The New Wild West: Law, Regulation, Conflict, and the Future of Space

Chris Impey
Department of Astronomy, University of Arizona

ABSTRACT

This article explores issues and concerns raised by increased human activity in space. As space travel follows the arc of civil aviation, an activity that is hazardous and only for the wealthy will become safe and within reach of potentially large audiences for tourism and for recreation. Entrepreneurs are planning for habitats on the Moon and Mars, and other investors see the prospect of mining asteroids and mineral resources on the Moon. Space activity occurs in an environment with very weak regulation and little established space law. Space debris is growing to a level where it could threaten all low Earth orbit activity. Ethical issues are raised by commercial space activity, and the only United Nations treaties dealing with space do not address private or commercial ownership of real estate in space. In the new "Wild West" of space travel, judicious regulation and law can help mitigate some of the worst outcomes of exploration and exploitation of the new off-Earth frontier.

Keywords: space travel, space debris, space law, ethics, sustainability, commerce, tourism, regulation

El nuevo salvaje oeste: leyes, regulaciones, conflictos y el futuro del espacio

RESUMEN

Este artículo explora los problemas y preocupaciones que plantea el aumento de la actividad humana en el espacio. A medida que los viajes espaciales siguen el ejemplo de la aviación civil, una actividad peligrosa y exclusiva para los ricos se volverá segura y accesible para un público potencialmente amplio, tanto para el turismo como para la recreación. Emprendedores planean hábitats en la Luna y Marte, y otros inversores ven la posibilidad de explotar asteroides y recursos minerales en la Luna. La actividad espacial se desarrolla en un entorno con una regulación muy débil y una legislación espacial poco consolidada. Los desechos espaciales es-

 doi: 10.18278/sesa.5.2.16

tán creciendo hasta un nivel que podría amenazar toda la actividad en órbita terrestre baja. La actividad espacial comercial plantea cuestiones éticas, y los únicos tratados de las Naciones Unidas que abordan el espacio no abordan la propiedad privada o comercial de bienes inmuebles en el espacio. En el nuevo "salvaje oeste" de los viajes espaciales, una regulación y una legislación sensatas pueden ayudar a mitigar algunos de los peores resultados de la exploración y explotación de la nueva frontera extraterrestre.

Palabras clave: viajes espaciales, desechos espaciales, derecho espacial, ética, sostenibilidad, comercio, turismo, regulación

新的法外之地：法律、监管、冲突、以及太空的未来

摘要

本文探究了人类在太空的活动增多所引发的问题和关切。随着太空旅行追随民航的发展轨迹，一项危险且只有富人才能进行的活动将变得安全，并有可能吸引大量游客进行旅游和娱乐。企业家们正在规划在月球和火星上建立栖息地，其他投资者看到了开采小行星和月球矿产资源的前景。太空活动发生在一个监管非常薄弱、几乎没有太空法的环境中。太空垃圾正在增长到可能威胁所有低地球轨道活动的水平。商业太空活动引发了伦理问题，而联合国唯一涉及太空的条约并未涉及太空不动产的私人或商业所有权。在太空旅行的新"法外之地"中，明智的监管和法律能帮助减轻由"探索和开发新的地外边界"所带来的部分最坏结果。

关键词：太空旅行，太空垃圾，太空法，伦理，可持续性，商业，旅游业，监管

Introduction

The commercial sector is now carrying out more launches to Earth orbit than governments, and there are very few laws or regulations to protect against space debris, harm to humans, or the militarization of space.

Space travel is entering a new phase. For over half a century after the launch of Sputnik in 1957, space was the exclusive playground of the world's two superpowers: the United States and the former Soviet Union (Hardesty & Eisman, 2007). The rivalry originated during the depths of the Cold War and reached its pinnacle with the race to land humans on the Moon. Subsequently, the difficulties and expense of space travel, and the easing of tensions between the two superpowers, spurred cooperation, starting with the 1970's Apollo-Soyuz program (Ross-Nazal, 2010). Wider cooperation came with the International Space Station (ISS), which has been continually occupied for 25 years by a total of 280 astronauts representing 22 different nations (Catchpole, 2008). With the waning of Russia as a space power, the new rivalry is between the United States and China, a country with grand ambitions in space (Harvey, 2019). India, Brazil, Japan, and the Arab Emirates also have growing aspirations in space (Oniosun, 2023). Recent rapid progress comes from the commercial sector. SpaceX and Blue Origin have developed reusable rockets to lower the cost per kilogram launched to Earth orbit. There are over three dozen private space companies, but these two are led by billionaires who have invested from their fortunes to sustain a development phase while there is no substantial revenue stream from tourism (Davenport, 2019). Traffic in space is increasing dramatically. In 2023, there were 223 space launches, up from 186 in 2022, and almost three times the 85 launches in 2016. SpaceX alone accounted for 98 of the launches (McDowell, 2023). The world space economy was worth over half a trillion dollars in 2023 (Space Foundation, 2024).

Impacts on the Environment

At first glance, the environmental impact of space travel may seem inconsequential. There are only a few hundred space launches per year, compared with nearly 40 million flights by commercial aircraft (Statista, 2024). The space industry only burns 2% of the fossil fuel burned by conventional aviation, although that percentage is likely to rise rapidly if projections for satellite launches and space tourism hold. However, aircraft release pollutants in the troposphere and lower stratosphere, while rockets release pollutants all the way up to the mesosphere, where they last a lot longer. A 2022 study on the impact of rockets that burn RP-1 found that each year 1000 metric tons of black carbon are added to the stratosphere (Ryan et al., 2022). RP-1 is the kerosene used in the past by Saturn, Delta, Altas, and Soyuz, and currently used by SpaceX for its Falcon 9 rocket. Particles emitted by rockets are 500 times more efficient at holding heat in the atmosphere than all other sources of soot combined, with an enhanced warming effect on the climate. If that amount grows by a factor of ten, the stratosphere will warm by 1.5 degrees Celsius, and the ozone layer will get thinner. A life cycle assessment of the greenhouse gas impact of human space travel found that the impact is 550 to 1,300 times the average global citizen's annual impact on a per-launch basis and 2,000 to 4,600 times the hourly impact of a global citizen on a per-hour basis (Carbajales-Dale & Murphy, 2023). The workhorse of large future payloads is SpaceX's Starship, which exceeds the lift capability of the Saturn V rocket (Seedhouse, 2022). The good news is that Starship's Raptor engines burn liquid oxygen and liquid methane, so they have a smaller carbon footprint than the engines burning RP-1. However, their rocket exhaust contains soot, water vapor, which is a potent greenhouse gas, and methane, which is 80 times more potent than carbon dioxide in trapping heat (McDonald, 2018). More broadly, the increased volume of launches increases the rate of old rockets and satellites burning up on reentry. This leaves metallic ash at high altitudes where it lasts a very long time, with adverse effects on the ozone layer (Boley & Byers, 2021). Many of these effects are difficult to model and still poorly understood. A less direct environmental impact is degradation of the quiet and dark skies that research astronomers depend on. Small satellites are spoiling an increasing number of deep images of the universe, and they are causing interference to sensitive radio observations of cosmic sources (Witze, 2019).

The Problem of Space Debris

A predictable consequence of the rapidly increasing number of orbital launches is a growing amount of space debris (Madi & Sokolova, 2020). Low Earth orbit is a junk yard. Detritus of our activity in space includes obsolete spacecraft and satellites, rocket parts, metal fragments ranging in size down to a fleck of paint, and fragmentation or collision debris, sometimes created deliberately. The kinetic energy of objects moving at speeds of up to 18,000 mph means that even the paint flecks can cause damage to a satellite or spacecraft. Surveillance networks can track and catalog nearly 38,000 space objects. Since the start of the Space Age, nearly 20,000 satellites have been placed in Earth orbit, of which 13,000 are still in space and 10,000 are still functioning. There are currently 40,500 pieces of debris larger than 10 cm, and statistical models estimate 1.1 million between 1 cm and 10 cm and 130 million between 1 mm and 1 cm (European Space Agency, 2024). The total mass of all space objects in Earth orbit is 13,000 metric tons, which is 1% of the mass of the entire atmosphere. A hundred companies plan to launch "constellations" of small satellites (Curzi et al., 2020). Although projections are uncertain, Earth orbit may eventually host a million satellites (Falle et al., 2023). The collision rate will inevitably increase and there is a cascading effect even with no additional launches. The direst outcome is that exponentially increasing debris renders low Earth orbit unusable (Kessler & Cour-Palais, 1978). Space debris has been called a "tragedy of the commons," the situation where everyone benefits from using a valuable resource, but no one takes ownership of its preservation (Wang, 2013). When no single country or party is responsible for mitigation, it is important to create incentives not to make the problem even worse (Garber, 2017). That already happens for new large satellites, which have built-in deorbiting mechanisms, and for SpaceX mega-constellation satellites, which are in low enough orbits that they de-orbit naturally due to atmospheric drag in 5 to 7 years. NASA has taken an important step by more accurately defining the risks from space debris and by conducting a cost-benefit analysis of remediation measures. For example, the report compares the cost of shielding spacecraft to the cost of tracking smaller pieces of debris, or the costs of removing 50 large pieces of debris to removing 50,000 smaller pieces (Locke et al., 2024). Luckily, there are mitigation strategies that could alleviate the problem, including nets, magnets, harpoons, and lasers (Ledkov & Aslanov, 2022; Svotina & Cherkasova, 2023).

Competition and Conflict

Most space activity is driven by economic motives, with secondary rationales of scientific research and exploration. However, there is real concern about the militarization of space and the potential for armed conflict off-Earth (Dawson, 2018). The original space race between the United States and the Soviet Union had a Cold War backdrop with existential overtones. The new landscape of space geopolitics is more complex. Democratization means that a growing set of countries are operating in space for national prestige or industrial benefit (Goswamy & Garretson, 2020). In the United States, the formation of a sixth branch of the Armed Forces in 2019, the Space Force, was a sign that space was a new arena for competition and potential conflict (Ruff et al., 2022). The Space Force budget rapidly eclipsed NASA's budget and was $29 billion in FY24 (Department of the Air Force, 2024). In 2024, the Center for Strategic and International Studies released the seventh in its series of Space Threat Assessments (Swope et al., 2024). The report summarizes counterspace capabilities, with a focus on China and Russia. It concludes that both countries are conducting space operations that suggest espionage or the development and testing of orbital counterspace weapons. But public reporting cannot fully capture these threats, which operate in the shadows and often under the guise of harmless activities. Also in 2024, the Secure World Foundation released a report on counterspace capabilities worldwide (Weedon & Samson, 2024). The report summarizes weapons of four types. Cyberattacks target data or the systems that control the flow of data. Electronic weapons jam signals from a satellite or issue false commands to an enemy satellite to disrupt its operations. Non-kinetic weapons like lasers can disrupt satellites or ground systems without making physical contact. Kinetic weapons aim to eliminate satellites or space assets. Collectively, these weapons can deceive, disrupt, degrade, or destroy. In the contested arena of space, the boundary between defense and offense is blurred. The potential for conflict with China is particularly acute (Nawaz et al., 2022). China has outsized ambitions in space, launching over 100 spacecraft every year, and having recently deployed a space station and landed rovers on the Moon and Mars (Goswami, 2018). China is working on an array of technologies to weaponize space and their aim is to match or exceed American capabilities to gain military and economic advantage (Gould, 2021). The necessary response, in a report framed with dark humor, is to develop a "Defense Against the Dark Arts" (Harrison et al., 2021).

Laws and Regulations Off-Earth

Space is the new "Wild West." There have only ever been two treaties that have the force and the jurisdiction of international law. The United Nations Outer Space Treaty of 1967 specified that no country can claim ownership of the Moon or any part of it and that celestial bodies should only be used for peaceful purposes (United Nations, 1967). The most important part of the treaty was the prohibition of nuclear weapons in space. However, the treaty says nothing about corporations and individuals, and it says nothing about the utilization of space resources, so it is not helpful in an era when commercial activity in space is surging. Subsequently, the Moon Agreement of 1979 held that the Moon and its natural resources are the common heritage of humanity. However, it is moot since none of the major space-faring countries have signed it (United Nations, 1979). Additionally, there is a "Rescue Agreement" dealing with returning astronauts from deep space, a "Liability Convention" to address damage caused by deep space objects, and a "Registration Agreement" to track all objects launched into space. Continuing U.N. oversight comes through the Committee on the Peaceful Uses of Outer Space (COPUS), set up by the General Assembly in 1959. COPUS has 112 members, and it meets every year (United Nations, 2024a). It has approved 21 non-binding sustainability guidelines (United Nations, 2024b), and for the first time in half a century is considering new treaties. With the ominous threat of space conflict, it's notable that in 2021 NATO extended Article 5 to cover attacks on space assets (North Atlantic Treaty Organization, 2024). As international space law languishes, countries have been acting to protect their interests and those of their citizens. In November 2015, Barack Obama signed the U.S. Commercial Space Launch Competitiveness Act into law. The law recognizes the right of Americans to own any space resources that they harvest, and it encourages commercial exploitation of asteroids (Molloy, 2015). In 2020, Donald Trump went further, signing an executive order that said the U.S. does not view space as a "global commons." In the United States, the regulatory environment is loose, reflecting successive governments' beliefs that private enterprise has the acumen and technical ability to make commercial spaceflight a successful business (Nield, Owens, & Sloan, 2008). The field of space ethics is young and evolving but is finally getting scholarly attention (Schwartz and Milligan, 2021). It should aim to identify principles for arriving at rational compromises between the different stakeholders in space.

Conclusion

This brief survey of the rapidly evolving space industry has one main conclusion. As humans live and work off-Earth in increasing numbers, they will do so in a largely ungoverned and unregulated environment. The current activity is being propelled by technologists, deep-pocketed entrepreneurs, and governments motivated by their own geopolitical interests. If space is to be a sustainable and equitable environment in the future, much more attention will need to be paid to ethical, legal, and environmental concerns.

References

Boley, A.C., & Byers, M. (2021). Satellite mega-constellations create risks in low Earth orbit, the atmosphere and on Earth. *Scientific Reports*, *11*, 10642. https://doi.org/10.1038/s41598-021-89909-7

Carbajales-Dale, M., & Murphy, D.W. (2023). The environmental and moral implications of human space travel. *Science of the Total Environment*, *856*(2). https://doi.org/10.1016/j.scitotenv.2022.159222

Catchpole, J.E. (2008). *The International Space Station: Building for the future*. Berlin, Springer Praxis.

Curzi, G., Modenini, D., & Totora, P. (2020). Large constellations of small satellites: A survey of near future challenges and missions. *Aerospace, 7*(9), 133-151. https://doi.org/10.3390/aerospace7090133

Davenport, C. (2019). *The space barons: Elon Musk, Jeff Bezos, and the quest to colonize the cosmos*. New York, PublicAffairs.

Dawson, L. (2018). *War in space: The science and technology behind our next theater of conflict*. Berlin, Springer Praxis.

Department of the Air Force (2024). Fiscal year 2025 budget request, *Department of the Air Force*. https://www.spaceforce.mil/News/Article-Display/Article/3703322/

European Space Agency (2024). Space debris by the numbers, European Space Agency. https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

Falle, A., Wright, E., Boley, A., & Byers, M. (2023). One million (paper) satellites. *Science, 382*(6667), 150-152. https://doi.org/10.1126/science.adi4639

Garber, S.J. (2017). Incentives for keeping space clean: Orbital debris and mitigation waivers. *Journal of Space Law, 41*(2), 179-201.

Goswami, N. (2018). China in space: Ambitions and possible conflict. *Strategic Studies Quarterly*, *12*(1), 74-97. http://www.jstor.org/stable/26333878

Goswamy, N., & Garretson, P.A. (2020). *Scramble for the skies: The great power competition to control the resources of outer space*. Lanham, MD, Lexington Books.

Gould, J. (2021). China aims to weaponize space, says intel community report.

Defense News. https://www.defensenews.com/congress/2021/04/14/china-aims-to-weaponize-space-says-intel-community-report/

Hardesty, V., & Eisman, G. (2007). *Epic rivalry: The inside story of the Soviet and American space race*. National Geographic Society.

Harrison, T., Johnson, K., & Young, M. (2021). Defense against the dark arts in space: Protecting space systems from counterspace weapons. *Center for Strategic and International Studies*. https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210225_Harrison_Defense_Space.pdf

Harvey, P. (2019). *China in Space: The great leap forward*. Berlin, Springer Praxis.

Kessler, D.J., & Cour-Palais, B.G. (1978). Collision frequency of artificial satellites: The creation of a debris belt. *Journal Geophys. Res. Space Physics, 83*(A6), 2637-2646. https://doi.org/10.1029/JA083iA06p02637

Ledkov A., & Aslanov, V. (2022). Review of contact and contactless active space debris removal approaches. *Progress in Aerospace Sciences, 134*, 100858. https://doi.org/10.1016/j.paerosci.2022.100858

Locke, J., Colvin, T.J., Ratliff, L., Abdul-Hamid, A., & Samples, C. (2024). Cost and benefit analysis of mitigating, tracking, and remediating orbital debris. *NASA*, Report ID 20240003484. https://www.nasa.gov/wp-content/uploads/2024/05/2024-otps-cba-of-orbital-debris-phase-2-plus-svgs-v3-tjc-tagged.pdf?emrc=224cd2

Madi, M., & Sokolova, O., eds. (2020). *Space debris peril: Pathways to opportunities*. Boca Raton, FL, CRC Press.

McDonald, J. (2018). How potent is methane? *FactCheck.org*. https://www.factcheck.org/2018/09/how-potent-is-methane/

McDowell, J. (2023). *Space activities in 2023*. https://planet4589.org/space/papers/space23.pdf

Molloy, M. (2015). Asteroid mining made legal after passing of historic space bill by US. *Telegraph*. https://www.telegraph.co.uk/news/worldnews/northamerica/usa/12019740/Who-owns-space-Asteroid-mining-made-legal-in-US-after-passing-of-2015-space-bill.html.

North Atlantic Treaty Organization (2024). NATO's overarching space policy, *NATO*. https://www.nato.int/cps/en/natohq/official_texts_190862.htm

Nawaz, R., Bilal, A., & Rehman, M. (2022). United States – China space offensive: a dangerous competition. *Astropolitics, 20*(1), 27-42. https://doi.org/10.1080/14777622.2022.2078195

Nield, G., Owens, D.B., & Slan, J. (2008). The origin and practice of U.S. commercial human spaceflight regulations. International Astronautical Congress, Glasgow. https://www.faa.gov/sites/faa.gov/files/space/additional_information/international_affairs/The_Origin_and_Practice_of_U.S._Commerical_Human_Space_Flight_Regulations_IAC_Glasgow_Oct_2008.pdf

Oniosun, T.I. (2023). *A holistic framework for classifying countries in the space sector*. https://dx.doi.org/10.2139/ssrn.4602331

Ross-Nazal, J. (2010). Détente on Earth and in space: The Apollo-Soyuz test project. *Organization of American Historians Magazine of History*, *24*(3), 29-34. https://doi.org/10.2307/maghis/24.3.29

Ryan, R.G., Marais, E.A., Balhatchet, C.J., & Eastham, S.D. (2022). Impact of rocket launch and space debris air pollutant emissions on stratospheric ozone and global climate. *Earth's Future*, *10*(6). https://doi.org/10.1029/2021EF002612

Ruff, J.W.A., Stelmach, G., & Jones, M.D. (2022). Space for stories: Legislative narratives and the establishment of the US Space Force. *Policy Sciences, 55*, 509-553. https://doi.org/10.1007/s11077-022-09455-5

Schwartz, J.S.J., & Milligan, T. (2021). "Space ethics" according to space ethicists. *The Space Review*. https://www.thespacereview.com/article/4117/1

Seedhouse, E. (2022). *SpaceX: Starship to Mars – The first 20 years*. Berlin, Springer Praxis.

Space Foundation (2024). Space Foundation announces $570B space economy in 2023, driven by steady private and public sector growth. *SpaceFoundation.org*. https://www.spacefoundation.org/2024/07/18/the-space-report-2024-q2/

Statista (2024). *Number of flights performed by the global airline industry from 2004 to 2023, with a forecast for 2024*. https://www.statista.com/statistics/564769/airline-industry-number-of-flights/

Svotina, V.V., & Cherkasova, M.V. (2023). Space debris removal – review of technologies and techniques. Flexible or virtual connection between space debris and service spacecraft. *Acta Astronautica, 204*, 840-853. https://doi.org/10.1016/j.actaastro.2022.09.027

Swope, C., Bingen, K.A., Young, M., Chang, M., Songer, S., & Tammelleo, M. (2024). *Space threat assessment 2024*, Center for Strategic and International Studies. https://www.csis.org/analysis/space-threat-assessment-2024

United Nations (1967). Treaty on principles governing the activities of states in the exploration and use of outer space, including the Moon and other celestial bodies. *United Nations*. https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

United Nations (1979). Agreement governing the activities of states on the Moon and other celestial bodies. *United Nations*. https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/intromoon-agreement.html

United Nations (2024a). Space Law, United Nations Office for Outer Space Affairs. *United Nations*. https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html

United Nations (2024b). Guidelines for the long-term sustainability of outer space activities of the Committee on the Peaceful Uses of Outer Space. *United Nations*. https://spacesustainability.unoosa.org/sites/spacesustainability.unoosa.org/files/21-02562_lts_ebook_english_june2021.pdf

Wang, P. (2013). Tragedy of commons in outer space – the case of space debris. *64th International Astronautical Congress, 56th IISL Colloquium on the Uses of Outer Space (E7)*. https://dx.doi.org/10.2139/ssrn.2260856

Weedon, B., & Samson, V. (2024). *Global counterspace capabilities.* Secure World Foundation. https://swfound.org/media/207826/swf_global_counterspace_capabilities_2024.pdf

Witze, A. (2019). SpaceX launch highlights threat to astronomy from 'megaconstellations.' *Nature, 575*, 268-269.

Conflicts of Interest

The author has no conflicts of interest to report. Some of the ideas discussed in this article were presented in a paper published in *Studia Humana* in 2021, and a non-technical summary of similar themes was published in the online newspaper *The Hill* in 2022.