An obligation to colonize outer space", Futures, Vol. 110, Pg. 38-40, published June 2019, accessed 11-1-2021, https://www.sciencedirect.com/science/article/abs/pii/S0016328718302660#!] HWIC

We have an obligation to colonize outer space. This colonization may include establishing bases on the Moon, Mars, and other bodies in the solar system, perhaps leading to terraforming some of them, as well as building the sorts of space colonies championed by Gerard O’Neill.1 By doing so we may save humanity from collisions with asteroids and other cosmic catastrophes, while also bringing clean energy to Earth and giving us access to the resources of the solar system. Carrying out such tasks will, moreover, increase our scientific knowledge of heaven and Earth. A collision with a large asteroid may bring human life on Earth to an end. Space colonization would allow human life to continue. Smaller, and far more likely, collisions will cause great destruction and kill millions of people. Furthermore, a heavy human presence throughout the solar system would make it possible, even highly probable, that many such collisions may be prevented, thus saving billions of humans, and many other living beings, from a horrible death. And whether we are able to avert such a catastrophes, the sun will become a red giant in four or five billion years; but even long before then, it will make the Earth an unbearable planet. In the long run, thus, space colonization will give terrestrial life another chance. Space colonization will give us many opportunities to improve the Earth itself, for example by moving polluting industries into space, providing clean solar power from space at reasonable prices, and making available to our home planet many of the resources of the asteroids and other bodies in the solar system. Doing so will enable us to increase our knowledge of the universe, and particularly of planetary science, which would then permit a wiser approach to our own planet. The word limit narrows my scope, and thus I will concentrate on the likelihood of collisions with comets and asteroids. Gravitational disturbances of the asteroid belt, the Kuiper Belt (a little beyond Pluto) or of the Oort cloud, in the outskirts of the solar system, send many large bodies towards the sun.2 Some of them collide with the planets and moons of the solar system. Consider that there are trillions of objects larger than 1 km and billions larger than 20 km in the Oort cloud alone. Given its position, and its gravitation, the Earth becomes a target for collisions. Even in recent geologic times (within the last 100 million years) large meteors indeed have collided with the Earth, altered the weather catastrophically and brought extinction to the majority of species then living. One asteroid about 10 km in diameter, now called the Alvarez asteroid, is held responsible for the disappearance of the dinosaurs about 65 million years ago,3 although some think a comet may have been the culprit.4 And in 1994, large fragments of Comet Shoemaker-Levy 9 hit the atmosphere of Jupiter at velocities over 200,000 km per hour, exploding with a brightness as much as fifty times that of the entire planet, and ejecting searing materials thousands of kilometers above the clouds. Had Shoemaker-Levy 9 hit the Earth instead, we would have gone the way of the dinosaurs.5 Apart from the realization that our natural history has to make conceptual room for such catastrophes,6 there is a most obvious practical issue of survival involved. With a reliable tracking system in place, space technology might allow us to change the orbits of those comets or asteroids most in danger of colliding with the Earth. But how worried should we be? According to present models, meteors large enough to create Meteor Crater in Arizona would hit an urban area every 100,000 years on average. That meteor was presumably 60 m across; the crater is 1.2 km across. A body with a diameter of 250 m would cause a crater 5 km across and destroy some 10,000 square Kilometers (about the area of greater Los Angeles). And global catastrophes would take place every 300,000 years. These would be caused by meteors with a diameter of approximately 1.7 km.7 What is the evidence for these calculations? Soon after impact on Earth, craters are attacked by wind, water, life, lava and a myriad of tectonic motions. In the blink of an eye, geologically speaking, all obvious traces of them disappear from the surface of our active planet. But we find a good record on the Moon. And in Venus, where most of the surface is 600 million years old, the spacecraft Magellan counted nearly one thousand impact craters at least twice the diameter of Meteor Crater. Venus is almost the same size as Earth, and in the Earth’s vicinity, and since the impacts are geologically recent, the Venusian impact record makes it reasonable to fear catastrophic impact on Earth every half a million years or so.8 Still greater collisions, with bodies of 5 km across, would happen, on the average every 20 million years.9 Apart from the asteroid that led to the extinction of the dinosaurs and the majority of species on Earth 65 million years ago, there have been at least two more impacts by asteroids 10 km or larger in the last 300 million years.10 New worries have been caused by the discovery of “rogue planets,” i.e. planets that were expelled from their solar systems and boulder their way through interstellar space. Some will be rocky like the Earth and some will resemble Jupiter, even much larger, carrying their large moons with them. Were one of them to come into our solar system, it would disrupt the orbits of our planets, perhaps sending the Earth itself into interstellar space. A collision would pulverize both bodies. Some scientists think that there are far more rogue planets than stars in the Milky Way, whereas the lowest estimate of Jupiter-size rogue planets is that of one per every four stars.11 Whether those of us living today will experience such catastrophes, eventually our descendants will be thankful to us for creating a warning system and the technology to prevent disaster.12 There can hardly be a better reason than the preservation of life, and perhaps the survival of the species, to establish the importance of colonizing space. An expansion of human colonies throughout the solar system would make it far easier to reach, say, an asteroid in a collision path with the Earth, when it is still very far away, and thus when the angle is small and the necessary alteration of its path will be relatively minor. Such deflection can be accomplished by several means: astronauts could make a smaller asteroid collide with the larger one, or use one of the mass drivers designed by O’Neill. Nuclear explosions might work also. If we are established in outer space. To do a proper mission starting from Earth may take many years, thus making it far less likely to succeed. Robotic deep-space missile platforms, which can never achieve human flexibility, let alone human ingenuity, are unlikely solutions, as can be gathered from previous discussion on robotic missions.13

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#### Space-for-space economy is beginning to develop now because of private enterprise in space

Weinzierl and Sarang 21 (Matt, PhD in Economics Harvard University, Joseph and Jacqueline Elbling Professor of Business Administration at HBS and a Research Associate at the National Bureau of Economic Research, and Mehak, Research Associate at Harvard Business School and the Lunar Exploration Projects Lead for the MIT Space Exploration Initiative, Harvard Business Review, "The Commercial Space Age is Here," 2/12, <https://hbr.org/2021/02/the-commercial-space-age-is-here>)

In 2019, 95% of the estimated $366 billion in revenue earned in the space sector was from the space-for-earth economy: that is, goods or services produced in space for use on earth. The space-for-earth economy includes telecommunications and internet infrastructure, earth observation capabilities, national security satellites, and more. This economy is booming, and though research shows that it faces the challenges of overcrowding and monopolization that tend to arise whenever companies compete for a scarce natural resource, projections for its future are optimistic. Decreasing costs for launch and space hardware in general have enticed new entrants into this market, and companies in a variety of industries have already begun leveraging satellite technology and access to space to drive innovation and efficiency in their earthbound products and services. In contrast, the space-for-space economy — that is, goods and services produced in space for use in space, such as mining the Moon or asteroids for material with which to construct in-space habitats or supply refueling depots — has struggled to get off the ground. As far back as the 1970s, research commissioned by NASA predicted the rise of a space-based economy that would supply the demands of hundreds, thousands, even millions of humans living in space, dwarfing the space-for-earth economy (and, eventually, the entire terrestrial economy as well). The realization of such a vision would change how all of us do business, live our lives, and govern our societies — but to date, we’ve never even had more than 13 people in space at one time, leaving that dream as little more than science fiction. Today, however, there is reason to think that we may finally be reaching the first stages of a true space-for-space economy. SpaceX’s recent achievements (in cooperation with NASA), as well as upcoming efforts by Boeing, Blue Origin, and Virgin Galactic to put people in space sustainably and at scale, mark the opening of a new chapter of spaceflight led by private firms. These firms have both the intention and capability to bring private citizens to space as passengers, tourists, and — eventually — settlers, opening the door for businesses to start meeting the demand those people create over the next several decades with an array of space-for-space goods and services.

#### Space-for-space is key for continued space-for-earth developments like asteroid mining

Weinzierl and Sarang 21 (Matt, PhD in Economics Harvard University, Joseph and Jacqueline Elbling Professor of Business Administration at HBS and a Research Associate at the National Bureau of Economic Research, and Mehak, Research Associate at Harvard Business School and the Lunar Exploration Projects Lead for the MIT Space Exploration Initiative, Harvard Business Review, "The Commercial Space Age is Here," 2/12, <https://hbr.org/2021/02/the-commercial-space-age-is-here>)

To be sure, people have dreamt of using the vacuum and weightlessness of space to source or make things that cannot be made on earth for half a century, and time and again the business case has failed to pan out. Skepticism is natural. Those failures, however, have been in space-for-earth applications. For example, two startups of the 2010s, Planetary Resources, Inc. and Deep Space Industries, recognized the potential of space mining early o

n. For both companies, however, the lack of a space-for-space economy meant that their near-term survival depended on selling mined material — precious metals or rare elements — to earthbound customers. When it became clear that demand was insufficient to justify the high costs, funding dried up, and both companies pivoted to other ventures. These were failures of space-for-earth business models — but the demand for in-space mining of raw building material, metals, and water will be enormous once humans are living in space (and are therefore far cheaper to supply). In other words, when people are living and working in space, we are likely to look back on these early asteroid mining companies less as failures and more as simply ahead of their time.

#### Mining solves extinction from scarcity.

Pelton 17—(Director Emeritus of the Space and Advanced Communications Research Institute at George Washington University, PHD in IR from Georgetown).. Pelton, Joseph N. 2017. The New Gold Rush: The Riches of Space Beckon! Springer. Accessed 8/30/19.

Are We Humans Doomed to Extinction? What will we do when Earth’s resources are used up by humanity? The world is now hugely over populated, with billions and billions crammed into our overcrowded cities. By 2050, we may be 9 billion strong, and by 2100 well over 11 billion people on Planet Earth. Some at the United Nations say we might even be an amazing 12 billion crawling around this small globe. And over 80 % of us will be living in congested cities. These cities will be ever more vulnerable to terrorist attack, natural disaster, and other plights that come with overcrowding and a dearth of jobs that will be fueled by rapid automation and the rise of artifi cial intelligence across the global economy. We are already rapidly running out of water and minerals. Climate change is threatening our very existence. Political leaders and even the Pope have cautioned us against inaction. Perhaps the naysayers are right. All humanity is at tremendous risk. Is there no hope for the future? This book is about hope. We think that there is literally heavenly hope for humanity. But we are not talking here about divine intervention. We are envisioning a new space economy that recognizes that there is more water in the skies that all our oceans. Th ere is a new wealth of natural resources and clean energy in the reaches of outer space—more than most of us could ever dream possible. There are those that say why waste money on outer space when we have severe problems here at home? Going into space is not a waste of money. It is our future. It is our hope for new jobs and resources. The great challenge of our times is to reverse public thinking to see space not as a resource drain but as the doorway to opportunity. The new space frontier can literally open up a “gold rush in the skies.” In brief, we think there is new hope for humanity. We see a new a pathway to the future via new ventures in space. For too long, space programs have been seen as a money pit. In the process, we have overlooked the great abundance available to us in the skies above. It is important to recognize there is already the beginning of a new gold rush in space—a pathway to astral abundance. “New Space” is a term increasingly used to describe radical new commercial space initiatives—many of which have come from Silicon Valley and often with backing from the group of entrepreneurs known popularly as the “space billionaires.” New space is revolutionizing the space industry with lower cost space transportation and space systems that represent significant cost savings and new technological breakthroughs. “New Commercial Space” and the “New Space Economy” represent more than a new way of looking at outer space. These new pathways to the stars could prove vital to human survival. If one does not believe in spending money to probe the mysteries of the universe then perhaps we can try what might be called “calibrated greed” on for size. One only needs to go to a cubesat workshop, or to Silicon Valley or one of many conferences like the “Disrupt Space” event in Bremen, Germany, held in April 2016 to recognize that entrepreneurial New Space initiatives are changing everything [ 1 ]. In fact, the very nature and dimensions of what outer space activities are today have changed forever. It is no longer your grandfather’s concept of outer space that was once dominated by the big national space agencies. The entrepreneurs are taking over. The hopeful statements in this book and the hard economic and technical data that backs them up are more than a minority opinion. It is a topic of growing interest at the World Economic Forum, where business and political heavyweights meet in Davos, Switzerland, to discuss how to stimulate new patterns of global economic growth. It is even the growing view of a group that call themselves “space ethicists.” Here is how Christopher J. Newman, at the University of Sunderland in the United Kingdom has put it: Space ethicists have offered the view that space exploration is not only desirable; it is a duty that we, as a species, must undertake in order to secure the survival of humanity over the longer term. Expanding both the resource base and, eventually, the habitats available for humanity means that any expenditure on space exploration, far from being viewed as frivolous, can legitimately be rationalized as an ethical investment choice. (Newman) On the other hand there are space ethicists and space exobiologists who argue that humans have created ecological ruin on the planet—and now space debris is starting to pollute space. Th ese countervailing thoughts by the “no growth” camp of space ethicists say we have no right to colonize other planets or to mine the Moon and asteroids—or at least no right to do so until we can prove we can sustain life here on Earth for the longer term. However, for most who are planning for the new space economy the opinion of space philosophers doesn’t really fl oat their boat. Legislators, bankers, and aspiring space entrepreneurs are far more interested in the views of the super-rich capitalists called the space billionaires. A number of these billionaires and space executives have already put some very serious money into enterprises intent on creating a new pathway to the stars. No less than five billionaires with established space ventures—Elon Musk, Paul Allen, Jeff Bezos, Sir Richard Branson, and Robert Bigelow—have invested millions if not billions of dollars into commercializing space. They are developing new technologies and establishing space enterprises that can bring the wealth of outer space down to Earth. This is not a pipe dream, but will increasingly be the economic reality of the 2020s. These wealthy space entrepreneurs see major new economic opportunities. To them space represents the last great frontier for enterprising pioneers. Th us they see an ever-expanding space frontier that offers opportunities in low-cost space transportation, satellite solar power satellites to produce clean energy 24h a day, space mining, space manufacturing and production, and eventually space habitats and colonies as a trajectory to a better human future. Some even more visionary thinkers envision the possibility of terraforming Mars, or creating new structures in space to protect our planet from cosmic hazards and even raising Earth’s orbit to escape the rising heat levels of the Sun in millennia to come. Some, of course, will say this is sci-fi hogwash. It can’t be done. We say that this is what people would have said in 1900 about airplanes, rocket ships, cell phones and nuclear devices. The skeptics laughed at Columbus and his plan to sail across the oceans to discover new worlds. When Thomas Jefferson bought the Louisiana Purchase from France or Seward bought Alaska, there were plenty of naysayers that said such investment in the unknown was an extravagant waste of money. A healthy skepticism is useful and can play a role in economic and business success. Before one dismisses the idea of an impending major new space economy and a new gold rush, it might useful to see what has already transpired in space development in just the past five decades. The world’s first geosynchronous communications satellite had a throughput capability of about 500 kb / s. In contrast, today’s state of the art Viasat 2 —a half century later— has an impressive throughput of some 140 Gb/s. Th is means that the relative throughput is nearly 300,000 greater, while its lifetime is some ten times longer (Figs. 1.1 and 1.2 ). Each new generation of communications satellite has had more power, better antenna systems, improved pointing and stabilization, and an extended lifetime. And the capabilities represented by remote sensing satellites , meteorological satellites , and navigation and timing satellites have also expanded their capabilities and performance in an impressive manner. When satellite applications first started, the market was measured in millions of dollars. Today commercial satellite services exceed a quarter of a billion dollars. Vital services such as the Internet, aircraft traffi c control and management, international banking, search and rescue and much, much more depend on application satellites. Th ose that would doubt the importance of satellites to the global economy might wish to view on You Tube the video “If Th ere Were a Day Without Satellites?” [ 2 ]. Let’s check in on what some of those very rich and smart guys think about the new space economy and its potential. (We are sorry to say that so far there are no female space billionaires, but surely this, too, will come someday soon.) Of course this twenty-fi rst century breakthrough that we call the New Space economy will not come just from new space commerce. It will also come from the amazing new technologies here on Earth. Vital new terrestrial technologies will accompany this cosmic journey into tomorrow. Information technology, robotics, artificial intelligence and commercial space travel systems have now set us on a course to allow us humans to harvest the amazing riches in the skies—new natural resources, new energy, and even totally new ways of looking at the purpose of human existence. If we pursue this course steadfastly, it can be the beginning of a New Space renaissance. But if we don’t seek to realize our ultimate destiny in space, Homo sapiens can end up in the dustbin of history—just like literally millions of already failed species. In each and every one of the five mass extinction events that have occurred over the last 1.5 billion years on Earth, some 50–80 % of all species have gone the way of the T. Rex, the woolly mammoth, and the Dodo bird along with extinct ferns, grasses and cacti. On the other hand, the best days of the human race could be just beginning. If we are smart about how we go about discovering and using these riches in the skies and applying the best of our new technologies, it could be the start of a new beginning for humanity. Konstantin Tsiokovsky, the Russian astronautics pioneer, who fi rst conceived of practical designs for spaceships, famously said: “A planet is the cradle of mankind, but one cannot live in a cradle forever.” Well before Tsiokovsky another genius, Leonardo da Vinci, said, quite poetically: “Once you have tasted flight, you will forever walk the earth with your eyes turned skyward, for there you have been, and there you will always long to return.” The founder of the X-Prize and of Planetary Resources, Inc., Dr. Peter Diamandis, has much more brashly said much the same thing in quite diff erent words when he said: “The meek shall inherit the Earth. The rest of us will go to Mars.” The New Space Billionaires Peter Diamandis is not alone in his thinking. From the list of “visionaries” quoted earlier, Elon Musk, the founder of SpaceX; Sir Richard Branson, the founder of Virgin Galactic; and Paul Allen, the co-founder of Microsoft and the man who financed SpaceShipOne, the world’s first successful spaceplane have all said the future will include a vibrant new space economy. Th ey, and others, have said that we can, we should and we soon shall go into space and realize the bounty that it can offer to us. Th e New Space enterprise is today indeed being led by those so-called space billionaires , who have an exciting vision of the future. They and others in the commercial space economy believe that the exploitation of outer space may open up a new golden age of astral abundance. They see outer space as a new frontier that can be a great source of new materials, energy and various forms of new wealth that might even save us from excesses of the past. Th is gold rush in the skies represents a new beginning. We are not talking about expensive new space ventures funded by NASA or other space agencies in Europe, Japan, China or India. No, these eff orts which we and others call New Space are today being forged by imaginative and resourceful commercial entrepreneurs. Th ese twenty-fi rst century visionaries have the fortitude and zeal to look to the abundance above. New breakthroughs in technology and New Space enterprises may be able to create an “astral life raft” for humanity. Just as Columbus and the Vikings had the imaginative drive that led them to discover the riches of a new world, we now have a cadre of space billionaires that are now leading us into this New Space era of tomorrow. These bold leaders, such as Paul Allen and Sir Richard Branson, plus other space entrepreneurs including Jeff Bezos of Amazon and Blue Origin, and Robert Bigelow, Chairman of Budget Suites and Bigelow Aerospace, not only dream of their future in the space industry but also have billions of dollars in assets. These are the bright stars of an entirely new industry that are leading us into the age of New Space commerce. These space billionaires, each in their own way, are proponents of a new age of astral abundance. Each of them is launching new commercial space industries. They are literally transforming our vision of tomorrow. These new types of entrepreneurial aerospace companies—the New Space enterprises—give new hope and new promise of transforming our world as we know it today. The New Space Frontier What happens in space in the next few decades, plus corresponding new information technologies and advanced robotics, will change our world forever. These changes will redefi ne wealth, change our views of work and employment and upend almost everything we think we know about economics, wealth, jobs, and politics. Th ese changes are about truly disruptive technologies of the most fundamental kinds. If you thought the Internet, smart phones, and spandex were disruptive technologies, just hang on. You have not seen anything yet. In short, if you want to understand a transition more fundamental than the changes brought to the twentieth century world by computers, communications and the Internet, then read this book. There are truly riches in the skies. Near-Earth asteroids largely composed of platinum and rare earth metals have an incredible value. Helium-3 isotopes accessible in outer space could provide clean and abundant energy. There is far more water in outer space than is in our oceans. In the pages that follow we will explain the potential for a cosmic shift in our global economy, our ecology, and our commercial and legal systems. These can take place by the end of this century. And if these changes do not take place we will be in trouble. Our conventional petro-chemical energy systems will fail us economically and eventually blanket us with a hydrocarbon haze of smog that will threaten our health and our very survival. Our rare precious metals that we need for modern electronic appliances will skyrocket in price, and the struggle between “haves” and “have nots” will grow increasingly ugly. A lack of affordable and readily available water, natural resources, food, health care and medical supplies, plus systematic threats to urban security and systemic warfare are the alternatives to astral abundance. The choices between astral abundance and a downward spiral in global standards of living are stark. Within the next few decades these problems will be increasingly real. By then the world may almost be begging for new, out of- the-box thinking. International peace and security will be an indispensable prerequisite for exploitation of astral abundance, as will good government for all. No one nation can be rich and secure when everyone else is poor and insecure. In short, global space security and strategic space defense, mediated by global space agreements, are part of this new pathway to the future.

## Case

#### The private sector fuels space exploration— most of the global space industry is already commercialized and demands are set on an upward trend Urrutia ‘18

(Doris Elin Urrutia, October 12, 2018, Urrutia is a journalist for Inverse that bridge archaeological and paleontological discoveries with modern life. She also writes about astronomy and spaceflight for Space.com and on marine life for Scientific American, “How Will Private Space Travel Transform NASA's Next 60 Years?”, [https://www.space.com/42113-nasa-future-private-spaceflight.html //](https://www.stltoday.com/opinion/columnists/unions-ignore-long-history-of-excluding-minorities-from-jobs/article_ef58bccd-f04a-5172-8dbd-18b8ee5eb9e2.html%20/)NL)

First, people should understand that about **75 percent of the worldwide space enterprise is already commercial**, said Scott Hubbard, an adjunct professor in the Department of Aeronautics and Astronautics at Stanford University. This includes the satellites belonging to DirecTV and Sirius XM radio. “What's new is the extension of that into the human realm," said Hubbard, who also previously directed NASA's Ames Research Center in Silicon Valley. He served as the agency's "Mars czar," restructuring NASA's robotic Red Planet-exploration program after it suffered several failures in the 1990s. And if private companies can get the price of a suborbital flight down to about $50,000, "you get a lot of interest," Hubbard told Space.com. The highest-profile program currently in the works between NASA and the private sector is the agency's Commercial Crew Program, said Eric Stallmer, president of the nonprofit Commercial Spaceflight Federation. Commercial Crew is encouraging the development of U.S. spacecraft that will carry astronauts to and from the International Space Station (ISS). Toward this end, NASA has awarded multibillion-dollar contracts to both SpaceX and Boeing, which are building capsules called Crew Dragon and CST-100 Starliner, respectively. These craft are currently scheduled to start flying astronauts sometime next year. There's also the maturing commercial cargo program, which has given contracts to SpaceX and Northrop Grumman Corp. to fly robotic cargo missions to the ISS. Both of these companies have already completed numerous such flights. Both Hubbard and Stallmer said that **NASA wins by relying on private industry to provide such services in low Earth orbit.** Hubbard argued that this strategy allows the space agency to continue "exploring the fringe where there really is no business case." NASA has a budget about five times larger than the next biggest national space agency out there, but the U.S. agency's ambitious goals are still costly, said Stallmer. **To get the most bang** for the buck, "you'd have to **leverage the innovation and technology that is in the private sector and let NASA do the exquisite" projects.** The "exquisite" projects, Stallmer explained, are the "push-the-envelope-type things on deeper space exploration." "I see it not only as a cooperation or a collaboration, but maybe even interdependence," Hubbard said. "Without a thriving spaceflight entrepreneurship sector, I don't think that deep-space exploration with [regular] people is sustainable," he added. "And I think using the way in which the private sector has demonstrated they can reduce costs, through more nearly assembly-line production techniques, is really critical to sustainable space exploration in the future." Phil McAlister, director of commercial spaceflight at NASA, also advocated these public-private partnerships. Private companies offer the advantages of "being quick, being nimble, being fast, making a decision maybe without perfect knowledge — then moving forward and adjusting as required," McAlister told Space.com. NASA officials, he said, "have a lot of meetings … a lot of discussions, and things tend to take longer" than in private industry. **"The private sector wanting to move fast and wanting to be cost-effective** and NASA having our 50 years of human spaceflight experience … you bring those two things together**, and they actually complement each other very effectively," McAlister said.**

### Mining Adv

#### Asteroid mining enables space colonization – even if Earth species goes extinct, we can escape if we mine asteroids – turns their climate extinction scenarios

Ravisetti 21

Monisha Ravisetti (science writer @ CNET BA in philosophy NYU), 10-4-2021, "Rare asteroids near Earth may contain precious metals worth $11.65 trillion," CNET, https://www.cnet.com/news/rare-asteroids-near-earth-may-become-targets-for-space-mining/, // HW AW

Scientists just calculated that one of two metallic asteroids floating in Earth's vicinity may contain precious metals worth about $11.65 trillion. The expensive nugget, in fact, could boast more iron, nickel and cobalt than the entirety of our global metal reserves. Called metal-rich near-Earth asteroids, these rare, hefty mineral deposits measure over a mile wide. The one reckoned to be a metal motherlode is labeled 1986 DA, and the other, 2016 ED85. The duo "could be possible targets for asteroid mining in the future," according to the [new analysis published Friday](https://iopscience.iop.org/article/10.3847/PSJ/ac235f) in The Planetary Science Journal. Space mining has gained traction in the scientific community because experts believe the feat could provide [cost-effective metals](https://science.howstuffworks.com/asteroid-mining.htm) for a lunar or Mars-based colony, ultimately extending humanity's reach in exploring space. With a cosmic mine, building materials wouldn't have to withstand the expensive shuttle from Earth to space. Further, the team behind the math suggests these unique floating orbs may shed much-needed light on the authenticity of another metallic treasure NASA is [headed to in 2022](https://www.jpl.nasa.gov/missions/psyche) -- the mysterious shiny space globe known as 16 Psyche. 16 Psyche has its own allure for space mining enthusiasts. An artist's illustration shows what asteroid 16 Psyche might look like. Maxar/ASU/P.Rubin/NASA/JPL-Caltech Instead of trees, oceans or stretches of soil, the bizarre body is thought to consist of hills and valleys made of pure metal. Scientists contend it's the remaining core of an ancient rocky planet that was once destroyed. Interestingly, Earth's covered-up core looks awfully similar. Aptly dubbed "mini Psyches," the valuable smaller asteroids described in the new study are presumably pieces that have broken off from a similar naked center, though the research team notes they don't think these fragments are offshoots of 16 Psyche in particular. Still, 16 Psyche has become a rather hot topic of discussion among [scientists](https://earthsky.org/space/asteroid-psyche-metal-or-rubble-pile/) and even the [public](https://www.forbes.com/sites/jamiecartereurope/2020/12/05/a-bizarre-trillion-dollar-asteroid-worth-more-than-our-planet-is-now-aligned-with-the-earth-and-sun/?sh=689f08431c9a) -- it's suspected to hold minerals worth $10,000 quadrillion. Let that sink in. The exorbitant figure, however, has generated [considerable doubt](https://www.cnet.com/news/10000-quadrillion-asteroid-psyche-may-not-be-as-valuable-as-first-thought/) because scientists can't be sure what 16 Psyche is made of until a spacecraft inspects it. It's too far away for precise spectrum analysis, a scientific method that leverages electromagnetic emission and absorption signals to learn about objects' compositions. Until such an examination can happen, something NASA's mission intends to perform, researchers have to consider the option that it's merely some sort of rubble. That's what makes data from the "mini Psyches" indispensable -- they may offer a first look at their namesake's features. Proximity to our home planet deems it much easier for scientists to capture the rocks' spectral info from Earth. "It is rewarding that we have discovered these 'mini Psyches' so close to the Earth," Vishnu Reddy, associate professor at the University of Arizona's Lunar and Planetary Laboratory and principal investigator of the NASA grant that funded the work, said [in a statement](https://www.eurekalert.org/news-releases/930288). Sifting through the collected data, researchers found the orbiting blocks are made of 85% metal, such as iron and nickel, and only 15% silicate, which is basically regular rock. As such, some ambiguity about 16 Psyche might soon be alleviated thanks to the baby versions of it -- including whether it'll add to the crew of treasure troves for future space miners. Regardless, while the trio of metallic hunks definitely seem to hint at our sci-fi fantasies of space mining inching toward reality, one thing is absolutely certain: They're a pretty hard-core squad.

#### Asteroid mining is critical to future survival – it can fund more space exploration, eliminate resource scarcity, build space cities to house millions, and manufacture organs to save lives

Elvis 21 [Martin Elvis is a senior astrophysicist at the Center for Astrophysics | Harvard & Smithsonian. He is the author of Asteroids: How Love, Fear, and Greed Will Determine Our Future in Space (2021). “Riches in space.” Aeon. July 2, 2021. <https://aeon.co/essays/asteroid-mining-could-pay-for-space-exploration-and-adventure>] HW AL

Asteroids are the remnants of our solar system’s youthful exuberance, the leftover crumbs from when the planets formed. For much of the space age, asteroids were ignored in favour of the far more glamorous planets, and the Moon. The asteroids – dark, misshapen rocks, hard to see and hard to find – have long flown beneath our notice. But that was a mistake. They have a crucial role to play in the future of our species – in fact, the survival and flourishing of humanity are tied up with asteroids. There are three reasons. They bear messages from the beginnings of the solar system, before our Earth came into being, and how we got here matters to where we’re going. They are also hoards of resources that might lead us to a future without scarcity. And last – a minor detail – a single asteroid could wipe us off the face of our planet. Let’s look at each in turn. Asteroids are the remnants of collisions between some of the first mini-planets (called ‘planetesimals’) that formed in abundance when the solar system was no older than a few million years. As a result, many asteroids are just piles of broken rubble held together by their own weak gravity, about a million times more feeble than the gravity we feel here on Earth. Untangling the eventful history of the solar system is easier with asteroids because they’re unsullied envoys from those turbulent early times. Unlike the planets, nothing much has happened to the asteroids in the past few billion years. And there are millions of them, the vast majority orbiting the Sun between Mars and Jupiter in a band called the ‘Main Belt’. An animation depicts a mapping of the positions of known near-Earth objects at points in time over the past 20 years, and finishes with a map of all known asteroids as of January 2018. Courtesy of JPL/NASA Perhaps 10,000 asteroids the size of sports stadiums are on orbits that swing close to Earth. As the dinosaurs would attest, our planet occasionally gets hit. But the results aren’t always a bad thing: it’s looking likely that Earth’s oceans were filled by water brought by asteroids. Along with water, asteroids might even have brought the ingredients of life to Earth in the form of so-called ‘prebiotic’ molecules, including amino acids and, as recently found, components of proteins and sugars. Learning more about asteroids means learning more about our origins. What can we actually do with asteroids? That brings us to my favourite thing about them: their resources. Being an idealistic astrophysicist, my interest is in the money to be made from them. That really is idealistic because, if we can make a profit mining the asteroids, then doing bigger things in space will become a lot cheaper. Capitalism has its faults, but one thing it does well is to make things cheaper. I want to use it as a tool so that we can build far bigger telescopes than we could practically realise

today. What do astronomers want? More light! Bigger telescopes! Asteroid mining could make that dream a reality. The siren call of asteroids for miners is that the Main Belt asteroids contain vast amounts of resources. The iron found in asteroids adds up to some 10 million times the iron that we have in proven reserves on Earth. That’s a lot. It’s enough to build many rings of iron girders all the way around Earth’s orbit, along the lines of the science fiction novel Ringworld (1970) by Larry Niven. Not that a ringworld is a sensible thing to make, but it is a really big ring. More plausibly, with that much iron we could build cities in space, as envisaged by the physicist Gerard K O’Neill in the 1970s. Each of these cities would be big enough for a million people to live in. They would be rotating cylinders, and as a citizen of one you would be walking around inside the cylinder’s surface, feeling a fake gravity from the centrifugal force. That’s the scale of resources we’re talking about. These vast material supplies could make for an era that people call ‘post-scarcity’, where there’s plenty for everyone, just as there is in the 23rd century of the Star Trek science fiction franchise. The starship crew on Star Trek don’t work to keep themselves fed and housed, that’s taken for granted. They work for adventure and exploration. Asteroid wealth could help all of us take a step towards that happy state. The problem is how to get started. Iron in space is not going to make for giant profits in the short run. On the ground, it sells for less than $200 a ton. It would be worth more in space, but unfortunately there’s no one to buy huge tonnages of iron in space. To adapt the tagline from the Alien movies – ‘In space, no one can hear you sell.’ It certainly isn’t worth bringing space iron back to Earth since the cost of doing so would far exceed the price it could command. Starting to mine space for resources will have to begin with something so valuable that the cost of obtaining it in space is small by comparison. For now, the best bets are precious metals and – surprise – water. Precious metals are obvious. Platinum sells for about $33.5 million a ton, and we know from meteorites that some asteroids are richer in platinum than any mine on Earth. That sounds promising. Platinum sales run at about 200 tons, or billions of dollars, per year. The bad news is that ‘richer than any mine on Earth’ is still concentrations of just tens of grams per ton, and extracting those precious grams isn’t easy. We can’t just bring an asteroid near to Earth to start extracting the platinum where we can have heavy machinery to work on it. That would take way too much fuel because, to carry more mass, rockets have to carry exponentially more fuel; unlike airplanes, they don’t get the oxygen for free from their surroundings, they have to pull it along with them. Any refining of platinum will have to be done robotically out in the native orbit of the asteroid. That’s quite a challenge. Water is a less obvious money-maker. The surprise is that water is also worth millions per ton – if it’s sold in space. Water in space is really useful. It’s good for drinking, and the oxygen in it is good for breathing. You can split the hydrogen from the oxygen in H2O and you’ve got rocket fuel, and water is good at absorbing radiation to protect people from cancer-causing cosmic rays. So, in principle, water in orbit is pretty valuable. The good news is that up to 10 per cent of a water-rich asteroid can be water. It won’t be simple ice, most likely, but will be bound into clays and other rocks. Even better, water is much easier to extract than precious metals. Simply heating up the rock will release water that can then be captured. How much is space water worth? Until recently, it cost $20 million to get a ton of water into even a low orbit – say, to the International Space Station (ISS). To get a ton of water to a high orbit, like the 24-hour orbit of TV transmitting satellites, would cost about three times as much. SpaceX has started to cut that cost; for now, it’s charging about $3 million a ton to a low orbit on a Falcon 9 rocket. Water from asteroids might be able to compete with those prices and still return a nice profit. But the bad news is that, right now, there’s no one in space who wants to buy water. At least not yet. That might be about to change. We won’t get to build cities in space unless we can build simpler space stations first, and do so at an affordable cost that can scale. If we have space stations, they will need supplies, especially of water and perhaps construction materials. That demand could create a business delivering these supplies from space instead of from Earth. In this case, the asteroids would have the most to offer. So space stations – particularly commercial space stations – are the key to acquiring asteroid resources. Why build space stations? There are three primary uses: research, manufacturing and tourism. Research has always been done on the ISS, but facilities and time have been in short supply. In recent years, the equipment has improved a lot, but astronaut time is still scarce. Each astronaut has to look after multiple experiments. Multitalented and smart as the astronauts all are, they simply can’t have all the experience of the scientists whose experiments they’re operating. A lot of effort goes into automating those experiments so that the astronauts aren’t overwhelmed. It would be far more efficient if the scientists who invent the experiments also get to be the ones who carry them out in space. Then their years of experience could be put to good use operating and watching over their studies. Spotting subtle anomalies that could be a sign of a failure, or of a discovery, is much better done in person by experts. But, until now, scientists didn’t have that opportunity, and they would have likely declined it if offered the chance. That’s because training for a mission to the ISS takes more than two years full-time and requires learning Russian. If you take two years off from doing your research, then you’re no longer at the forefront and you’ll have lost your edge. Few top scientists would risk that, however much fun it might be to float in space. We scientists live for our research. Fortunately, the new commercial stations will be much easier to train for, taking a couple of months or so, because they’ll have a single manufacturer with consistent, uniform interfaces, and a separate professional crew to deal with maintenance and emergencies. The companies with advanced plans so far are all US-based, so English will be the language used. As English is the lingua franca of science, it poses little challenge to scientists worldwide. Manufacturing in space has always seemed like a fool’s errand. Whatever you make out there would have to be worth outrageous amounts to cover the shipping costs back to Earth. Now, though, those costs have come down almost 10-fold, with more reductions promised. As a result, a few items do pass that test. Already, there are first tests taking place on the ISS to see if the advantages of manufacturing in almost zero gravity (‘micro-gravity’) are really as great as some have suggested. The most popular idea is to make super-powerful optical fibres that could carry far more data traffic than current transoceanic fibres can. They could potentially do so more cheaply because they would be simpler: they wouldn’t need repeater stations. Certainly, the demand is there, since there’s no limit to the number of cat videos we must share. These ‘ZBLAN’ optical fibres showed dramatic improvements when small amounts were made during brief, half-minute long intervals of weightlessness on a parabolic flight. There are a few companies already trying to make ZBLAN fibres on the ISS. The results must be promising because they went back after their first attempt. A kilogram of fancy optical fibres already sells for about $1 million to $20 million. That will pay for the postage and still give you change! Another idea is to 3D-print human organs in space. Why? Printing ears on Earth has been done, using a scaffolding that later dissolves away. But some organs are trickier, and scaffolds don’t always work. Without that support, the layers of cells tend to slip and slide out of position, which is not the desired effect for something meant to keep you alive. In micro-gravity, the slipping and sliding should be much smaller. The goal is eventually to be able to print a human heart. A heart weighs less than a kilogram. Even with packaging to keep it healthy, **the transport cost of bringing a new heart down to Earth is going to be far less than it’s worth to the recipient.** Again, first experiments toward this goal are underway on the ISS.

#### Only asteroid mining can provide us with the research and understanding to prevent extinction

Elvis 21 [Martin Elvis is a senior astrophysicist at the Center for Astrophysics | Harvard & Smithsonian. He is the author of Asteroids: How Love, Fear, and Greed Will Determine Our Future in Space (2021). “Riches in space.” Aeon. July 2, 2021. <https://aeon.co/essays/asteroid-mining-could-pay-for-space-exploration-and-adventure>] HW AL

If knowledge or greed isn’t motivation enough to set your sights on the asteroids, then the one thing virtually all people agree on is that having humanity wiped off the face of Earth would be bad, at least for us. Of all the multiple threats to humanity’s existence, the only one that we can definitely eliminate is that of a large asteroid slamming into our home planet and killing us off, together with most other species, following the lead of the dinosaurs who were made extinct by an asteroid slamming into the ocean. There’s a T-shirt popular among space cadets that has the slogan ‘Asteroids are nature’s way of saying “How’s that space programme coming along?”’ If we can find all the killer asteroids, then we can divert them to render them harmless. Best to play it safe. There are several searches underway for undiscovered, potentially dangerous asteroids. Thanks to the first big survey, Spaceguard, 90 per cent of the dinosaur-killer-sized asteroids out there have already been found. None of them pose any danger for the next century at least. That still leaves an uneasily large number of about 100 extinction-event-sized rocks out there that we haven’t found yet. Smaller, city-killer asteroids are much less well-surveyed for. To remedy this concern, two new surveys will begin in the next few years, and they will both be more or less done by 2030. They are the Vera C Rubin Observatory ‘Legacy Survey of Space and Time’, which will start scanning the whole sky every few nights from 2023 onwards. Its mission has been complicated by the mushrooming constellations of thousands of internet satellites now being launched by several companies, with SpaceX being the most visible. Hopefully a solution will be found. The Vera C Rubin Observatory, on a mountain in Chile, will record its image using normal visible light. For asteroids, that light is reflected sunlight. But many asteroids are pitch black, reflecting only a few percent of the sunlight pouring on to their surfaces. How do you find those dark asteroids? The answer is to use the long wavelength – infrared – light they emit because they’re warm: their ‘black body radiation’. NASA is building a special mission just for this purpose. Developed by a team lead by Amy Mainzer, now of the University of Arizona, Tucson, it’s called the Near-Earth Object Surveillance Mission. Starting around 2025, it will scan the sky repeatedly for five years looking for moving objects that are bright in infrared light, and has wavelengths some 10 to 20 times longer than we can see with our eyes. The team’s tagline is ‘Finding Asteroids Before They Find Us.’ Good idea! This will be the first time that humanity has deliberately changed the orbit of any celestial body An advantage of using the black body radiation is that it also tells us quite accurately how big each asteroid is. That helps in assessing their threat, as well giving us a first guess at how much they might yield in resources. Combining the two surveys will indicate how much sunlight each asteroid reflects – its ‘albedo’ – and that’s a clue to what they’re made of. We want to know that because a metal asteroid of a given size is more dangerous than one made of rock, and is more difficult to push out of the way. The composition also helps us explore all two dozen types of asteroid out there, the better to decipher the history of our solar system. As a side product, the surveys will pin down their potential value. By 2030, we’ll have better rockets than we have today. Several are set to fly within five years. They’ll let us reach many more asteroids with more massive payloads to deflect them, study them or mine them. Also by 2030, several more asteroids will have been visited by our exploration spacecraft. JAXA, the Japanese space agency, and NASA each had recent missions to return samples from carbonaceous asteroids. The Japanese Hayabusa2 went to the spinning-top-shaped asteroid named Ryugu, and NASA’s OSIRIS-REx went to the asteroid called Bennu. Such carbonaceous asteroids are the least changed, we believe, from the time of their formation at the beginning of the solar system’s formation. They are called carbonaceous because they are chockfull of organic (carbon-containing) molecules; many of them also contain quite a lot of water. There are more missions planned to more distant asteroids such as Psyche, a metal asteroid in the Main Belt, and to the Trojan asteroids trailing Jupiter’s orbit. OSIRIS-REx samples and leaves asteroid Bennu. Courtesy of NASA **Every time we visit an asteroid, it surprises us.** Bennu was found to be throwing rocks off its surface as it spun around its axis, and when OSIRIS-REx put down its outstretched arm to grab a sample off the surface, the arm sank half a metre into the asteroid; it stopped going deeper only when the retrorockets fired to stop it. That’s really not how rubble behaves on Earth! The more we know about asteroids, the more confident we can be that we can deflect their path away from Earth. A NASA mission called DART will make a high-speed impact on the small moon of the asteroid Didymos in late 2022 to see if we can slow down a dangerous asteroid to stop it causing devastation on Earth. (Don’t worry: the target was chosen to be a safe one for us.) This will be the first time that humanity has deliberately changed the orbit of any celestial body. It isn’t likely to be the last. Once all the good-sized accessible asteroids have been found, their orbits mapped, their sizes known, and at least a good clue found as to what they’re made of, the barriers to mining them will be much lower. **After visiting a half dozen asteroids up close, we’ll have learned a great deal about their origins, how to deflect them should one be headed our way, and how to handle them.** That will put us in a good place to begin to extract their resources. I predict this will happen right around 2030, when demand for in-space materials should be picking up. **The stars seem to be aligning for mining the asteroids. Mining will expand our capabilities in space, especially making it easier to deflect a dangerous asteroid.** In a virtuous cycle, those new capabilities will lead us on to greater exploration of the many worlds in our solar system and, with bigger, better telescopes, to the Universe beyond. It should be fun.

#### Asteroid mining solves water conflict and Kessler syndrome

Tillman 19

Nola Taylor Tillman (contributing writer for space.com, loves astronomy and space, and this article cites an asteroid researcher at Johns Hopkins, it is not Nola’s own analysis), 9-29-2019, "Tons of Water in Asteroids Could Fuel Satellites, Space Exploration," Space, https://www.space.com/water-rich-asteroids-space-exploration-fuel.html, // HW AW

When it comes to mining space for water, the best target may not be the moon: Entrepreneurs' richest options are likely to be [asteroids](https://www.space.com/51-asteroids-formation-discovery-and-exploration.html) that are larger and closer to Earth. A recent study suggested that roughly 1,000 water-rich, or hydrated, asteroids near our planet are easier to reach than the lunar surface is. While most of these space rocks are only a few feet in size, more than 25 of them should be large enough to each provide significant water. Altogether, the [water locked in these asteroids](https://www.space.com/how-much-water-in-asteroids.html) should be enough to fill somewhere around 320,000 Olympics-size swimming pools — significantly more than the amount of water locked up at the lunar poles, the new research suggested. Because asteroids are small, they have less gravity than Earth or the moon do, which makes them easier destinations to land on and lift off from. If engineers can figure out how to mine water from these space rocks, they could produce a source of ready fuel in space that would allow spacecraft designers to build [refuelable models](https://www.space.com/orbit-fab-demonstrates-satellite-refueling-technology-on-iss.html) for the next generation of satellites. Asteroid mining could also fuel human exploration, saving the expense of launching fuel from Earth. In both cases, would-be space-rock miners will need to figure out how to free the water trapped in hydrated minerals on these asteroids. "Most of the hydrated material in the near-Earth population is contained in the largest few hydrated objects," Andrew Rivkin, an asteroid researcher at Johns Hopkins University Applied Physics Research Laboratory in Maryland, told Space.com. Rivkin is the lead author on the paper, which estimated that near Earth asteroids could contain more easily accessible water than the lunar poles. Related: [NASA Wants a New Space Telescope to Protect Us All from Dangerous Asteroids](https://www.space.com/nasa-to-build-near-earth-asteroid-hunter-telescope.html) "A sure thing" According to the United Nations Office for Outer Space Affairs, more than 5,200 of the objects launched into space are still in orbit today. While some continue to function, the bulk of them buzz uselessly over our heads every day. **They carry fuel on board, and when they run out, they are either lowered into destructive orbits or left to become** [**space junk**](https://www.space.com/16518-space-junk.html)**, useless debris with the potential to cause enormous problems for working satellites.** [**Refueling satellites in space**](https://www.space.com/8339-wet-asteroid-space-gas-station.html) **could change that model, replacing it with long-lived, productive orbiters.** "It's easier to bring fuel from asteroids to geosynchronous orbit than from the surface of the Earth," Rivkin said. "If such a supply line could be established, it could make [asteroid mining](https://www.space.com/39363-planetary-resources-asteroid-mining-satellite-launches.html) very profitable." Hunting for space water from the surface of the Earth is challenging because the planet's atmosphere blocks the wavelength of light where water can be observed. The asteroid warming as it draws closer to the sun can also complicate measurements. Instead, Rivkin and his colleagues turned to a class of space rocks called Ch asteroids. Although these asteroids don't directly exhibit a watery fingerprint, they carry the telltale signal of oxidized iron seen only on [asteroids](https://www.space.com/51-asteroids-formation-discovery-and-exploration.html) with signatures of water-rich minerals, which means the authors felt confident assuming that all Ch asteroids carry this rocky water. Based on meteorite falls, a previous study estimated that Ch asteroids could make up nearly 10% of the [near-Earth objects](https://www.space.com/nasa-to-build-near-earth-asteroid-hunter-telescope.html) (NEOs). With this information, the researchers determined that there are between 26 and 80 such objects that are hydrated and larger than 0.62 miles (1 km) across. Right now, only three NEOs have been classified as Ch asteroids, although others have been spotted in the asteroid belt. Most NEOs are discovered and observed at wavelengths too short to reveal the iron band that marks the class. Carbon-rich asteroids, which include Ch asteroids and other flavors, are also darker than the more common stony asteroids, making them more challenging to observe. Although Ch asteroids definitely contain water-rich minerals, that doesn’t necessarily mean that they will always be the best bet for space mining. It comes down to risk. Would an [asteroid-mining](https://www.space.com/moon-asteroid-space-mining-with-concentrated-sunlight.html) company rather visit a smaller asteroid that definitely has a moderate amount of water, or a larger one that could yield a larger payday but could also come up dry? "Whether getting sure things with no false positives, like the Ch asteroids, is more important or if a greater range of possibilities is acceptable with the understanding that some asteroids will be duds is something the miners will have to decide," Rivkin said. Not too big, not too small In addition to estimating the number of large, water-rich asteroids might be available, the study also found that as many as 1,050 smaller objects, roughly 300 feet (100 meters) across, may also linger near Earth. Their small bulk will make them [easier to mine](https://www.space.com/30213-asteroid-mining-planetary-resources-2025.html) because their low gravity will require less fuel to escape from, but they will produce less water overall, and Rivkin expects that the handful of larger space rocks will be the first targets. "It seems likely that the plan for these companies will be to find the largest accessible asteroid with mineable material with the expectation that it will be more cost-effective than chasing down a large number of smaller objects," Rivkin said. "How 'accessible' and 'mineable material' and 'cost-effective' are defined by each company is to be seen." But asteroids will certainly be more accessible than the moon, another [potential source](https://www.space.com/41164-mining-moon-water-plans-take-shape.html) of space-based water-rich minerals. According to Rivkin, landing safely on the lunar surface takes more than a hundred times the change of velocity required to land on an asteroid. Similarly, taking off from the moon means breaking free from its gravity, requiring even more fuel. "Even asteroids that are a bit farther from the Earth than the moon can be reached with less fuel than the lunar surface," Rivkin said.

#### Global water war is inevitable in the squo – extraction, climate change, drought – best analysis

Milne 21

Sandy Milne (austrailian journalist, has written a whole lot of articles about austrialian military), 16 aug 21, "How water shortages are brewing wars," BBC, https://www.bbc.com/future/article/20210816-how-water-shortages-are-brewing-wars, // HW AW

**Unprecedented levels of dam building and water extraction by nations on great rivers are leaving countries further downstream increasingly thirsty, increasing the risk of conflicts**. Speaking to me via Zoom from his flat in Amsterdam, Ali al-Sadr pauses to take a sip from a clear glass of water. The irony dawning on him, he lets out a laugh. "Before I left Iraq, I struggled every day to find clean drinking water." Three years earlier, al-Sadr had joined protests in the streets of his native Basra, demanding the authorities address the city's growing water crisis. "Before the war, Basra was a beautiful place," adds the 29-year-old. "They used to call us the Venice of the East." Bordered on one side by the Shatt al-Arab River, the city is skewered by a network of freshwater canals. al-Sadr, a dockhand, once loved working alongside them. "But by the time I left, they were pumping raw sewage into the waterways. We couldn't wash, the smell [of the river] gave me migraines and, when I finally fell sick, I spent four days in bed." In the summer of 2018, tainted water sent [120,000 Basrans to the city's hospitals](https://news.yahoo.com/more-basra-water-crises-unless-iraq-govt-fixes-090656526.html) – and, when police opened fire on those who protested, al Sadr was lucky to escape with his life. "Within a month I packed my bags and left for Europe," he says. Around the world, stories like al Sadr's are becoming far too common. As much as a quarter of the world's population now [faces severe water scarcity](https://news.trust.org/item/20200902202142-ku0o2) at least one month out of the year and – as in al-Sadr's case – it is leading many to seek a more secure life in other countries. "If there is no water, people will start to move," says Kitty van der Heijden, chief of international cooperation at the Netherlands' foreign ministry and an expert in hydropolitics. **Water scarcity affects roughly 40% of the world's population and, according to predictions by the United Nations and the World Bank, drought could put up to** [**700 million people at risk of displacement**](https://www.unccd.int/actions/drought-initiative) **by 2030**. People like van der Heijden are concerned about what that could lead to. "If there is no water, politicians are going to try and get their hands on it and they might start to fight over it," she says. Over the course of the 20th Century, global water use grew at more than twice the rate of population increase. Today, **this dissonance is leading many cities – from** [**Rome**](https://www.bbc.com/news/world-europe-41081066) **to** [**Cape Town**](https://www.wri.org/insights/3-things-cities-can-learn-cape-towns-impending-day-zero-water-shut)**,** [**Chennai**](https://www.npr.org/sections/goatsandsoda/2019/06/25/734534821/no-drips-no-drops-a-city-of-10-million-is-running-out-of-water?t=1626365858497) **to** [**Lima**](http://news.bbc.co.uk/1/hi/world/americas/3697647.stm) **– to ration water. Water crises have been ranked in the top five of the World Economic Forum's** [**Global Risks by Impact**](http://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2021.pdf) **list nearly every year since 2012**. In 2017, severe droughts contributed to the [worst humanitarian crisis since World War Two](https://www.un.org/press/en/2017/sc12748.doc.htm), when 20 million people across Africa and the Middle East were forced to leave their homes due to the accompanying food shortages and conflicts that erupted. Peter Gleick, head of the Oakland-based Pacific Institute, has spent the last three decades studying the link between water scarcity, conflict and migration and believes that water conflict is on the rise. "With very rare exceptions, no one dies of literal thirst," he says. "But more and more people are dying from contaminated water or conflicts over access to water." Falling water quality around Basra, southern Iraq, has been exacerbated by reduced river flows due to damming in Turkey (Credit: Haidar Mohammed Ali/AFP/Getty Images) Gleick and his team are behind the [Water Conflict Chronology](http://www.worldwater.org/conflict/map/): a log of 925 water conflicts, large and small, stretching back to the days of the Babylonian king Hammurabi. It is not, by any means, exhaustive and the conflicts listed vary from full blown wars to disputes between neighbours. But what they reveal is that the relationship between water and conflict is a complex one. "We categorised water conflicts in three groups," says Gleick. "As a 'trigger' of conflict, where violence is associated with disputes over access and control of water; as a 'weapon' of conflict, where water or water systems are used as weapons in conflicts, including for the use of dams to withhold water or flood downstream communities; and as 'casualties' or 'targets' of conflicts, where water resources or treatment plants or pipelines are targeted during conflicts." Leaf through the records he and his colleagues have compiled, however, and it becomes clear that the bulk of the conflicts are agriculture-related. It's perhaps not surprising as agriculture [accounts for 70%](https://www.worldbank.org/en/topic/water-in-agriculture#:~:text=Currently%2C%20agriculture%20accounts%20(on%20average,to%20the%20evapotranspiration%20of%20crops).) of freshwater use. In the semi-arid Sahel region of Africa, for example, there are regular reports of herdsmen and crop farmers clashing violently over scarce supplies of water needed for their animals and crops. But as demand for water grows, so too does the scale of the potential conflicts. You might also like: [The city running out of water](https://www.bbc.com/future/article/20181011-how-to-solve-delhis-water-crisis) [How long can you survive without water?](https://www.bbc.com/future/article/20201016-why-we-cant-survive-without-water) [The megacity digging a million wells](https://www.bbc.com/future/article/20201006-india-why-bangalore-is-digging-a-million-wells) "The latest research on the subject does indeed [show water-related violence increasing over time](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3076402/)," says Charles Iceland, global director for water at the World Resources Institute. "Population growth and economic development are driving increasing water demand worldwide. Meanwhile, climate change is decreasing water supply and/or making rainfall increasingly erratic in many places." Nowhere is the dual effect of water stress and climate change more evident than the wider Tigris-Euphrates Basin – comprising Turkey, Syria, Iraq and western Iran. According to satellite imagery, the region is [losing groundwater faster than almost anywhere else in the world](https://www.stimson.org/2021/joint-working-group-on-international-and-eu-water-diplomacy-in-focus-the-euphrates-tigris-river-basin/). And as some countries make desperate attempts to secure their water supplies, their actions are affecting their neighbours. India's Northern Plains are one of the most fertile farming areas in the world, yet today, villagers regularly clash over water scarcity During June 2019, as Iraqi cities sweltered through a [50C (122F) heatwave](https://www.independent.co.uk/climate-change/news/climate-change-apartheid-poor-iraq-effects-heatwave-a9049206.html), Turkey said it would [begin filling its Ilisu dam](https://www.reuters.com/article/us-turkey-dam-idUSKCN1US194) at the origins of the Tigris. It is the latest in a long-running project by Turkey to build 22 dams and power plants along the Tigris and the Euphrates that, according to a report by the French International Office for Water, is significantly [affecting the flow of water into Syria, Iraq and Iran](https://www.oieau.org/eaudoc/system/files/documents/40/204634/204634_doc.pdf). It claims that when complete Turkey's Guneydogu Anadolu Projesi (GAP) could include as many as [90 dams and 60 power plants](https://www.oieau.org/eaudoc/system/files/documents/40/204634/204634_doc.pdf). (See [how dams such as the Ilisu are reshaping our planet](https://www.bbc.com/future/article/20201021-how-dams-have-reshaped-our-planet).) As water levels behind the mile-wide Ilisu dam rose, [the flow from the river into Iraq halved](https://www.independent.co.uk/news/world/middle-east/iraq-water-rivers-shortage-drought-baghdad-war-isis-a8426766.html). Thousands of kilometres away in Basra, al-Sadr and his neighbours saw the [quality of their water deteriorate](https://www.hrw.org/report/2019/07/22/basra-thirsty/iraqs-failure-manage-water-crisis). In August, hundreds of people began pouring into Basra's hospitals suffering from rashes, abdominal pain, vomiting, diarrhoea, and even cholera, [according to Human Rights Watch](https://www.hrw.org/report/2019/07/22/basra-thirsty/iraqs-failure-manage-water-crisis). "There's actually two parts to the story in Basra," Iceland says. "Firstly, you have the obvious discharge of wastewater into local waterways without any treatment. But you've also got to consider the damming at the Turkish border – with less freshwater flowing down the Tigris and Euphrates, saltwater is intruding further up the river (from the Persian Gulf). Over time, it's ruining crops and it's making people sick." It's a complicated picture, but this ability to see links between the seemingly disparate has informed Iceland's work with the Dutch government-funded Water, Peace and Security (WPS) partnership, a group of six American and European NGOs (including the Pacific Institute and the World Resources Institute). They've developed a [Global Early Warning Tool](https://waterpeacesecurity.org/map), which uses machine learning to predict conflicts before they happen. It combines data about rainfall, crop failures, population density, wealth, agricultural production, levels of corruption, droughts, and flooding, among many other sources of data to produce conflict warnings. They are displayed on a red-and-orange Mercator projection down to the level of administrative districts. Currently it is warning of around 2,000 potential conflict hotspots, with an accuracy rate of 86%. (Read more about [how AI can help to identify conflicts before they happen](https://www.bbc.com/future/article/20190219-how-artificial-intelligence-could-unlock-world-peace).) The Indus River is a vital water source for northern India and Pakistan, but originates in the mountains of Tibet that are controlled by China (Credit: Nadeem Khawar/Getty Images) But while the WPS Tool can be used to identify locations where conflicts over water are at risk of breaking out, it can also help to inform those hoping to understand what is happening in areas that are already experiencing strife due to water scarcity. India's Northern Plains, for example, are one of the most fertile farming areas in the world, yet today, [villagers regularly clash over water scarcity](https://www.thekashmirmonitor.net/2-haryana-villages-clash-over-water-8-bikes-set-on-fire-12-injured/). The underlying data reveals that population growth and high levels of irrigation have outstripped available groundwater supplies. Despite the area's lush-looking cropland, the WPS map ranks nearly every district in Northern India as "extremely high" in terms of baseline water stress. Several key rivers which feed the area – the Indus, Ganges and Sutlej – all originate on the Tibetan side of the border yet are vital for water supplies in both India and Pakistan. compounds the problem. Several border skirmishes have broken out recently between India and China, which lays claim to upstream areas. A violent clash in May last year in the Galwan Valley, through which a tributary to the Indus flows, left 20 Indian soldiers dead. Less than a month later there were reports that China was building "structures" that might dam the river and so restrict its flow into India. But the data captured by the Global Early Warning tool also reveals some strange trends. In some of the most water-stressed parts of the world, there appears to be a net-migration of people into these areas. Oman, for example, suffers higher levels of drought than Iraq but received hundreds of thousands of migrants per year prior to the pandemic. That's because Oman fares far better than the latter in terms of corruption, water infrastructure, ethnic fractionalisation, and hydropolitical tension. "A community's vulnerability to drought is more important than the drought itself," says Lina Eklund, of a physical geography researcher at Sweden's Lund University

#### History agrees

Kolmannskog 8(Vikram Odedra, April, Norweigan Refugee Council, “Future floods of refugees: A comment on climate change, conflict and forced migration”, http://www.nrc.no/arch/\_img/9268480.pdf, Accessed 6/28/08)

**Water scarcity may trigger distributional conflicts**. Water scarcity by itself does not necessarily lead to conflict and violence, though. There is an interaction with other socio-economic and political factors: The potential for conflict often relates to social discrimination in terms of access to safe and clean water. The risk can therefore be reduced by ensuring just distribution so that people in disadvantaged areas also have access to the safe and clean water. As already pointed out, **a main problem today (and probably for the near future) is still the so-called economic water scarcity, and good water management can prevent conflict. Within states, groups have often defended or challenged traditional rights of water use: In semi-arid regions such as the Sahel there have been tensions between farmers and nomadic herders**. According to *The Stern Review on The Economics of Climate Change*,41 **the droughts in the Sahel in the 1970s and 1980s may have been caused partly by climate change and contributed to increased competition for scarce resources between these groups. The Tuareg rebellion in Mali in the beginning of the 1990s, is also mentioned as an example of a climate change-related conflict. Many of the drought-struck nomads sought refuge in the cities or left the country. The lack of social networks for the returnees, the continuing drought, competition for land with the settled farmers and dissatisfaction with the authorities, were factors that fuelled the armed rebellion. In the past there have been few examples of “water wars” between states**. In fact there are several cases of cooperation (for example between Palestine and Israel), but these have generally concerned benefit-sharing, not burden-sharing. According to Fred Pearce, the defining crises of the 21st century will involve water.42 He sees the Six Day War in 1967 between Israel and its neighbours as the first modern “water war”, specifically over the River Jordan. **Most of the world’s major rivers cross international boundaries, but are not covered by treaties. According to Pearce, this is a recipe for conflict and for upstream users to hold downstream users to ransom**. This could be helped by internationally brokered deals for sharing such rivers.

### Kessler

#### The probability of collisions is low, leaving us with a large window of opportunity to intercept these events

#### Colin Stuart 7/9/21

{Colin Stuart, astronomy author & speaker, journalist for The Guardian, New Scientist, Wall Street Journal & European Space Agency, “Space Junk: Is it a disaster waiting to happen?”, <https://www.sciencefocus.com/news/space-junk-is-it-a-disaster-waiting-to-happen/>}

A UN report from 2013 projected that catastrophic **collisions** may **occur once every five to nine years** over the next two centuries.

It’s already happening. In 2009 an Iridium communications satellite collided with the derelict Russian Kosmos 2251 satellite destroying both spacecraft. That event happened at about the same altitude as one of the biggest dangers: the eight-tonne Earth observation satellite Envisat. **It will remain in orbit for the next 150 years and there’s a 15 to 30 per cent chance that it will collide with another piece of space junk in that time.**

**Kessler syndrome doesn’**t necessarily have to **play out quickly**. These **impacts** could be the first domino, with crashes **ramp**ing **up** significantly **over time.**