# Resolved: The appropriation of outer space by private entities is unjust

## Framework

### My value is morality for two reasons

1. The resolution’s use of the word “unjust” implies a moral question.
2. Morality allows us to perceive what is inherently good or bad. It’s the value upon which we can conceptualize all other values, thus it must be prioritized.

### My criterion is environmental justice

#### Environmental justice means ensuring the planet remains livable

Bolte et al. 11, [Bavarian Health and Food Safety Authority, Oberschleissheim, Germany,] 3-3-2011, "Environmental Justice: Social Disparities in Environmental Exposures and Health: Overview," Elsevier B.V., <https://www.sciencedirect.com/science/article/pii/B9780444522726006851> PM

Introduction There is growing evidence that the gap in environmental resources and health has recently been widening not only between north and south, but also within industrialized countries (e.g., USA and Europe). The great number of multidisciplinary studies in this field is just beginning to make it clear that health disparities are inextricably linked with inequalities in the social, physical, and manmade environmental conditions across economic strata. To reach a better understanding of ethnic and socioeconomic inequalities in health and well-being, one must examine the conceptual and practical aspects of environmental justice as a dimension of the social causes of environmental inequality. Environmental injustice becomes evident from the disproportionate exposure to environmental hazards that affect mainly economically disadvantaged populations and communities of ethnic minorities with low capability for adjustment, rendering them more vulnerable. Early efforts to address various forms of structurally embedded environmental racism and social injustice were started in the USA during the 1980s by environmental organizations, social movements, and primarily locally based (grassroots) groups. The community of environmental justice activists has grown quickly over the past three decades in several countries, popularizing its concept and goals. The movement has attracted increasing public awareness, supported by substantial research, and to some extent political acceptance. In addition, methodological considerations mainly in the area of epidemiology were one recent cause for the growing interest in social disparities in environmental exposures and health. Definition and Main Features of Environmental Justice Environmental justice, environmental equity, and environmental racism are different phrases that describe and explain central features of the environmental justice movement, focusing on the disparate impact of hazardous waste sites and other polluting facilities located in or near distressed neighborhoods with high concentrations of ethnic minorities and economically disadvantaged populations. Because the concepts and contexts associated with each of these labels are complex and multidimensional, the meaning of environmental justice and injustice has changed over time and can differ considerably. Following the core definition from the Environmental Protection Agency (EPA), environmental justice seeks the equitable treatment and involvement of people of all races, cultures, incomes, and educational levels in the development, implementation, and enforcement of environmental programs, laws, rules, and policies. Therefore, the concept of environmental justice as a term with a more political connotation implies justice on a distributive, procedural, and precautionary level. Distributive justice requires an equitable distribution of the costs of environmental risks and of the benefits of environmental values across the demographic and geographic scales. Considerable emphasis is placed on procedural justice defined as the extent to which political decisionmaking processes are applied fairly and people are empowered to control and influence the decisions that affect them (e.g., higher fines for dumping waste in white versus minority communities). The precautionary principle is based on the attitude that uncertainties in short- or longterm environmental impacts resulting from deteriorating conditions in the everyday environment where people live and work call for decision-making to keep public health from harm. 459 With recent distributional challenges of globalization, urbanization, and environmental degradation (e.g., ozone depletion, water security, declining biodiversity, and deforestation) as well as climate change, the environmental justice concept has moved toward a broader understanding, now including generational and international environmental justice. Generational environmental justice refers to the concept of sustainability (including global ecological integrity and global environmental justice) and the responsibility of current generations to ensure a healthy and safe environment for future generations. (‘‘We’re only borrowing the world from our children.’’) It implies avoiding environmental degradation, which brings injustice on future generations for the sake of short-term economic gains in the present. As more environmental resources become ever scarcer, the increasing burden in hazardous environmental conditions imposed by more affluent countries on developing countries touches on an important issue of international environmental justice. Therefore, the concept of environmental justice has been taken up by many countries.

## Contention 1 is Tourism

#### Outer Space as a private sector is growing significantly right now

Weinzierl 21, 2-12-2021, "The Commercial Space Age Is Here," Harvard Business Review, <https://hbr.org/2021/02/the-commercial-space-age-is-here> PM

There’s no shortage of hype surrounding the commercial space industry. But while tech leaders promise us moon bases and settlements on Mars, the space economy has thus far remained distinctly local — at least in a cosmic sense. Last year, however, we crossed an important threshold: For the first time in human history, humans accessed space via a vehicle built and owned not by any government, but by a private corporation with its sights set on affordable space settlement. It was the first significant step towards building an economy both in space and for space. The implications — for business, policy, and society at large — are hard to overstate. In 2019, [95%](https://brycetech.com/reports) 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](https://hbsp.harvard.edu/product/716037-PDF-ENG) 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](https://hbsp.harvard.edu/product/720027-PDF-ENG) 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](https://ntrs.nasa.gov/citations/19780004167) 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](https://www.space.com/6503-population-space-historic-high-13.html) 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](https://www.nasa.gov/press-release/nasa-s-spacex-crew-1-astronauts-headed-to-international-space-station/) (in cooperation with NASA), as well as upcoming efforts by [Boeing](https://www.nasa.gov/feature/boeing-s-starliner-makes-progress-ahead-of-flight-test-with-astronauts), [Blue Origin](https://www.blueorigin.com/news/nasa-selects-blue-origin-national-team-to-return-humans-to-the-moon), and [Virgin Galactic](https://spacenews.com/virgin-galactic-prepares-to-transition-to-operations) 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. Welcome to the (Commercial) Space Age In our [recent research](https://www.hbs.edu/faculty/Publication%20Files/jep.32.2.173_Space,%20the%20Final%20Economic%20Frontier_413bf24d-42e6-4cea-8cc5-a0d2f6fc6a70.pdf), we examined how the model of centralized, government-directed human space activity born in the 1960s has, over the last two decades, made way for a new model, in which public initiatives in space increasingly share the stage with private priorities. Centralized, government-led space programs will inevitably focus on space-for-earth activities that are in the public interest, such as national security, basic science, and national pride. This is only natural, as expenditures for these programs must be justified by demonstrating benefits for citizens — and the citizens these governments represent are (nearly) all on earth. In contrast to governments, the private sector is eager to put people in space to pursue their own personal interests, not the state’s — and then supply the demand they create. This is the vision driving SpaceX, which in its first twenty years has entirely upended the rocket launch industry, securing 60% of the global commercial launch market and building ever-larger spacecraft designed to ferry passengers not just to the International Space Station (ISS), but also to its own promised [settlement on Mars](https://www.spacex.com/media/making_life_multiplanetary_transcript_2017.pdf). Today, the space-for-space market is limited to supplying the people who are already in space: that is, the handful of astronauts employed by NASA and other government programs. While SpaceX has grand visions of supporting large numbers of private space travelers, their current space-for-space activities have all been in response to demand from government customers (i.e., NASA). But as decreasing launch costs enable companies like SpaceX to leverage economies of scale and put more people into space, growing private sector demand (that is, tourists and settlers, rather than government employees) could turn these proof-of-concept initiatives into a sustainable, large-scale industry. This model — of selling to NASA with the hopes of eventually creating and expanding into a larger private market — is exemplified by SpaceX, but the company is by no means the only player taking this approach. For instance, while SpaceX is focused on space-for-space transportation, another key component of this burgeoning industry will be manufacturing. [Made In Space, Inc.](https://madeinspace.us/capabilities-and-technology/archinaut/) has been at the forefront of manufacturing “in space, for space” since 2014, when it 3D-printed a wrench onboard the ISS. Today, the company is exploring other products, such as high-quality fiber-optic cable, that terrestrial customers may be willing to pay to have manufactured in zero-gravity. But the company also recently received a [$74 million contract](https://www.nasa.gov/press-release/nasa-funds-demo-of-3d-printed-spacecraft-parts-made-assembled-in-orbit) to 3D-print large metal beams in space for use on NASA spacecraft, and future private sector spacecraft will certainly have similar manufacturing needs which Made In Space hopes to be well-positioned to fulfill. Just as SpaceX has begun by supplying NASA but hopes to eventually serve a much larger, private-sector market, Made In Space’s current work with NASA could be the first step along a path towards supporting a variety of private-sector manufacturing applications for which the costs of manufacturing on earth and transporting into space would be prohibitive. Another major area of space-for-space investment is in building and operating space infrastructure such as habitats, laboratories, and factories. Axiom Space, a current leader in this field, recently [announced](https://www.theverge.com/2021/1/26/22250327/space-tourists-axiom-private-crew-iss-price) that it would be flying the “first fully private commercial mission to space” in 2022 onboard SpaceX’s Crew Dragon Capsule. Axiom was also [awarded](https://spacenews.com/nasa-selects-axiom-space-to-build-commercial-space-station-module/) a contract for exclusive access to a module of the ISS, facilitating its plans to develop modules for commercial activity on the station (and eventually, beyond it). This infrastructure is likely to spur investment in a wide array of complementary services to supply the demand of the people living and working within it. For example, in February 2020, Maxar Technologies was awarded a [$142 million contract](https://www.builtincolorado.com/2020/02/03/maxar-technologies-142m-nasa-contract) from NASA to develop a robotic construction tool that would be assembled in space for use on low-Earth orbit spacecraft. Private sector spacecraft or settlements will no doubt have need for a variety of similar construction and repair tools.

#### “Space tourism” launches by major private space organizations are carbon-dirty, current evidence proves

Marais 21, 7-26-2021, [Eloise Marais, Associate Professor in Physical Geography, UCL] "Space tourism: Rockets emit 100 times more CO2 per passenger than flights – imagine a whole industry," The Conversation, <https://www.space.com/space-tourism-rockets-emit-100-times-more-co2> PM

The commercial race to get tourists to space is heating up between Virgin Group founder Sir Richard Branson and former Amazon CEO Jeff Bezos. On Sunday 11 July, Branson ascended 80 km to reach the edge of space in his piloted Virgin Galactic VSS Unity spaceplane. Bezos’ autonomous Blue Origin rocket which launched July 20, coinciding with the anniversary of the Apollo 11 moon landing. Though Bezos loses to Branson in time, he is set to reach higher altitudes (about 120 km). The launch will demonstrate his offering to very wealthy tourists: the opportunity to truly reach outer space. Both tour packages will provide passengers with a brief ten-minute frolic in zero gravity and glimpses of Earth from space. Not to be outdone, Elon Musk’s SpaceX will provide four to five days of orbital travel with its Crew Dragon capsule later in 2021. What are the environmental consequences of a space tourism industry likely to be? Bezos boasts his Blue Origin rockets are greener than Branson’s VSS Unity. The Blue Engine 3 (BE-3) will launch Bezos, his brother and two guests into space using liquid hydrogen and liquid oxygen propellants. VSS Unity used a hybrid propellant comprised of a solid carbon-based fuel, hydroxyl-terminated polybutadiene (HTPB), and a liquid oxidant, nitrous oxide (laughing gas). The SpaceX Falcon series of reusable rockets will propel the Crew Dragon into orbit using liquid kerosene and d . Burning these propellants provides the energy needed to launch rockets into space while also generating greenhouse gases and air pollutants. Large quantities of water vapour are produced by burning the BE-3 propellant, while combustion of both the VSS Unity and Falcon fuels produces CO₂, soot and some water vapour. The nitrogen-based oxidant used by VSS Unity also generates nitrogen oxides, compounds that contribute to air pollution closer to Earth. Roughly two-thirds of the propellant exhaust is released into the stratosphere (12 km-50 km) and mesosphere (50 km-85 km), where it can persist for at least two to three years. The very high temperatures during launch and re-entry (when the protective heat shields of the returning crafts burn up) also convert stable nitrogen in the air into reactive nitrogen oxides. These gases and particles have many negative effects on the atmosphere. In the stratosphere, nitrogen oxides and chemicals formed from the breakdown of water vapour convert ozone into oxygen, depleting the ozone layer which guards life on Earth against harmful UV radiation. Water vapour also produces stratospheric clouds that provide a surface for this reaction to occur at a faster pace than it otherwise would. Space tourism and climate change Exhaust emissions of CO₂ and soot trap heat in the atmosphere, contributing to global warming. Cooling of the atmosphere can also occur, as clouds formed from the emitted water vapour reflect incoming sunlight back to space. A depleted ozone layer would also absorb less incoming sunlight, and so heat the stratosphere less. Figuring out the overall effect of rocket launches on the atmosphere will require detailed modelling, in order to account for these complex processes and the persistence of these pollutants in the upper atmosphere. Equally important is a clear understanding of how the space tourism industry will develop. Virgin Galactic anticipates it will offer 400 spaceflights each year to the privileged few who can afford them. Blue Origin and SpaceX have yet to announce their plans. But globally, rocket launches wouldn’t need to increase by much from the current 100 or so performed each year to induce harmful effects that are competitive with other sources, like ozone-depleting chlorofluorocarbons (CFCs), and CO₂ from aircraft. During launch, rockets can emit between four and ten times more nitrogen oxides than Drax, the largest thermal power plant in the UK, over the same period. CO₂ emissions for the four or so tourists on a space flight will be between 50 and 100 times more than the one to three tonnes per passenger on a long-haul flight. In order for international regulators to keep up with this nascent industry and control its pollution properly, scientists need a better understanding of the effect these billionaire astronauts will have on our planet’s atmosphere.

#### Commercial space launches contribute to climate change

Mann 10, 10-22-2010, "Space tourism to accelerate climate change," Nature, <https://www.nature.com/articles/news.2010.558> PM

Scientists predict that soot from commercial space flight will change global temperatures. Virgin Galactic are one of many companies pushing forward with commercial spaceflight — but at what cost to the environment? Credit: Photo: Mike Mills Climate change caused by black carbon, also known as soot, emitted during a decade of commercial space flight would be comparable to that from current global aviation, researchers estimate. The findings, reported in a paper in press in Geophysical Research Letters1, suggest that emissions from 1,000 private rocket launches a year would persist high in the stratosphere, potentially altering global atmospheric circulation and distributions of ozone. The simulations show that the changes to Earth's climate could increase polar surface temperatures by 1 °C, and reduce polar sea ice by 5–15%. "There are fundamental limits to how much material human beings can put into orbit without having a significant impact," says Martin Ross, an atmospheric scientist at the Aerospace Corporation in Los Angeles, California and an author of the study. Private space flight is a rapidly maturing industry. Spaceport America, a launch site in Las Cruces, New Mexico, opened its first runway on 22 October. During the next three years, companies such as Virgin Galactic, headquartered at Spaceport America, expect to make up to two launches per day for space tourists. Meanwhile, the NASA Authorization Act passed by US Congress in September provides US$1.6 billion in private space-flight investments to develop vehicles to take astronauts and cargo into orbit. “There are fundamental limits to how much material human beings can put into orbit without having a significant impact. , ” Commercial rockets burn a mixture of kerosene and liquid oxygen. But several private space-flight companies, such as Virgin Galactic, may soon use a more economical 'hybrid' rocket engine that ignites synthetic hydrocarbon with nitrous oxide, says Ross. These hybrid engines emit more black carbon than a kerosene and oxygen engine, he adds. "Rain and weather wash out these particles from the atmosphere near Earth's surface, but in the stratosphere there isn't any rain and they can remain for 3 to 10 years," says Michael Mills, an atmospheric chemist at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and another author of the paper. Soot surprise The researchers ran global atmospheric models of an injection of about 600 tonnes of black carbon per year at a single location: Las Cruces. The results showed a soot layer in the stratosphere that stays within 10° latitude of the launch site, says Ross. Furthermore, around 80% of the black carbon remained in the Northern Hemisphere, spreading out to between 25° and 45° northern latitude. The black carbon layer caused the temperature to decrease about 0.4 °C in the tropics and subtropics, whereas the temperature at the poles increased by between 0.2 and 1 °C, he says, emphasizing that the exact details would have to be refined with further models. The black carbon also caused ozone reductions of up to 1.7% in the tropics and subtropics, and increases of 5–6% in the polar regions. The results are surprising, says Simone Tilmes, an atmospheric chemist at NCAR who was not involved in the study. "What's interesting is that if you force the whole climate system in one point or one hemisphere you can make big changes," she says. Further, more detailed studies examining the circulation of particulates will to help to reduce some of the uncertainties in the model, she adds Ross and his team hope to organize scientists, engineers and members of the private space-flight industry to discuss the kinds of measurements that need to be made to produce more definitive results. "The goal here is to support the commercial space industry so that it can develop normally," says Ross. He compares the problem to another one facing the industry: space debris — waste that remains in orbit and can present a potential collision risk to astronauts. "We have to come together to take care of the space commons," he says.

#### Climate change disproportionately affects people of color globally

Pellow 12 David Naguib Pellow 12, Ph.D. Professor, Don Martindale Endowed Chair – University of Minnesota, “Climate Disruption in the Global South and in African American Communities: Key Issues, Frameworks, and Possibilities for Climate Justice,” February 2012, <http://www.jointcenter.org/sites/default/files/upload/research/files/White_Paper_Climate_Disruption_final.pdf> [Premier]

It is now known unequivocally that significant warming of the atmosphere is occurring, coinciding with increasing levels of atmospheric CO2. Dr. John Holdren, Director of the White House Office of Science and Technology Policy, prefers the term “global climate disruption” to “climate change” because it more fully captures the harm being done to the planet (Holdren 2007). The term “climate change” infers a naturally occurring process rather than a disruption created by specific human activity. Moreover, the terms “global warming” and “climate change” might be construed as occurring in a uniform, even, gradual, and benign fashion, none of which is true. One solid indicator of Holdren’s point is the fact that climate disruptions affect communities, nations, and regions of the globe in vastly different ways. While contributing the least of anyone to the causes of climate disruption, people of color, women, indigenous communities, and global South nations often bear the brunt of climate disruption in terms of ecological, economic, and health burdens—thereby giving rise to the concept of climate injustice (Roberts and Parks 2007). These communities are among the first to experience the effects of climate disruption, which can include “natural” disasters, rising levels of respiratory illness and infectious disease, heat-related morbidity and mortality, and large increases in energy costs. They also bear the burdens created by ill-conceived policies designed to prevent climate disruption. The effects of climate injustice have been evident for years. Flooding from severe storms, rising sea levels and melting glaciers affect millions in Asia and Latin America, while sub-Saharan Africa is experiencing sustained droughts. Consider that nearly 75 percent the world’s annual CO2 emissions come from the global North, where only 15 percent of the global population resides. If historic responsibility for climate change is taken into account, global North nations have consumed more than three times their share of the atmosphere (in terms of the amount of emissions that we can safely put into the atmosphere) while the poorest 10 percent of the world’s population has contributed less than 1 percent of carbon emissions. Thus the struggle for racial, gender, and economic justice is inseparable from any effort to combat climate disruption. Climate justice is a vision aimed at dissolving and alleviating the unequal burdens created by climate change. The topic of climate justice is a major point of tension in both U.S. and international policy efforts to address climate disruption because it would require wealthy nations that have contributed the most to the problem to take on greater responsibilities for solutions. For many observers, the path is clear: for humanity’s survival, for justice, and for sustainability, they maintain that we must reduce our emissions and consumption here at home in the global North.

## Contention 2 is Debris Crowd-Out

#### Orbital space debris is a growing problem.

Strauss 18, 8-31-2018, "Will space be kept clean of debris? Americans are skeptical," Pew Research Center, <https://www.pewresearch.org/fact-tank/2018/08/31/as-debris-piles-up-americans-are-skeptical-enough-will-be-done-to-limit-space-junk/> PM

Private companies such as SpaceX, Blue Origin and Virgin Galactic are becoming increasingly important players in space exploration. Many Americans are confident these companies will be profitable, but they’re more skeptical they will keep space clean of debris, according to a recent Pew Research Center survey. Over the past 60 years, more than 5,250 space launches have spawned an orbital junkyard consisting of around 23,000 objects large enough to be detected, with a combined (Earth) weight of over 8,000 tons. While that’s a small amount compared with the more than 3.5 million tons of garbage the world produces every single day, it’s enough to pose a growing hazard to satellites and space stations. There is at least one terrestrial clean-up strategy that could be applied to space junk: recycling. Among the estimated 4,500 satellites in orbit, only about 1,500 are still functional. But those roughly 3,000 dead satellites contain valuable components that could be repurposed for other uses. Some could be towed to Mars, to assist missions to the red planet, where they could be repaired. Other satellites with valuable building materials could be melted down by a solar-powered orbiting forge. But most of the orbital debris is space-age flotsam and jetsam, such as spent rocket stages, screws and lens caps. There are about 23,000 detectable objects at least 2 to 4 inches in size in low-Earth orbit (the preferred altitude for most satellites and space missions) or about 1 to 3 feet in size in geostationary orbit (the ideal altitude for surveillance and communications satellites). What’s more, these objects can create more pieces of debris when they collide with one another or explode in orbit, due to leftover fuel or battery failures. Around 290 such “fragmentation events” are known to have occurred since 1961, creating an estimated 750,000 objects larger than about 0.5 inches in size. Circling the Earth at speeds around 10 times faster than a bullet, the kinetic energy of even miniscule objects can pack a punch strong enough to puncture the hull of a space station or damage solar panels and communication arrays. As more satellites are launched into space, the probability of collisions grows. There are, however, preventive measures that could mitigate the problem. For instance, engineers are developing technology to facilitate the venting of leftover fuel, thereby averting explosions in orbit. Or, satellites could be equipped with low-tech devices, such as balloons, that would enable Earth-based operators to guide them into the atmosphere – where they would burn up – at the end of their operational lifetimes.

#### SpaceX and private satellites lead to crowd out of the orbit, increasing likelihood of collision.

Pultarova 21, 8-18-2021, "SpaceX Starlink satellites responsible for over half of close encounters in orbit, scientist says," Space, <https://www.space.com/spacex-starlink-satellite-collision-alerts-on-the-rise> PM

Operators of satellite constellations are constantly forced to move their satellites because of encounters with other spacecraft and pieces of space junk. And, thanks to SpaceX's Starlink satellites, the number of such dangerous approaches will continue to grow, according to estimates based on available data. SpaceX's Starlink satellites alone are involved in about 1,600 close encounters between two spacecraft every week, that's about 50 % of all such incidents, according to Hugh Lewis, the head of the Astronautics Research Group at the University of Southampton, U.K. These encounters include situations when two spacecraft pass within a distance of 0.6 miles (1 kilometer) from each other. Lewis, Europe's leading expert on space debris, makes regular estimates of the situation in orbit based on data from the Socrates (Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space ) database. This tool, managed by Celestrack, provides information about satellite orbits and models their trajectories into the future to assess collision risk. Lewis publishes regular updates on Twitter and has seen a worrying trend in the data that reflects the fast deployment of the Starlink constellation. "I have looked at the data going back to May 2019 when Starlink was first launched to understand the burden of these megaconstellations," Lewis told Space.com. "Since then, the number of encounters picked up by the Socrates database has more than doubled and now we are in a situation where Starlink accounts for half of all encounters." The current 1,600 close passes include those between two Starlink satellites. Excluding these encounters, Starlink satellites approach other operators’ spacecraft 500 times every week. A graph showing the growing number of close encounters in space involving Starlink satellites as plotted by Professor Hugh Lewis using data from the Socrates database. (Image credit: Hugh Lewis) In comparison, Starlink's competitor OneWeb, currently flying over 250 satellites, is involved in 80 close passes with other operators' satellites every week, according to Lewis' data. And the situation is bound to get worse. Only 1,700 satellites of an expected constellation of tens of thousands have been placed into orbit so far. Once SpaceX launches all 12,000 satellites of its first generation constellation, Starlink satellites will be involved in 90% of all close approaches, Lewis’ calculations suggest. A graph showing the number of close encounters between Starlink satellites and spacecraft of other operators plotted by Professor Hugh Lewis based on data from the Socrates database. (Image credit: Hugh Lewis) The risk of collision Siemak Hesar, CEO and co-founder of Boulder, Colorado, based Kayhan Space, confirms the trend. His company, which develops a commercial autonomous space traffic management system, estimates that on average, an operator managing about 50 satellites will receive up to 300 official conjunction alerts a week. These alerts include encounters with other satellites as well as pieces of debris. Out of these 300 alerts, up to ten might require operators to perform avoidance maneuvers, Hesar told Space.com. Kayhan Space bases their estimates on data provided by the U.S. Space Surveillance Network. This network of radars and telescopes, managed by the U.S. Space Force, closely monitors about 30,000 live and defunct satellites and pieces of debris down to the size of 4 inches (10 centimeters) and provides the most accurate location data of the orbiting objects. The size of this catalog is expected to increase ten times in the near future, Hesar added, partly due to the growth of megaconstellations, such as Starlink, and partly as sensors improve and enable detection of even smaller objects. The more objects in the catalog mean more dangerously close encounters. "This problem is really getting out of control," Hesar said. "The processes that are currently in place are very manual, not scalable, and there is not enough information sharing between parties that might be affected if a collision happens." Hesar compared the problem to driving on a highway and not knowing that there has been an accident a few miles ahead of you. If two spacecraft collide in orbit, the cloud of debris the crash generates would threaten other satellites travelling through the same area. "You want to have that situational awareness for the other actors that are flying in the neighbourhood," Hesar said. A visualization of satellites and space debris around Earth. (Image credit: NASA) Bad decisions Despite the concerns, only three confirmed orbital collisions have happened so far. Earlier this week, astrophysicist and satellite tracker Jonathan McDowell, who's based at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, found evidence in Space-Track data that the Chinese meteorological satellite Yunhai 1-02, which disintegrated in March this year, was actually hit by a piece of space debris. The worst known space collision in history took place in February 2009 when the U.S. telecommunication satellite Iridium 33 and Russia's defunct military satellite Kosmos-2251 crashed at the altitude of 490 miles (789 kilometres). The incident spawned over 1,000 pieces of debris larger than 4 inches (10 cm). Many of these fragments were then involved in further orbital incidents. Lewis is concerned that with the number of close passes growing, the risk of operators at some point making a wrong decision will grow as well. Avoidance maneuvers cost fuel, time and effort. Operators, therefore, always carefully evaluate such risks. A decision not to make an avoidance maneuver following an alert, such as that made by Iridium in 2009, could, however, clutter the orbital environment for years and decades. "In a situation when you are receiving alerts on a daily basis, you can't maneuver for everything," Lewis said. "The maneuvers use propellant, the satellite cannot provide service. So there must be some threshold. But that means you are accepting a certain amount of risk. The problem is that at some point, you are likely to make a wrong decision." Hesar said that uncertainties in the positions of satellites and pieces of debris are still considerable. In case of operational satellites, the error could be up to 330 feet (100 meters) large. When it comes to a piece of debris, the uncertainty about its exact position might be in the order of a mile or more. "This object can be anywhere in this bubble of multiple kilometres," Hesar said. "At this point, and for the foreseeable future, avoidance is our best recourse. People that say 'I'm going to take the risk', in my humble opinion, that's an irresponsible thing to do." In September 2019, ESA's wind-monitoring satellite Aeolus came dangerously close to one of SpaceX's Starlink spacecraft. The space agency had to move the spacecraft to prevent a collision. (Image credit: ESA) Starlink monopoly Lewis is concerned about the growing influence of a single actor — Starlink — on the safety of orbital operations. Especially, he says, as the spaceflight company has entered the satellite operations world only recently. "We place trust in a single company, to do the right thing," Lewis said. "We are in a situation where most of the maneuvers we see will involve Starlink. They were a launch provider before, now they are the world's biggest satellite operator, but they have only been doing that for two years so there is a certain amount of inexperience." SpaceX relies on an autonomous collision avoidance system to keep its fleet away from other spacecraft. That, however, could sometimes introduce further problems. The automatic orbital adjustments change the forecasted trajectory and therefore make collision predictions more complicated, according to Lewis. "Starlink doesn't publicize all the maneuvers that they're making, but it is believed that they are making a lot of small corrections and adjustments all the time," Lewis said. "But that causes problems for everybody else because no one knows where the satellite is going to be and what it is going to do in the next few days."

#### Earth observation satellites key to warming adaptation

Alonso 18 [(Elisa Jiménez Alonso, communications consultant with Acclimatise, climate resilience organization) “Earth Observation of Increasing Importance for Climate Change Adaptation,” Acclimatise, May 2, 2018, <https://www.acclimatise.uk.com/2018/05/02/earth-observation-of-increasing-importance-for-climate-change-adaptation/>] TDI

Earth observation (EO) satellites are playing an increasingly important role in assessing climate change. By providing a constant and consistent stream of data about the state of the climate, EO is not just improving scientific outcomes but can also inform climate policy. Managing climate-related risks effectively requires accurate, robust, sustained, and wide-ranging climate information. Reliable observational climate data can help scientists test the accuracy of their models and improve the science of attributing certain events to climate change. Information based on projections from models and historic data can help decision makers plan and implement adaptation actions. Providing information in data-sparse regions Ground-based weather and climate monitoring systems only cover about 30% of the Earth’s surface. In many parts of the world such data is incomplete and patchy due to poorly maintained weather stations and a general lack of such facilities. EO satellites and rapidly improving satellite technology, especially data from open access programmes, offer a valuable source information for such data-sparse regions. This is especially important since countries and regions with a lack of climate data are often particularly vulnerable to climate change impacts. International efforts for systematic observation The importance of satellite-based observations is also recognised by the international community. Following the recommendations of the World Meteorological Organization’s (WMO) Global Climate Observing System (GCOS) programme, the UNFCCC strongly encourages countries that support space agencies with EO programmes to get involved in GCOS and support the programme’s implementation. The Paris Agreement highlights the need for and importance of effective and progressive responses to the threat of climate change based on the best available scientific knowledge. This implies that climate knowledge needs to be strengthened, which includes continuously improving systematic observations of the Earth’s climate. To meet the need of such systematic climate observations, GCOS developed the concept of the Essential Climate Variable, or ECV. According to WMO, an ECV “is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth’ s climate.” In 2010, 50 ECVs which would help the work of the UNFCCC and IPCC were defined by GCOS. The ECVs, which can be seen below, were identified due to their relevance for characterising the climate system and its changes, the technical feasibility of observing or deriving them on a global scale, and their cost effectiveness. The 50 Essential Climate Variables as defined by GCOS. One effort supporting the systemic observation of the climate is the European Space Agency’s (ESA) Climate Change Initiative (CCI). The programme taps into its own and its member countries’ EO archives that have been established in the last three decades in order to provide a timely and adequate contribution to the ECV databases required by the UNFCCC. Robust evidence supporting climate risk management Earth observation satellites can observe the entire Earth on a daily basis (polar orbiting satellites) or continuously monitor the disk of Earth below them (geostationary satellites) maintaining a constant watch of the entire globe. Sensors can target any point on Earth even the most remote and inhospitable areas which helps monitor deforestation in vast tropical forests and the melting of the ice caps. Without insights offered by EO satellites there would not be enough evidence for decision makers to base their climate policies on, increasing the risk of maladaptation. Robust EO data is an invaluable resource for collecting climate information that can inform climate risk management and make it more effective.