Arizona Law Journal of Emerging Technologies

Volume 8 *Article 4*

2-2025

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Roy Balleste
Stetson University College of Law

Recommended Article Citation

Roy Balleste, *In Search of the Rule of Law*, 8 Ariz. L. J. Emerging Tech., no.4, 2025, https://doi.org/10.2458/azlawjet.8093.

2024-2025 https://journals.librarypublishing.arizona.edu/azlawjet/ Vol. 8, Art. 4

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Table of Contents

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Roy Balleste[1]

"So ends my last signal until we reach our destination. We are now on automatic, a mere hundred and five light years from our base . . . . and at the mercy of computers, I've tucked in my crew for the long sleep . I'll join them presently . . . . Within the hour we shall complete the sixth month of our flight from Cape Kennedy. By our time, that is . . . ." — Colonel Gerorge Taylor[2]

I. In Search of Meaning

The choice to launch a spacecraft is not made lightly. Traveling into the unknown is not for the timid. Astronauts and other stakeholders will surely face dangers after they land on the Moon, travel to Mars, and explore beyond. The harshness of the space environment exacerbates the complexity. This task is theoretically possible, albeit it will be costly and challenging. It is accurate to project that the future of humanity holds the potential for interstellar space travel. Observing the landscape of the next twenty years, and even one hundred years, offers a beginning that traces its wisdom into the past and advances into the future. As expressed in *Human Issues in Space Exploration,* "[w]e cannot fail to be awed by the dramatic leap from speculative to factual inquiry about issues so profound as the nature and origin of the solar system and the evolution of life within it."[3] The results of long-term missions and space exploration highlight how crossing the great distances of space and time might provide explorers with an unparalleled view of the universe.

Astronauts will encounter increasingly significant challenges due to the slow progression of new space regulations, the growing number of geopolitical conflicts, and the ever-expanding innovation of technological capabilities. This is specifically the case

[1] Dr. Roy Balleste is a Professor of Law, Director of International Initiatives, and Director of the Law Library at Stetson University College of Law. Professor Balleste has concentrated his scholarship on the areas of astronautical ethics, great power competition, cybersecurity law, space law, space cybersecurity, and space power. Balleste is a core expert and member of the editorial board of the Manual on International Law Applicable to Military Uses of Outer Space (MILAMOS). Balleste holds a Ph.D. in Space Cybersecurity (Capitol Technology University) and a J.S.D. in Intercultural Human Rights (internet governance, St. Thomas University); an LL.M. in Air and Space Law (McGill University); an LL.M. in Intercultural Human Rights (St. Thomas University); an M.S. in Cybersecurity (Norwich University); and a J.D. (St. Thomas University). Professor Balleste is a member of the International Institute of Space Law. He is the Director of Information Security for ABH Aerospace. This article is dedicated to his wife, Enarda, and his daughter Arya. Professor Balleste offers his deepest and most sincere gratitude to the Stetson University College of Law administration for the support received during the drafting of this article.

[2] Michael Wilson, *Planet of the Apes*, IMSDB, https://imsdb.com/scripts/Planet-of-the-Apes,-The.html (last visited Feb. 10, 2025) (Colonel George Taylor is portrayed by award-winning actor Charlton Heston).

[3] Goody et al., *Human Issues in Space Exploration*, 33(8) BULL. AM. ACAD. ARTS & SCI. 10, 11 (1980).

with long-duration space flight, where "[l]ong-range missions include projects to set up manned bases on the moon or Mars or long-duration space flight and would also include projects such as a space hotel."[4] Future missions to Mars, Neptune, the Kuiper Belt,[5] Proxima b (also known as Proxima Centauri b)—the nearest and possibly a life-sustaining exoplanet[6]—hold immense promise for discovery. Astronauts will set forth on an expedition that has the potential to enhance humanity's future. The legal implications associated with long-duration missions are significant. Indeed, "no fundamental principles of physics, no short-term biological issues and no questions of sound engineering practice appear to stand in the way of proposals for the construction of space colonies, [and] the return of raw materials from space to Earth . . . ."[7]

Among these initiatives, interstellar exploration is expected to be the most challenging. The evolving future compels legal scholars to contemplate the implications of interplanetary discovery. This exploration means the commencement of an odyssey that will profoundly alters humanity's position within the fabric of time.[8] The unfolding future urges legal scholars to contemplate the implications of interstellar exploration.

Entering the great expense of outer space represents experiencing life through a continuum of moments that can be envisioned as temporal coordinates—instances in a continuum—where the passing of time seemingly necessitates a human being to live moment by moment in a designated order of coordinates.[9] As such, "[w]e seem free to move around in space at will, but in time we are like helpless rafters in a mighty stream propelled into the future at the rate of one second per second."[10] Human existence is limited to instances of seconds. Traveling through time and space diminishes our control and understanding of the moments lived and modifies the sequence of events experienced.[11] As J. Richard Gott stated: "One wishes one could sometimes paddle ahead to investigate the shores of the future, or perhaps turn around and go against the current to visit the past."[12]

Space exploration means the commencement of an odyssey that fundamentally influences humanity's position within the fabric of time itself.[13] The fabric of time can be illustrated as coordinates. These fascinating temporal coordinates are based on four dimensions, the fourth dimension being time.[14] For example, one of these coordinates

[4] FRANCIS LYALL AND PAUL B. LARSEN, SPACE LAW: A TREATISE 128 (3d ed. 2025).
[5] *See generally The Kuiper Belt*, NASA, https://science.nasa.gov/solar-system/kuiper-belt/ (last visited Feb. 10, 2025).
[6] *See Proxima b 3D Model*, NASA (May 1, 2019), https://science.nasa.gov/resource/proxima-b-3d-model.
[7] Goody et al., *supra* note 3, at 12.
[8] *See* William Grey, *Troubles with Time Travel*, 74 PHIL. 55, 57 (1999).
[9] *See id.*
[10] J. RICHARD GOTT, TIME TRAVEL IN EINSTEIN'S UNIVERSE: THE PHYSICAL POSSIBILITIES OF TRAVEL THROUGH TIME 4–5 (2001).
[11] *See id.* at 5.
[12] *Id.*
[13] Grey, *supra* note 8.
[14] *See* GOTT, supra note 10, at 8.

could represent the position of a traveler in space and time.[15] Think of a two-dimensional representation, where a chart on paper illustrates traveling to a particular point in any city. In this case, "o" equals the point of origin, "d" equals distance, and "h" equals height.[16] In that case, the final piece of the puzzle to assemble is the temporal coordinate, where "t" stands for time or the time of arrival.[17] For astronauts experiencing moments in time that deviate from those traditionally expected, law and physics must reconcile to facilitate their integration with cybersecurity into an intricate equation. The current discussions on emerging space operations highlight the difficulties and security challenges threatening space exploration.[18] It is a new reality in which political and military objectives intersect with escalating geopolitical tensions, and state-sponsored cyber attacks have become more common, highlighting the necessity to defend critical space infrastructure.[19] Understanding the intersection of cyberspace and outer space entails identifying technological and policy responses that promote humanity's well-being.[20] This intersection of cybersecurity and space becomes unexpectedly significant when analyzed from the perspective of the speed of light.

The principles of special relativity assert that the fundamental laws governing the universe maintain consistency across all uniformly moving inertial frames.[21] Think of life and every moment, every decision made as one of these frames. Special relativity asserts that the speed of light, denoted as "c," remains unchanged across all inertial frames and does not depend on the velocity of its source.[22] In other words, traveling into deep space requires tackling the consequences of the speed of light. "The speed of light traveling through a vacuum is exactly 299,792,458 meters (983,571,056 feet) per second. That's about 186,282 miles per second — a universal constant known in equations as 'c', or light speed."[23] The journey begins with the acknowledgment that, as posited by Einstein's theory of special relativity, no entity within the cosmos can exceed the speed of light, establishing a fundamental speed limit that governs the entirety of the universe.[24] Consequently, the travel speed of an astronaut holds little significance when contemplating the choices encountered in daily life or the constraints imposed by the speed of light. Albert Einstein's theory of special relativity posits that as an object approaches the speed of light, it's time experience diminishes relative to an observer at

[15] *See id.*
[16] *See id.*
[17] *See id.*
[18] *See* David Vergun, *Space Challenges Prompt DOD Response, Space Superiority*, U.S. DEP'T OF DEF. (Aug. 21, 2020), https://www.defense.gov/News/News-Stories/Article/Article/2321670/space-challenges-prompt-dod-response-space-superiority/.
[19] *See* Christian Vasquez, *Space Is Essential for Infrastructure. Why Isn't It Considered Critical?*, CYBERSCOOP (Apr. 1, 2024), https://cyberscoop.com/space-critical-infrastructure/.
[20] Roy Balleste, *Cyberspace Domain and Legal Norms*, *in* A RESEARCH AGENDA FOR CYBERSECURITY LAW AND POLICY 5, 6 (Roy Balleste et al., eds., 2025).
[21] AKHILA RAMAN, SPECIAL RELATIVITY AND TIME TRAVEL REVISITED 1 (2001).
[22] *Id.*
[23] Vicky Stein, *What Is the Speed of Light?*, SPACE.COM (Oct. 29, 2024), https://www.space.com/15830-light-speed.html.
[24] *Id.*

rest.[25] This concept is frequently exemplified via the "twin paradox" illustration.[26] In this scenario, one twin on Earth ages more rapidly than the twin in space, who journeys near the speed of light.[27] At such extraordinary velocities, it is anticipated that space crews will encounter time and space distortions, leading to a perception of distances and time intervals different from the experiences of their family members on Earth.[28]

Traveling through space changes how time passes for astronauts, raising questions about the meaning of human existence which transcends commercial, legal, and political considerations. A simple yet meaningful example of this physical reality, demonstrated mathematically by Einstein, is the case of Sergei K. Krikalev, a Russian cosmonaut who spent about 803 days in space.[29] Through the intricate tapestry of mathematical reasoning, his experience revealed that time unfolds at a different pace for those in motion, including any intrepid astronaut who traverses the cosmos.[30] For Krikalev aboard the Mir space station, hurtling through the void at 17,000 miles per hour, the passage of time diverged from time on Earth.[31] It is remarkable that during his time in orbit, Krikalev aged 1⁄48 of a second less than his colleagues on Earth.[32] This also meant that Krikalev moved 1⁄48 of a second forward in time.[33] Einstein highlighted the varied ways stationary and moving observers perceive time.[34] In space, this meant that Kirkalev moved 1⁄48 of a second forward in time, which seems contradictory given that aging less also suggests moving slower.[35] However, as noted above, the science of time travel describes that traveling through time allows the human body to age less.[36] In Krikalev's case, he aged 1⁄48 of a second less while traveling faster, which also meant that he moved 1⁄48 of a second forward.[37]

Addressing this inescapable scientific principle necessitates the realization that an analysis of long-duration missions incorporates the mathematics of time travel with space law and cybersecurity standards. Space lawyers are on a journey that transcends time. It is a conscious process of looking back at past events and interpreting them in new ways based on what is known and the growing lessons expected to be discovered, forming the tapestry of human life.[38] This concept, firmly anchored in the tangible world, exists within a legal lacuna. Moreover, evaluating the dangers looming over

[25] Alexander Simmonds, *A Study of the Legal Implications of Time Dilation in Accordance with Einstein's Theory of Special Relativity*, 9 CAMBRIDGE L. REV. 1, 1 (2024).
[26] *Id.*
[27] *Id.*
[28] C. Vernon Leopold & Allison L. Scafuri, *Orbital Space Flight Under International Law*, 19 FED. BAR J. 227, 230 (1959).
[29] Tim Folger, *A Brief History of Time Travel*, SCI. AM., Sep. 2015, at 68, 70.
[30] *Id.*
[31] *Id.*
[32] *Id.*
[33] *Id.*
[34] GOTT, *supra* note 10, at 8.
[35] Folger, *supra* note 29.
[36] *See* GOTT, *supra* note 10, at 33–36.
[37] Folger, *supra* note 29.
[38] *See* Shelli Fedullo, *Time Travel*, PHILA. LAW. Spring 2021, at 2, 3.

astronauts is essential for the triumph of any mission. Mission planners will confront the uncomfortable complexity of astronauts stranded on an alien world.[39]

The *Apollo 11* mission represents a significant milestone in the history of humanity and signified a crucial moment of great legal significance. On July 16, 1969, *Apollo 11* (a Saturn V rocket) soared into the vast expanse of the cosmos, bearing the intrepid astronauts Neil A. Armstrong, Michael Collins, and Edwin E. Aldrin on their momentous voyage beyond the terrestrial bounds of Earth.[40] This peaceful exploration mission highlighted humanity's capacity to reach and stand on another celestial body. Over time, space stakeholders have learned that human spaceflight inherently carries an elevated risk of mortality linked to every phase of the journey—launch, mission, and return.[41] While the great goal of human existence is to explore uncharted places, many questions remain about the negative health consequences of spaceflight.

This exploratory goal merits attention, as humanity has not had a chance to stand on the Moon in almost 60 years. Indeed, the next step, NASA's *Artemis Program*, serves as the successor to the *Apollo* missions, which are expected to take humans to the Moon and beyond.[42] The *Artemis Program's* initial goal is not new, but this program has the potential to usher humanity back into space exploration and pave the way for the inaugural lunar base project.[43] The real challenge in the not-so-distant future would be the Moon's outpost, Mars exploration, and deep solar system travel.[44] Conversely, the endeavors of space exploration should be planned alongside the inherent aspects of cybersecurity. NASA should foresee humanity's inherent shortcomings that could threaten a mission's success.

Humanity's grasp of its place in the cosmos remains elusive. Indeed, if humanity continues to be divided against itself, it could very well be a scenario of shattered dreams. According to Clausewitz, the development of gunpowder and the continuous refinement of weapons are sufficient to demonstrate that civilizational progress has done nothing practical to modify or divert the drive to kill the adversary.[45] What should be the ultimate objective of exploring the vast expanse of the universe? The outcome must be based on a solid understanding of the tenets of the rule of law. The rule of law is not inherent to any nation or political ideology. This is a global matter where due process is upheld, safeguarding justice without granting specific groups preferential rights.[46] In other words, a reasonable assertion would be that national space agencies cannot

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[39] *See* Roy Balleste, *The Ethics of Space Exploration: Harrowing Stories of Death, Survival, and the Unknown*, 37 CONN. J. INT'L L. 141, 145–55 (2022).
[40] ROGER D. LAUNIUS, APOLLO: A RETROSPECTIVE ANALYSIS 18 (NASA History Office eds,. 2004).
[41] *See* John A. Staples & Donald A. Redelmeier, *Fatality Risks on the Road and in Space*, 127(6) AM. J. OF MED., 467–68 (2014).
[42] *Artemis II*, NASA, https://www.nasa.gov/mission/artemis-ii/ (last visited Feb. 10, 2025).
[43] *NASA's Artemis IV: Building First Lunar Space Station*, NASA, https://www.nasa.gov/general/nasas-artemis-iv-building-first-lunar-space-station/ (last visited Feb. 10, 2025).
[44] Balleste, *supra* note 39, at 158.
[45] PETER PARET, CLAUSEWITZ AND THE STATE: THE MAN, HIS THEORIES, AND HIS TIMES 384 (2018).
[46] *See* Jimmy Carter, *Rule of Law*, 5 EMORY INT'L L. REV. 1, 2 (1991).

guarantee faith in their programs' supremacy over other nations. Without a doubt, space lawyers might find themselves at a loss for words when advocating for an opposite proposition.[47]

The upcoming decades will see governments enhancing their capabilities in space, focusing on safeguarding their critical space infrastructure. This endeavor will necessitate a thorough engagement with the intricate legal challenges arising from the cyber vulnerabilities linked to the exploration of space. The exploration of outer space extends to the realm of cyberspace, encompassing all its myriad activities. The phrase "exploration and use" found in the *Outer Space Treaty*,[48] needs to be assessed and interpreted from the science of cybersecurity. Cybersecurity and the *Outer Space Treaty* are relevant for cyber operations that may impact space activities.[49] Excluding these activities from the freedoms and utilization of outer space lacks any moral, scientific, or legal basis. Naturally, this prompts the question of what ought to be the next step in the search for the rule of law. A fitting prelude to exploration might concentrate on the rights and freedoms associated with utilizing outer space alongside technological advancements that have enriched the human experience.

II. Astronauts' Legal Status

Throughout the nearly sixty years of human space exploration, NASA has meticulously developed health standards for astronauts to tackle adverse health effects while minimizing the peril of fatalities associated with space travel.[50] Regrettably, for example, there have been instances where astronauts have perished during testing (Apollo 1, AS-204), during ascent (Space Shuttle Challenger, STS-51L), and upon their return through the atmosphere (Space Shuttle Columbia, STS-107).[51] While the concept of traveling through space is exciting, it is also a journey through a harsh environment.

To be an astronaut is to represent humanity in "the most hazardous and dangerous and greatest adventure . . . ."[52] For example, a prolonged expedition to Mars, lasting approximately 1,100 days or more, presents potential hazards to astronauts' health.[53]
Future voyages will involve astronauts entering interstellar space to explore the unknown as members of nations that boldly engage in long-term missions and leverage

[47] *See* K. N. Llewellyn, *On the Good, the True, the Beautiful, in Law*, 9(2) U. CHI. L. REV. 224, 230 (1942).
[48] G.A. Res. 2222 (XXI), art. 1 (Jan. 27, 1967) [hereinafter Outer Space Treaty].
[49] Balleste, *supra* note 20, at 19–20.
[50] *See* Robert E. Lewis, *Lifetime Surveillance of Astronaut Health (LSAH)*, NASA (Mar. 16, 2023), https://www.nasa.gov/directorates/esdmd/hhp/lifetime-surveillance-of-astronaut-health-lsah/.
[51] *See American Human Spaceflight Accidents*, NASA, https://www.nasa.gov/headquarters/library/find/bibliographies/american-human-spaceflight-accidents/ (last visited Mar. 1, 2025); s*ee also The Worst Space Shuttle Disasters and Accidents in Space: The High Price for the High Ambition*, ORBITAL TODAY (March 25, 2024), https://orbitaltoday.com/2024/03/25/the-worst-space-shuttle-disasters-and-accidents-in-space-the-high-price-for-the-high-ambition/.
[52] JOHN F. KENNEDY, ADDRESS AT RICE UNIVERSITY ON THE NATION'S SPACE EFFORT (1962).
[53] EVAN LINCK ET AL., HUMAN HEALTH FACTORS: EVALUATION OF HUMAN MISSION TO MARS BY 2033 105 (Inst. for Def. Analyses eds., 2019).

the advantages of wormhole technology to navigate immense distances at remarkable velocities.[54] Humanity's endeavors among the stars will hinge upon the intricate embrace of theoretical physics, where wormholes emerge as mysterious bridges linking disparate realms of the cosmos.[55] This notion is elegantly underpinned by the profound significance of Einstein's field equations.[56]

The space objects that promise to extend humanity's reach into deep space require novel ideas and new working alliances.[57] The catalyst of exploration points in one direction, and humanity's deep space probes are the proof. Humanity's desire for knowledge motivated the design of Pioneer 10 which was tasked with examining the interplanetary space between Earth and Jupiter and moving beyond into the unknown.[58] Pioneer 10 was the first spacecraft to leave our solar system.[59] These reflections raise a question about the essential understanding required to venture into the solar system. As astronauts prepare for the future, NASA recognizes 232 areas where knowledge is unavailable and outlines 1,097 tasks necessary to bridge the gaps and enhance the security of these voyages.[60] NASA's identified factors are found in a database known as the Human Research Roadmap.[61]

> The human research roadmap focuses on the key known risk factors that have been directly observed (e.g., renal stone formation, bone and muscle loss), while others are more theoretical based on evidence derived from non-space health risks or extrapolated to fit the extreme conditions of an extended duration mission to Mars (e.g., radiation exposure, inadequate nutrition).[62]

Another factor that NASA is contemplating, and one that other space agencies should emulate, is the role played by the cyberspace domain. The NASA Space Security Best Practices Guide delineates the requirements for the ground segment and the spacecraft to pursue mission security, encompassing fundamental principles and controls.[63] Future research must extend beyond unmanned systems, prioritizing the anticipation of potential cyber threats to astronauts. The development of best practices necessitates consideration of potential state-sponsored actors capable of compromising crewed

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[54] Michael S. Morris & Kip S. Thorne, *Wormholes in Spacetime and Their Use for Interstellar Travel: A Tool for Teaching General Relativity*, 56 AM. J. PHYSICS, 395, 396 (1988).
[55] *See id.*
[56] *See id.*
[57] John Shin, *Why Space Is the Next Frontier for Cybersecurity*, FORBES (Aug. 20, 2021, 7:45 AM), https://www.forbes.com/sites/forbestechcouncil/2021/08/20/why-space-is-the-next-frontier-for-cybersecurity/?sh=508a4a2a41b1.
[58] Carl Sagan et al., *A Message from Earth*, 175(4024), SCI., 881, 881 (1972).
[59] *Id.*
[60] LINCK ET AL., *supra* note 53, at 107.
[61] *Id.*; *see also Human Research Roadmap*, NASA, https://humanresearchroadmap.nasa.gov/ (last visited Mar. 1, 2025).
[62] LINCK ET AL., *supra* note 53, at 107.
[63] *NASA's Space Security: Best Practices Guide (BPG)*, SPARTA, https://sparta.aerospace.org/countermeasures/nasabpg (last visited Feb. 10, 205).

spacecraft systems. This underscores the necessity for the rule of law in international relations to be significantly influenced by an evolving legal framework that governs the expanse of the galaxy and its intrinsic resources, all in pursuit of humanity's collective aspirations.[64] In confronting the shadows cast by nefarious actions in cyberspace, it is essential for every space industry participant to recognize that the essence of human behavior intricately shapes the very fabric of cybersecurity, which transcends the limits of terrestrial existence. As the landscape of threats evolves to encompass a network of interconnected domains, stakeholders must brace themselves for a rise in vulnerabilities. For example, a vulnerability may involve using proxies to engage in internationally wrongful acts to harm another nation.[65] To enhance the safety of these journeys, space law must adapt to technological advancements and establish a comprehensive international legal framework that will safeguard the exploration experience.[66]

The goal of long-duration missions echo the spirit of the 1958 United Nations General Assembly Resolution on the *Question of the Peaceful Use of Outer Space*.[67] The General Assembly established the United Nations Ad Hoc Committee on the Peaceful Uses of Outer Space, which took stock of "legal problems which [could] arise in the carrying out of programmes to explore outer space . . . ."[68] Technological problems also need to be considered, which lie at the intersection of outer space and cyberspace. This naturally encourages stakeholders to consider the spirit of the *Outer Space Treaty*, the absolute importance of protecting astronauts throughout long-term missions, and the cybersecurity of evolving technological innovations. Which space law principle ought to preside over these circumstances?

While considering the same threats and possibilities around the space industry, the maritime industry demonstrates how operational activities have transitioned toward "digitalization, integration, automation, and networked-based systems."[69] The increasing vulnerability at sea means that security breaches place "humans and the environment at risk . . ." thus generating financial losses for the shipping industry.[70] For example, the "shutdown of Maersk operations in 13 international ports [caused] losses of 300 million dollars."[71] The greater lesson learned from these and similar cases is that threats originate with the human person at its center because human behavior is the unintended or intentional source of cyber mishaps.[72] Even more relevant for astronauts is the seriousness associated with isolation, limited resources, and the potential of being

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[64] CARL Q. CHRISTOL, SPACE LAW: PAST, PRESENT, AND FUTURE 495 (1991).
[65] *See* U.N. G.A., Rep. of the Group of Governmental Experts on Developments in the Field of Information and Telecommunications in the Context of International Security, U.N. DOC A/70/174, at 28(e) (2015).
[66] CHRISTOL, *supra* note 64.
[67] *See* G.A. Res. 1348 (XIII) (Dec. 13, 1958).
[68] *Id*. at paragraph 1(d).
[69] Marie H. Larson & Mass S. Lund, *Cyber Risk Perception in the Maritime Domain: A Systematic Literature Review,* 9 IEEE ACCESS 144895, 144895 (2021).
[70] *Id.*
[71] *Id.*
[72] *Id.*

stranded in a remote location.[73] These issues and related questions, no doubt, could be carried over to the ambit of outer space. Consider that modern ships are highly sophisticated "sailing villages" equipped with an array of communication and information technologies.[74] Their complexity increases the surface area of vulnerabilities. While the subject of cyber threats regarding crewed missions remains mainly unexplored, "[c]rew members could be the originator of an attack - the attacker, the means by which an attack is conducted - the attack vector, or the crew could be harmed by the attack - the target."[75] In other words, humanity's entrance into a new age of exploration propels the need to understand cybersecurity for the benefit of astronauts. Nevertheless, space law appears not to keep up with the objects being launched and the astronauts who will soon follow. This situation opens the door to an array of threats that deter humanity's expansion into space.

US astronauts are expected to return to the Moon and travel to Mars this decade, eventually launching long voyages to other areas within our solar system.[76] If astronauts explore deeper into the solar system, then the technology they use must be secure. The challenge begins with recognizing that the current law governing outer space lags behind the relentless surge of objects launched into space, the intricate threat of cyber activities, and the voyages of those brave enough to traverse the stars.

The designation of astronauts as representatives of humanity was first formally established in the *UN Resolution of 1962*, ratified by the General Assembly on December 13, 1963.[77] The last paragraph of such resolution states:

> States shall regard astronauts as envoys of mankind in outer space, and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of a foreign State or on the high seas. Astronauts who make such a landing shall be safely and promptly returned to the State of registry of the space vehicle.[78]

The need to explore outer space in search of new worlds seems far removed from the trivialities of human existence. Outer space inspires a vision of peaceful exploration for the benefit of humanity. More than a vision, it is the law. The *Outer Space Treaty*, Article I, states that:

> The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of

[73] *Id*. at 144902.
[74] P. H. Meland et al., *A Retrospective Analysis of Maritime Cyber Security Incidents*, 15(3) TRANSNAV: INT'L J. ON MARINE NAVIGATION & SAFETY OF SEA TRANSP. 519, 521 (2021).
[75] GEGORY FALCO & NATHANIEL G. GORDON, CYBERSECURITY AND HUMAN SPACEFLIGHT SAFETY 3 (2023).
[76] Candler Hobbs, *The Future of Space Exploration,* GEOR. INST. OF TECH., C. OF ENG'G (Nov. 17, 2021), https://coe.gatech.edu/news/2021/11/future-space-exploration.
[77] Hamilton DeSaussure, *Astronauts and Seamen - A Legal Comparison*, 10 J. SPACE L. 165, 169 (1982).
[78] G.A. Res. 1962 (XVIII), ¶9 (Dec. 13, 1963).

> all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.
>
> Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.
>
> There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation.[79]

This language, in relevant part, is repeated in the initial lines of Article V of the *Outer Space Treaty* as it incorporates the status of astronauts.[80] Article V states that:

> States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party or on the high seas. When astronauts make such a landing, they shall be safely and promptly returned to the State of registry of their space vehicle.
>
> In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties.
>
> States Parties to the Treaty shall immediately inform the other States Parties to the Treaty or the Secretary-General of the United Nations of any phenomena they discover in outer space, including the moon and other celestial bodies, which could constitute a danger to the life or health of astronauts.[81]

The most relevant treaty, which expands the language of the *Outer Space Treaty*, is the *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space* ("*Rescue Agreement*").[82] Article 1 of the *Rescue Agreement* states:

> Each Contracting Party which receives information or discovers that the personnel of a spacecraft have suffered accident or are experiencing conditions of distress or have made an emergency or unintended landing

[79] Outer Space Treaty, *supra* note 48.
[80] DeSaussure, *supra* note 77.
[81] Outer Space Treaty, *supra* note 48, at art. V.
[82] G.A. Res. 2345 (XXII) (Apr. 22, 1968) [hereinafter Rescue Agreement].

> in territory under its jurisdiction or on the high seas or in any other place not under the jurisdiction of any State shall immediately:
>
> (a) notify the launching authority or, if it cannot identify and immediately communicate with the launching authority, immediately make a public announcement by all appropriate means of communication at its disposal;
>
> (b) notify the Secretary-General of the United Nations, who should disseminate the information without delay by all appropriate means of communication at his disposal.[83]

Although not binding on most nations, the *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* ("*Moon Agreement*") provides additional and useful guidance in Article 10, paragraph 1:

> States Parties shall adopt all practicable measures to safeguard the life and health of persons on the moon. For this purpose they shall regard any person on the moon as an astronaut within the meaning of article V of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies and as part of the personnel of a spacecraft within the meaning of the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space.[84]

Furthermore, Article 10, paragraph 2 of the *Moon Agreement* states that: "States Parties shall offer shelter in their stations, installations, vehicles and other facilities to persons in distress on the moon."[85] The *Rescue Agreement* and the *Moon Agreement* were drafted in the wake of the *Outer Space Treaty*, which embodied distinct and particular stipulations that originated from its foundational principles.[86] In the case of any inconsistency, "the provisions of these subsequent treaties will generally prevail over those of the Outer Space Treaty for those States that are Parties to each of those treaties . . . ."[87]

However, it is unclear how an emergency would be legally tackled on Mars or how a disabled crewed spacecraft would be recovered from Neptune's orbit. Nothing in these treaty provisions is immediately helpful for astronauts in distress once they enter areas beyond the Moon.[88] The *Rescue Agreement*, in its essence, skims the surface of the historical human condition, relegating the complexities of existence to cislunar activities

[83] *Id.* at art. 1.
[84] G.A. Res. 34/68, art. 10 ¶1 (Dec. 18, 1979). [hereinafter The Moon Agreement].
[85] *Id*. at art. 10 ¶2.
[86] Ram S. Jakhu & Steven Freeland, *The Sources of International Space Law*, in Proceedings OF THE 64TH INTERNATIONAL ASTRONAUTICAL CONGRESS 461, 466 (2013).
[87] *Id.*
[88] Balleste, *supra* note 39, at 143.

and confining itself to a scant four articles addressing the actual rescue of astronauts.[89] Though these articles highlight the critical task of retrieving and reinstating astronauts to their rightful jurisdictions, they ultimately achieve little meaningful consequence in addressing matters of long-duration missions.[90] Indeed, it remains to be revealed how the whole body of fundamental laws will be modernized for times of astronaut distress past the Moon.[91] As humanity ventures into the uncharted areas of deep space, the paramount challenge remains in safeguarding astronauts' well-being during missions.

III. A Race Towards the Rule of Law

Consider a crew traveling through the vastness of deep space, propelled at velocities approaching the speed of light. The vessel, a vestige of a once-mighty space launch system, glides into an uncharted expanse of the cosmos. The fabric of time and space has woven an unexpected tapestry of events for the astronauts, yielding consequences that stretch beyond their imagination.

In the seminal film *Planet of the Apes* from 1968, the notion of a long-duration mission is examined, intertwined with the implications of time travel.[92] In this story, four American astronauts embark on a voyage into the vastness of deep space, crossing the galaxy at the speed of light.[93] The mission commander, Colonel George Taylor, contemplates the implications of *time dilation* during their journey.[94] Time dilation introduced by Albert Einstein within the framework of his special relativity, elucidates the consequences of traversing the fabric of time.[95] Time dilation refers to the event where the passage of time varies according to velocity.[96] A person in motion at a higher velocity perceives time at a reduced speed compared to a slower individual,[97] and "[i]t's only when they reconnect and compare their watches that they realize that one watch says less time has passed while the other says more."[98] As noted earlier, the theory posits that as astronauts approach the speed of light, their passage of time experiences a

[89] *Id*. at 144.
[90] Rescue Agreement, *supra* note 82, at arts. I–IV.
[91] DeSaussure, *supra* note 77.
[92] Planet of the Apes is a science fiction film released on April 3, 1968 by 20th Century Studios. It is based on Pierre Boulle's 1963 novel La Planète des Singes. *See* PLANET OF THE APES (APJAC Productions 1968).
[93] RICH HANDLEY, TIMELINE OF THE PLANETS OF THE APES: THE DEFINITIVE CHRONOLOGY 13 (2008).
[94] Wilson, *supra* note 2.
[95] Daniel Buzzo, *Time Travel: Time Dilation*, *in* ELECTRONIC VISUALISATIONS AND THE ARTS 171, 171 (2014).
[96] Michael Lam, *Why Does Time Change when Traveling Close to the Speed of Light? A Physicist Explains*, THE CONVERSATION (Mar. 20, 2023), https://theconversation.com/why-does-time-change-when-traveling-close-to-the-speed-of-light-a-physicist-explains-197189.
[97] *Id.*
[98] *Id.*

dilation effect, contrasting sharply with the experience of people back on Earth.[99] The story also highlights the fictional Dr. Otto Victor Hasslein, who had "theorized the existence of a space-time tangent as a means of interstellar travel."[100] Due to time's relativistic characteristics, Hasslein posits that humanity should be capable of traversing vast distances in space at very high velocities, with time passing more slowly for astronauts.[101] Hasslein was "[d]etermined to prove his theory, [and drove] congressional funding into the development of an experimental spacedrive."[102] The U.S. then sends astronauts into a deep space mission.[103] During their travel, Colonel Taylor gazes through the spacecraft's front window, marveling at the mysteries of the cosmos that unravel before him; as the spacecraft moves forward, the following scene and monologue take place:[104]

> Stars glitter like diamonds on the black velvet backdrop of space. The Belt of Orion is center screen, but much nearer and larger than ever seen by an Earth-bound astronomer.
>
> A speck of light appears in the lower left corner of the screen. No spaceship can be seen, but only a glowworm, a solitary spermatozoan gliding through the womb of the universe. Over this, we HEAR the voice of [Taylor]. He is concluding a report. . . .
>
> Within the hour we shall complete the sixth month of our flight from Cape Kennedy. By our time, that is . . . . But according to Dr. Hasslein theory of time in a vehicle traveling at close to the speed of light, old Mother Earth has aged a few thousand years since our departure -- while we have scarcely aged at all.[105]

The theory of special relativity is intricately examined in the story of Colonel Taylor and his fellow spacefarers, who ventured into the vastness of the cosmos in pursuit of a new world.[106] Following a six-month voyage through the vastness of deep space, the spacecraft slows down from high speed and begins to enter the atmosphere of a world

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[99] *See* Paul Sutter, *Interstellar Astronauts Would Face Years-Long Communication Delays Due to Time Dilation*, SPACE.COM (Dec. 5, 2023), https://www.space.com/time-dilation-interstellar-communication-delays; Samantha Thompson, *The Real-Life Effects of Lightyear's Time Dilation,* SMITHSONIAN (Jul. 10, 2022), https://airandspace.si.edu/stories/editorial/real-life-effects-lightyears- time-dilation; *see also* Vicky Stein, *Einstein's Theory of Special Relativity*, SPACE.COM (Feb. 1, 2022), https://www.space.com/36273-theory-special-relativity.html.
[100] HANDLEY, *supra* note 93, at 9.
[101] *Id.*
[102] *Id.*
[103] *Id.* at 13.
[104] Wilson, *supra* note 2.
[105] *Id.*; s*ee also History of NASA's Spaceport*, NASA, https://www.nasa.gov/kennedy/kennedy-space-center-history/ ("In November 1963, President Lyndon Johnson designated the facilities of the Launch Operations Center and Station No. 1 of the Atlantic Missile Range as the John F. Kennedy Space Center. The Air Force subsequently changed the name of the Cape Canaveral Missile Test Annex to Cape Kennedy Air Force Station.").
[106] HANDLEY, *supra* note 93.

that seems to be of extraterrestrial origin.[107] While this sci-fi story emphasizes the practical implications of special relativity, in 1962, cosmologist Carl Sagan, then a doctoral student, unveiled a long-duration mission concept in his presentation before the American Rocket Society, aptly titled *Direct Contact Among Galactic Populations by Relativistic Interstellar Spaceflight*.[108] In his presentation, Sagan articulated the concepts surrounding interstellar travel, exploring the velocities that could enable a human crew to travel through the vast expanse of the galaxy within the span of a single lifetime.[109] Einstein would have understood Sagan's concept because it relates to Einstein's three laws of motion, however, in the context of high relativistic velocity in outer space, these can be understood as follows:

1. All motion is relative;
2. There is no such thing as absolute motion; and
3. There is no location in the universe that can be said to be at rest and to which all other motion should be referenced.[110]

The laws of motion serve as a reminder that velocity is a meaningless concept without a point of reference.[111] Indeed, the observer's frame of reference is a significant factor in determining velocity.[112] Two decades after Carl Sagan unveiled his long-duration mission concept, Kip Thorne, a theoretical physicist and friend of Sagan, also tackled the concept of interstellar spaceflight.[113] Thorne's work considered another spaceflight approach through wormholes.[114] Throne states that "[a] wormhole is a hypothetical shortcut for travel between distant points in the Universe."[115] Sagan and Thorne mathematically demonstrated, albeit via different methods, that interstellar flight is possible. Their mathematical theories demonstrated how general relativistic equations can assist explorers seeking to launch to distant locations.[116]

In the same manner, the actions of external actors carry substantial implications for space law and international law. Confronting the perils of interstellar travel necessitates meticulous preparation which encompasses reliable engineering, comprehensive training, and pioneering legal arrangements. This is the setting, in essence, in which Colonel Taylor records the last part of his message:

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[107] *Id*. at 190; *see also* Wilson, *supra* note 2 (A Series of Shots – A Distant Globe).
[108] *See* Carl Sagan, *Direct Contact Among Galactic Populations by Relativistic Interstellar Spaceflight*, 11 PLANETARY & SPACE SCI., 485, 485–98 (1963).
[109] *Id.*
[110] JOHN OLIVER RYAN, IT'S REALLY ABOUT TIME: THE SCIENCE OF TIME TRAVEL 36–37 (2021); s*ee generally* ISAAC NEWTON, THE MATHEMATICAL PRINCIPLES OF NATURAL PHILOSOPHY (1867).
[111] RYAN, *supra* note 110, at 35–37.
[112] *Id.*
[113] *See* Morris & Thorne, *supra* note 54, at 395–396; s*ee also* Gautham Shenoy, *The Interstellar Contributions of Kip Thorne, the Man Carl Sagan Contacted for Physics Advice*, FACTOR DAILY (Oct. 7, 2017), https://archive.factordaily.com/interstellar-kip-thorne-nobel-prize/.
[114] *See* Morris & Throne, *supra* note 54; s*ee also* Shenoy, *supra* note 113.
[115] KIP S. THORNE, BLACK HOLES & TIME WARPS: EINSTEIN'S OUTRAGEOUS LEGACY 484 (1994).
[116] *Id*. at 484–91.

> One final thought -- nothing scientific, purely personal. Seen from up here, everything looks different . . . Time bends and space is boundless. It squashes a man's ego. He begins to feel like no more than a mote in the eye of eternity. And he is nagged by a question: [w]hat if anything, will greet us on the end of man's first journey to a star? Are we to believe that throughout these thousands of galaxies, these millions of stars, only one, that speck of solar dust we call Earth, has been graced -- or cursed -- by human life? . . . I have to doubt it.[117]

For reasons not clear at the beginning of *Planet of the Apes*, the spacecraft crashes into an Earth-like exoplanet in the area that the astronauts later discover to be known as the Forbidden Zone.[118] The astronauts emerge from their suspended state, only to find that what they perceived as a mere six-month voyage has unfolded into 2,000 years on Earth, a consequence of navigating the galaxy at velocities approaching the speed of light.[119] The astronauts unfortunately realize that they have leaped forward thousands of years into the future.[120] In the vast expanse of their journey, where the fabric of time bent and warped, mere moments for the astronauts translated into more than a millennium on Earth.[121]

The vast expanse of deep space presents a tapestry of shadows and immense voids, sculpting humans' domains beyond their terrestrial home. The intricate geometry of the cosmos is shaped by the principles of relativity which invites humanity to reevaluate its comprehension of space time. Missions to Mars, the solar system, and interstellar exploration will be subject to the time-travel effect.[122] The manifestation of this effect becomes increasingly apparent when considering greater distances and higher velocities.[123] When contemplating a scenario similar to cosmonaut Krikalev's journey but longer, one may envision a launch into the vastness of space in 2025 to embark on a round-trip spanning 50 light-years.[124] If the spaceship were to travel at a velocity nearing the speed of light ($v \approx 0.99c$ or approximately 99% of that speed), then when it returns to Earth, an astronaut would expect to find himself approximately 14 years older.[125] Even though only 14 years elapsed for him during his absence, a staggering 101 years would unfold on Earth, marking the year 2126, and a testament to the peculiar nature of time in the realm of relativistic travel.[126] This mathematical reality presents challenges that transcend the boundaries of what is known, requiring a search for new legal frameworks.

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[117] Wilson, *supra* note 2.
[118] HANDLEY, *supra* note 93, at 190.
[119] *Id.*
[120] *Id.*
[121] *Id.*
[122] Folger, *supra* note 29.
[123] *Id.*
[124] *Id.*
[125] *Id.*
[126] *Id.*

The challenge arising from this story pertains to the likelihood of a government or a private enterprise ignoring the principles of theoretical physics. By extension, it follows that if astronauts are to succeed in their quest for knowledge, their actions must be guided by well-thought-out legal principles. These principles extend beyond the realms of mathematics, physics, and engineering, incorporating the disciplines of law and cybersecurity. Notably, Article III of the *Outer Space Treaty* compels that activities in the exploration and use of outer space shall be carried out "in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding."[127] Thus, "the relevant rules of general customary international law apply to outer space relations . . . ."[128] New laws are needed in every area where humans engage in activities, including on land, in the air, in space, and online.

In addition to the need for new laws, human conflict must also be considered when addressing the intersection of space exploration and cybersecurity. The US Doctrine for Space Forces emphasizes what it calls "war's enduring nature."[129] One of the key themes to be considered is the human condition and how human conduct influences conflict.[130] This doctrine echoes Clausewitz's words: "'War is the continuation of politics by other means.'"[131] In other words, the doctrine indicates that conflict is a form of socially accepted aggression with political undertones.[132] According to the doctrine, and throughout historical events, every sphere in which humanity vies for political aims has invariably harbored the potential for discord, emphasizing that it is the human spirit that engages in conflict rather than mere weaponry.[133] If this is the case, then the importance of adhering to international law and utilizing space for peaceful endeavors takes on a new meaning. This meaning recognizes the need to protect space from those who may attempt to hinder US objectives in space.[134] This also serves as a reminder that NASA's research roadmap recognized the difficulties in assessing the circumstances of prolonged missions in deep space due to the distance and the absence of rescue or resupply options.[135] In this setting, the modern space lawyers and space cybersecurity experts are pressed to identify solutions to questions arising from an evolving dual-purpose outer space industry in which commercial activities may also be used for military purposes.[136] Recognizing outer space as a warfighting domain changes the traditional cybersecurity dynamics understood until recently. Consequently, pursuing the rule of law demands new ways to tackle cyber operations to ensure peaceful and safe space exploration.

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[127] Outer Space Treaty, *supra* note 48, at art. III.
[128] Jakhu & Freeland, *supra* note 86, at 467.
[129] U.S. SPACE FORCE, SPACE CAPSTONE PUBLICATION: SPACEPOWER: DOCTRINE FOR SPACE FORCES 17 (2020).
[130] *Id.*
[131] *Id.*
[132] *Id.*
[133] *Id.*
[134] *Id.*
[135] LINCK ET AL., *supra* note 53.
[136] Steven Freeland, *Peaceful Purposes? Governing the Military Uses of Outer Space*, 18(1) EUR. J. L. REFORM 35, 38 (2016).

IV. Cybersecurity Law for Long-Duration Missions

NASA's *Apollo 11* heralded a new era of burgeoning space endeavors and a remarkable triumph of scientific excellence, serving as an extraordinary testament to the unbounded spirit of exploration beyond our planet. Indeed, Neil Armstrong noted that humanity's path forward needed to transcend the atmospheric boundaries and venture into the vastness of deep space.[137] Nevertheless, the pursuit of outer space must be regarded as a matter of utmost significance. Armstrong articulated it profoundly when he noted the prevalence of the unknowns, for example, noting how the systems of the lunar module had undergone testing solely within the confines of Earth, never having been subjected to the actual conditions of the cosmos.[138] There were countless concerns to contemplate during the final descent to the Moon.[139] For the crew, the landing presented an extraordinary challenge.[140] This challenge highlights the significant nature of deep space exploration and the complexities of long-duration missions, raising questions that stretch the limits of human understanding.

The legal dilemmas we face on Earth extend into space and evoke a sense of unease about our current circumstances. Unease is undeniably the case, as the relentless march of technology continues. The reality is that the current legal structure in cyberspace feels more like mere guidelines than binding legal norms, and this condition is gradually tainting humanity's endeavors beyond our planet. It is essential to acknowledge the complexities surrounding space operations that require a candid recognition of the current state of international legal collaboration, characterized by its slower pace and, at present, a notable absence.[141]

In this tumultuous environment, due care continues to be crucial in launching best practices to protect an organization.[142] Examining the threats and challenges within the space industry indicates a wide array of vulnerabilities.[143] Nowadays, criminal behavior has taken root in cyberspace, which is both a complicated information highway and an arena for warfare.[144] Space infrastructure requires procedures, practices, and strategies to safeguard and defend it in an evolving new space arena. The core of information protection is reflected in availability, integrity, and confidentiality.[145] It involves an

[137] JAMES R. HANSEN, FIRST MAN: THE LIFE OF NEIL A. ARMSTRONG 85 (2018).
[138] *Id.* at 291.
[139] *Id.*
[140] *Id.*
[141] Benjamin Ramsey, *An Ethical Decision-Making Tool for Offensive Cyberspace Operations*, 32 AIR & SPACE POWER J. 62, 63 (2018).
[142] MICHAEL E. WHITMAN & HERBERT J. MATTORD, PRINCIPLES OF INFORMATION SECURITY 42, 230 (2016).
[143] Mark Manulis et al., *Cyber Security in New Space: Analysis of Threats, Key Enabling Technologies and Challenges*, 20 INT'L J. INFO. SEC. 287, 295 (2021).
[144] Roy Balleste, *supra* note 20, at 11; *see also* John McClurg, *Cyberwar and Cybercrime Go Hand in Hand*, DARK READING (Nov. 10, 2022), https://www.darkreading.com/cyber-risk/cyberwar-and-cybercrime-go-hand-in-hand.
[145] JENIFER CAWTHRA ET AL., DATA INTEGRITY: IDENTIFYING AND PROTECTING ASSETS AGAINST RANSOMWARE AND OTHER DESTRUCTIVE EVENTS Volume A (2020).

organization's overall risk assessment and considers laws, due diligence, due care, and related risk management strategies.[146]

Given the offensive capabilities of hackers, terrorist groups, and criminal organizations engaged in transnational hostile cyber operations, stakeholders in the space sector have a vital responsibility to protect their space endeavors. They must take the initiative and proactively seek out novel ways to address urgent cyber threats while tackling four main factors.

The first factor is distance. For example, the Earth is about 34 million miles (54 million km) away from Mars (assuming that Mars has reached a position of perihelion in its orbit around the sun and the Earth is at an aphelion position).[147] The second factor involves the time dilation effect, as discussed previously. The third factor involves a malicious cyber operation perpetrated by a nation-state or a rogue actor to harm a crewed spacecraft. Space industry stakeholders are increasingly vulnerable to criminal activities, including "organized crime, transnational terrorism, and nonstate networks."[148] To address this problem head-on, a security framework designed explicitly for the space era will clarify how cybersecurity concepts can be applied to long-duration missions. The emerging landscape is one where cybercriminal activity can be more dangerous than ordinary criminal activity.

A recent initiative by NASA presents a step forward in finding a solution: technical specifications necessary for space systems designed for human use. These Technical Standards "define technical requirements necessary to produce human-rated space systems that protect the safety of the crew and passengers on NASA space missions."[149] These standards involve crewed space systems that are either developed or operated by NASA, in addition to those utilized for conducting NASA's human spaceflight missions.[150] It has been noted that further steps may be underway. U.S. congressmen Maxwell Alejandro Frost and Don Beyer "have proposed the Spacecraft Cybersecurity Act."[151] Should it come to fruition, the proposed legislation would compel NASA to fundamentally transform its approach to procuring and constructing its spacecraft by integrating stringent cybersecurity protocols.[152]

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[146] MICHAEL WHITMAN & HERBERT MATTORD, MANAGEMENT OF INFORMATION SECURITY 365–66 (5th ed., 2017).

[147] *The Mystery of the Red Planet: How Far Away Is Mars from Earth and How Long Will It Take to Get There*, ORBITAL TODAY (Aug. 12, 2022), https://orbitaltoday.com/2022/08/12/the-mystery-of-the-red-planet-how-far-away-is-mars-from-earth-and-how-long-will-it-take-to-get-there/.

[148] MICHAEL MIKLAUCIC AND JACQUELINE BREWER, CONVERGENCE: ILLICIT NETWORKS AND NATIONAL SECURITY IN THE AGE OF GLOBALIZATION XIII (2013).

[149] NASA, NASA TECHNICAL REQUIREMENT FOR HUMAN-RATING 5 (2023).

[150] *Id.*

[151] Sharon Lemac-Vincere, *Nasa's Science Mission Spacecraft Are at Risk from Hackers, but a New Law Could Help Protect Them*, THE CONVERSATION (July 23, 2024, 10:48 AM), https://theconversation.com/nasas-science-mission-spacecraft-are-at-risk-from-hackers-but-a-new-law-could-help-protect-them-235234.

[152] *Id.*

The next challenge is found in pursuing an ethical approach to improve responses to external national threats. While stakeholders find the cyber domains' interconnectedness beneficial, this convenience has facilitated a diverse landscape of threats. Myers S. McDougal, an international law scholar, alludes to the idea of an outer space domain governed by a legal process associated with a free society, "with a very broad sharing of power, and that the kind of public order established by such legal process comport with, and facilitate achievement of, the widely proclaimed values of human dignity."[153] The application of the rule of law to space operations must temper a public order that shares power. This goal coincides with Article III of the *Outer Space Treaty,* which integrates legal principles into evolving events in outer space.[154] In this new space age, "[a] more *substantive* . . . *concept* of the rule of law would aspire to filling the idea of the law with notions of substantive justice."[155] Justice must shine on the actions of those who now enter the new age of exploration because "[f]ull-scale industrialization of outer space is underway, and space has become a critical arena for military strategists in the global duel."[156]

Finally, the ethical analysis of space activities is the fourth factor to consider. The ethics of space raise the most difficult questions, such as those involving extended missions against the backdrop of rising geopolitical tensions and other threats.[157] One question arises from this final factor. The question concerns the security of crewed vessels and the duty to bring astronauts safely back home. James S. J. Schwartz and Tony Milligan, experts in space ethics, delved into the importance of individual behavior in achieving optimal results.[158] They stress the importance of meticulously weighing choices, examining every possible consequence, and ultimately suggesting the path that appears most advantageous.[159] The space ethics framework is based on the contrast between the process of a mission and its ultimate achievement.[160] This duality arises from the need for equilibrium to ensure that the goals of space missions can be rationally defended.[161] The unfolding tapestry of contemporary conflicts reveals a perplexing reality: the complex interplay of space endeavors, cyber activities, and the very essence of human spaceflight lingers in a nebulous legal area. The harshness of the space environment

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[153] *See* Myers S. McDougal, *Law and Public Order in Space*, *in* LAW AND POLITICS IN SPACE: SPECIFIC AND URGENT PROBLEMS IN THE LAW OF OUTER SPACE 105, 106 (Maxwell Cohen ed., 1964).
[154] Outer Space Treaty, *supra* note 48, at art. III.
[155] Siegfried Wiessner, *The Rule of Law: Prolegomena*, ZEITSCHRIFT FÜR DEUTSCHES UND AMERIKANISCHES RECHT, GER.-AM. L. REV. 82, 83 (2018).
[156] Siegfried Wiessner, *The Public Order of the Geostationary Orbit: Blueprints for the Future*, 9 YALE J. INT'L L. 217, 217 (1983).
[157] *See* Roy Balleste, *Ethics and Space Law, in* ELGAR CONCISE ENCYCLOPEDIA OF SPACE LAW 86, 88 (Mahulena Hofmann & P.J. Blount eds., 2025).
[158] S. Baum, *The Ethics of Outer Space: A Consequentialist Perspective*, *in* THE ETHICS OF SPACE EXPLORATION 109, 109 (James S.J. Schwartz & Tony Milligan eds., 2016).
[159] *Id.*
[160] Daniel Munro, *If Humanity is to Succeed in Space, Our Ethics Must Evolve*, CTR. INT'L GOVERNANCE INNOVATION (Apr. 4, 2022), https://www.cigionline.org/articles/if-humanity-is-to-succeed-in-space-our-ethics-must-evolve/.
[161] *Id.*

exacerbates the complexity. Still, ensuring the expansion of space exploration continues to be a paramount goal.

V. Conclusion: Beyond the Horizon

Long ago, Portuguese navigators, with their maritime technology, promoted the development of the first exploration age.[162] Their sailing journey between continents ranged between twenty and seventy-five days.[163] These maritime times pale in comparison with the staggering distances between planets and even more between galaxies. Now, astronauts return to space to embark on a similar and perilous adventure. Safeguarding against the unseen dangers of cyberspace is crucial for the well-being and continued existence of the brave souls venturing into the infinite void of outer space. Should a new legal arrangement emerge to tackle the complexities of traveling in the vast expanse of outer space, this evolution must unfold with a sense of immediacy. Indeed, the specter of threats looms ominously, casting a shadow over the potential for exploration to thrive beyond our world.

[162] NAMRATA GOSWANI & PETER. A. GARRETSON, SCRAMBLE FOR THE SKIES: THE GREAT POWER COMPETITION TO CONTROL THE RESOURCES OF OUTER SPACE 9 (2020).
[163] *Id*.