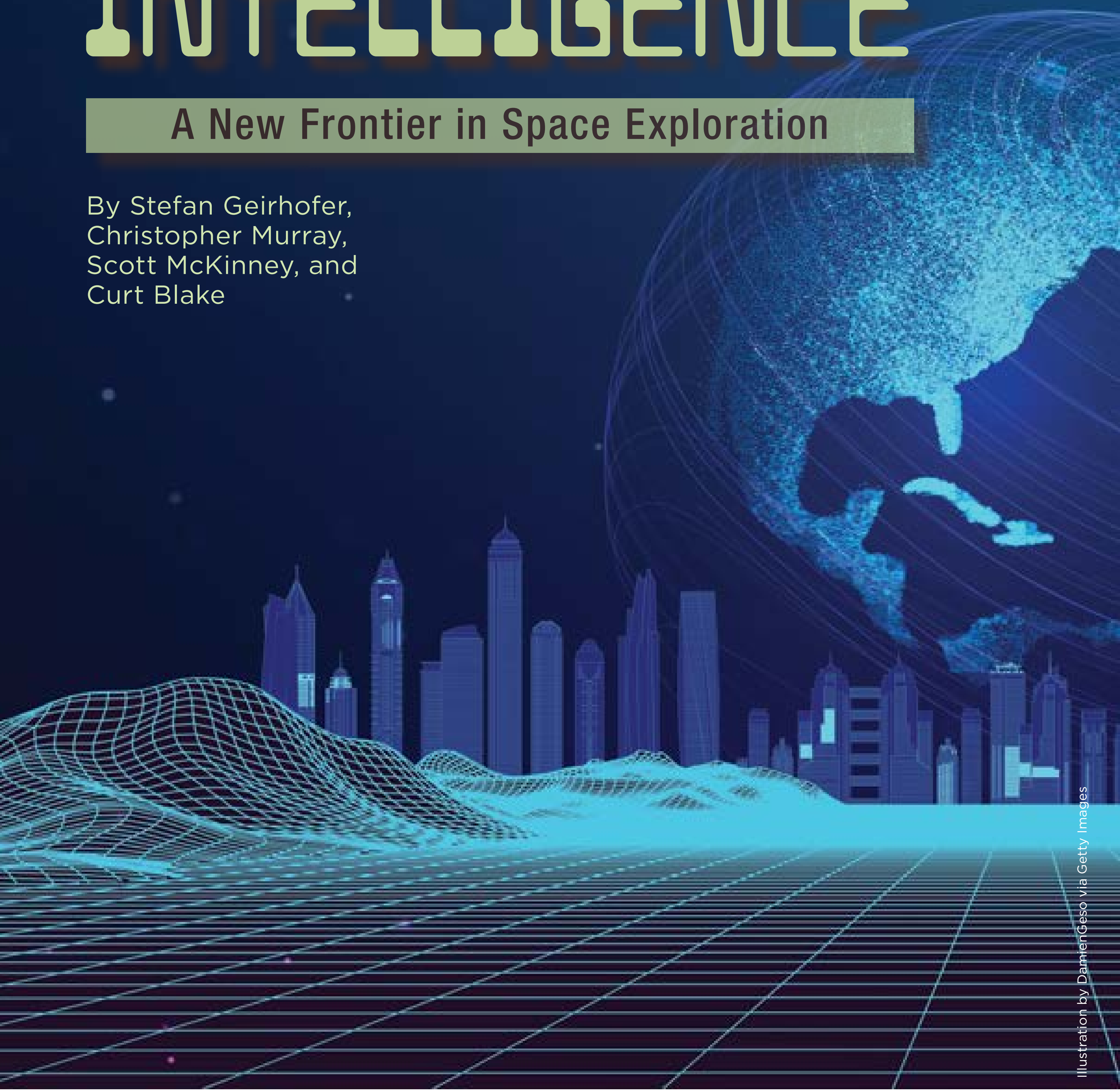
ARTIFICIAL INTELLIGENCE

A New Frontier in Space Exploration

By Stefan Geirhofer, Christopher Murray, Scott McKinney, and Curt Blake



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Commercial space exploration has seen rapid growth over the past decade and enabled applications that sound like science fiction: "self-driving" satellites that autonomously avoid collisions with space debris, spacecraft that continuously monitor Earth and use machine learning to sound the alarm upon detecting an anomaly, manufacturing applications for sensitive products like fiber optic cables or human organs, and data centers that operate in space. What would have been dismissed as fantasy not long ago is becoming a reality thanks to private investment in space exploration and advances in other high-tech fields, particularly artificial intelligence (AI). This article explores the intersection of AI and "NewSpace" with a focus on best practices for commercial contracting and protecting intellectual property (IP) rights in these frontier technologies.

USE CASES FOR AI AND NEWSPACE

AI technologies are quickly finding new and promising applications in the NewSpace industry, both on Earth and in space-based activities. On Earth, companies and public space programs are using AI for a wide array of applications, which range from product design (such as AI-assisted design of spacecraft or equipment) to AI-enhanced tracking and simulation of space-based events (such as orbital maneuvers and potential collisions).[1] Because these uses are carried out on Earth, however, they are subject to the same IP and liability regimes as other Earth-based activities, which are generally well-defined and understood. This article thus focuses primarily on potential implications of space-based applications of AI.

In space, applications of AI fall into three general categories: (1) the operation of space objects, such as satellites; (2) the observation of Earth and other celestial bodies; and (3) space-based research, development, and manufacturing efforts. Each of these categories raises unique, novel issues due to the international legal frameworks (or absence thereof) governing these activities.

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1. **Operation of space objects.** AI increasingly plays a role in helping space objects to navigate and act autonomously. Stanford researchers recently tested an autonomous satellite swarm in orbit, showing a potential future in which groups of satellites communicate and move in an automatically coordinated manner.[2] Already, though, satellites are using AI to help them navigate orbital maneuvers with some level of autonomy.[3] Satellites also communicate with Earth-based AI systems that alert satellites of potential collisions. Due to the rapidly increasing amount of in-orbit traffic and debris, these AI systems may well be the decisive factor in helping satellites to avoid potential collisions. As with self-driving cars on Earth, satellite autonomy (whether complete or partial) adds a new dimension to what happens in the event of a collision. In space, though, there is no default governing law to set the default rules in such an event, apart from the international treaties discussed below. AI's increasing role in the operation of space objects thus raises the question: What happens when satellites collide or cause damage to one another?
2. **Earth observation.** One highly valuable use of satellites is observing Earth-based events (known as Earth observation, or EO). To do this, satellites capture imagery or other signals that generally must then be sent to Earth-based computer systems to be processed into useful information. However, this process of data transfer is both time- and resource-intensive. AI is now being used to reduce the various bottlenecks caused by this constraint. For instance, the European Space Agency has introduced a miniature "cubesat" satellite that uses onboard AI systems to sort imagery, discard any unsatisfactory data, and then process useful data into insights that can be more efficiently downlinked to Earth-based systems.[4] The efficiency gains from onboard AI systems also are unlocking new EO use cases. The Group on Earth Observations recently reported that, in many of its work programs, AI is enabling the use of EO for higher-risk fields in which early detection is required, such as flood detection, hostile rocket launches, and wildfire monitoring. These use cases generally require multiple data transfers to produce the necessary information, but AI allows satellites to collect, sort, and process imagery onboard and then rapidly deliver already-useful insights to Earth-based systems.
3. **Space-based R&D.** Space has long been the setting for valuable research. Numerous research projects have been conducted on the International Space Station and, in more recent years, commercial satellites have contained research-oriented payloads. This research, though, is increasingly being augmented or automated entirely using AI systems. AI allows for significantly greater efficiency, given the especially high cost of sending humans into space. It also opens up entirely new research opportunities, such as deep space research for which direct human involvement is impractical or impossible. The microgravity environment in space also has proven useful for manufacturing certain delicate products, such as fiber-optic cables or human organs.[5] Both the increasing amount of space-based R&D and the increasing use of AI in connection with those efforts raise unique legal questions. For instance, who owns IP developed in space—and who (if anyone) owns such IP developed wholly by AI systems?

The applications noted above raise interesting legal questions due to the patchwork of international treaties and national laws associated with space launches and space-based activities. Allocating risk and mitigating potential ambiguity of IP ownership thus require an understanding of the interplay between these legal frameworks.

INTERNATIONAL TREATIES AS GUIDING PRINCIPLES

Space has traditionally been the exclusive domain of governments. The international treaties that form the backbone of space law date back to the 1960s and 1970s and provide important guiding principles on how space should be used by promoting peaceful use and prohibiting appropriation. While these guiding principles still permeate space law today, they leave many practical questions unanswered. The rise of commercial space exploration has highlighted these gaps and led to uncertainty about the protection of IP rights, the allocation of risks and liabilities, and the resolution of disputes among private actors.

The Outer Space Treaty is widely considered the Magna Carta of space law.[6] Negotiated during the Cold War and ratified in 1967, it seeks to promote the peaceful and scientific use of space by preventing nations from claiming space and celestial bodies as their territories, requiring that they conduct activities in space with "due regard" for the interests of other nations, and requiring nations to take responsibility for the activities of their citizens in space.

The Space Liability Convention of 1973 and the Registration Convention of 1975 expanded on these principles by requiring nations to assume responsibility for space objects launched from their territory or by their citizens.[7] This responsibility includes "absolute"

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liability for space objects that fall on Earth and fault-based liability for damage that occurs between space objects, such as due to a collision. The Registration Convention provides a recordation mechanism requiring states to maintain their own registry of space objects and providing updates to a registry maintained by the United Nations.

More recently, in 2020, the Artemis Accords have reaffirmed these principles and expanded on the principles of responsible use of space and cooperation among the treaty's signatories, including by encouraging the sharing of scientific data and conducting activities in a sustainable manner, such as by mitigating space debris.[8]

Yet, beyond these guiding principles, the foundational treaties leave many questions unanswered. For example, while prohibiting the appropriation of space and celestial bodies, can nations claim property interests in objects manufactured in space or on the moon? Similarly, if nations transport parts of asteroids or celestial bodies down to Earth, can they claim a property interest then? What about IP rights in new discoveries and products manufactured in space?

National laws have filled some of these gaps and generally sought to strike a balance between the competing goals of promoting space exploration and fostering a responsible use of space. Yet, applying national laws to space objects launched by or registered to that nation can result in tension with the high-level principles of sovereignty, jurisdiction, and enforcement set forth in international treaties. NewSpace companies should monitor evolving national laws relevant to their businesses as well as developments at the international level, particularly for applications that involve an interplay between different space objects or the manufacturing or creation of technology or IP rights in space.

IP PROTECTION AND ENFORCEMENT IN SPACE

IP laws are territorial in nature, meaning that an IP right granted in one country will generally not provide a remedy for infringing conduct in another. For space applications, patents and trade secrets are of key importance. Patents provide a time-limited right to exclude others from practicing an invention that might otherwise be exploited by a competitor's observing a satellite's behavior or algorithms. Trade secrets do not provide protection against independent development by others but offer certain protections against theft or unlawful reverse engineering. This article focuses on patent rights because misappropriation of trade secrets would presumably require access to the inner workings of a satellite or other space object, which would more likely occur on Earth than in space and therefore be governed by the national laws of the relevant jurisdiction.

International patent treaties have led to reasonably homogenous patent laws, which enable the registration of patent applications directed to a single invention in many jurisdictions subject to certain filing periods. Yet, even these international treaties are silent about conduct that occurs where there is no sovereign at all, as is the case in space.

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In the United States, Congress enacted the Patents in Space Act to expressly clarify that U.S. patent law applies to space objects registered with the United States as the launching state.[9] The act was motivated in part by a desire to clarify the law for activities conducted on the U.S. portions of the International Space Station, but it also extends to the expanding commercial U.S. space industry. The act shares similarities with the enforcement of U.S. patent laws on the high seas, where U.S. law similarly applies to U.S.-flagged vessels.

Despite this clarification, there remains uncertainty about enforcing other nations' patent laws on their registered space objects. For example, a U.S. company seeking to enforce its patents against another nation's space object would presumably need to apply for and have granted patents by that nation and then seek to enforce them in that nation's courts. Yet doing so may raise novel legal questions in nations that, unlike the United States, have not clearly extended their patent laws to their respective space objects.

Even if countries uniformly extended their patent laws to their respective space objects, there would still be novel legal questions associated with the operation of and interplay among space objects. For example, some space applications involve communication among satellites, whether for Earth observation, communication, or other purposes. Patents that cover such novel applications would be infringed by the interplay of multiple space objects—rather than infringing conduct that occurs solely within a single space object. Would national laws extend to such scenarios? It becomes even more complicated if space objects of different nations were involved.

Similarly, the scope of "space objects" is not clearly delineated under international law. Does the definition extend to objects made in space? Space's zero-gravity environment has proven conducive to manufacturing delicate objects ranging from cell cultures to fiber-optic cables. Although a manufacturing process occurring on a space object registered to a nation would

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arguably cover such fabrication, a patent directed to the end product itself may or may not be covered, depending on the interpretation of "space object." Recall that space objects are affiliated with a launching state, a phrase that leaves open how the creation of new objects in space (rather than "launched" objects) should be interpreted.

The issue of IP protection is further complicated by uncertainties surrounding the protection of patents directed to AI. Many countries are grappling with the issue of whether inventions obtained with AI assistance should be eligible for patent protection and, if so, who should own the resulting patents. For nongenerative, categorical AI systems that do not generate new content as output, there have traditionally been no limitations on patent eligibility aside from general eligibility requirements related to abstract ideas or software. However, the proliferation of generative AI systems that provide text, images, or computer code as outputs has raised the question of whether inventions created with the assistance of such AI models should be patent eligible, particularly in cases where a human operator is deemed to not have contributed significantly. As the caselaw of AI-assisted inventions develops, we may see a divergence between jurisdictions, which would lead to further uncertainty for space-based AI inventions in view of the jurisdictional issues discussed above.

COMMERCIAL RISK MANAGEMENT IN SPACE

Under the Space Liability Convention, nation states are responsible for space objects launched from their territory or by their citizens. Any claims are resolved between governments, however, with no room for private persons or companies to bring their own claims directly. Rather, private entities would petition their government to bring a claim at the international level. Practically speaking, the Space Liability Convention has been invoked only once in connection with the crash of a Soviet satellite in the 1970s in northern Canada.[10] The case was eventually settled by the Soviet Union through diplomatic channels and without an admission of fault.

Since nations can be liable for damage caused by space objects launched by or registered to them, some governments have established regulatory frameworks on a national level that require private companies to assume at least part of this liability. In the United States, for example, the Commercial Space Launch Act of 1984 sets up a framework that requires a waiver of claims among parties involved in the launch of space objects paired with mandatory insurance coverage. The federal government provides excess coverage for claims exceeding that amount.

These regulations, administered by the Federal Aviation Administration as part of granting a license for launching space objects, strike a balance between encouraging the safe use of space by having private actors assume responsibility for the risk of commercial endeavors and promoting private space exploration by covering potentially catastrophic liability beyond a cap that would be difficult to cover by insurance.

The required waiver of claims, which must be "flowed down" to subcontractors, serves the purpose of avoiding litigation among the customer and other contracting parties, who each must assume responsibility for injuries or property damage suffered by it or its own employees resulting from activity carried out under the launch license, regardless of fault.

The mandatory liability cross-waiver differs from more typical terrestrial commercial risk-management frameworks that allocate risk according to the category of claim, typically to the party best suited to minimize the risk. For example, a provider of on-vehicle software for an autonomous vehicle may be in the best position to defend and indemnify against a third-party's claims of IP infringement directed to the provider's software because the provider developed the software and is most familiar with its inner workings. However, liability resulting from a crash involving the autonomous vehicle would be more difficult to allocate and might require a root cause analysis to determine whether the on-board software, other parts of the vehicle, or perhaps even another motorist may have been at fault. For applications on Earth, the parties frequently negotiate indemnification provisions, representation and warranties, and limitation on liability to carefully allocate such risk. In space, absent gross negligence, this negotiated risk allocation is replaced by a statutorily mandated liability cap and insurance.

It is important to note that the liability cross-waiver is limited to injury or property damage and does not apply to other types of losses. For example, companies are free to establish contractual guardrails relating to IP rights whether in terms of ownership of IP rights developed in space or defenses against third-party infringement. While the jurisdictional issues discussed above still apply, parties are free to provide for assignments or allocation of IP as between themselves, possibly pursuant to any of the national laws that may be found to apply. Similarly, the parties may want to establish contractual guardrails against reverse engineering technology or source code embedded in their components. Such provisions provide contractual remedies to the parties even where a remedy under national IP laws or tort is not available due to jurisdictional challenges.

BEST PRACTICES FOR COMMERCIAL SPACE COMPANIES

Commercial space exploration companies should monitor national laws that apply in jurisdictions from which they conduct activities and determine the likely jurisdiction that will govern space objects launched by them. The same analysis applies to competitors' space objects as well since the enforcement of any IP rights against such competitors for conduct occurring in space may need to rely on the applicability of the space object's registration state. International law provides further guidance on the reach of a state's jurisdiction, particularly with respect to manufacturing in space (e.g., do manufactured

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articles on a space object remain part of the space object despite not having been launched) and any manufacturing on celestial bodies, such as the moon.

Moreover, companies should consider using contractual rights and obligations to fill gaps and ambiguities left by international and national laws. This includes contractual allocation and assignment of IP rights developed in space, as well as the commercial risk allocation mechanisms discussed above. While not enforceable against third parties that are not privy to such agreement, contractual mechanisms are a powerful tool to allocate rights and obligations between contracting parties. In the contract, the parties also would be free to resolve jurisdictional issues related to governing law and to provide for dispute resolution mechanisms, such as arbitration.

Lastly, companies should take advantage of regulatory frameworks that mitigate their liability exposure, such as in the United States, where the federal government covers liability above a certain threshold. To avail themselves of these protections, however, companies should ensure that they follow regulatory requirements, including binding subcontractors to the same cross-waivers through "flow down" provisions.

Stefan Geirhofer, Christopher Murray, Scott McKinney, *and* **Curt Blake** *are attorneys at Wilson Sonsini Goodrich & Rosati. Stefan and Christopher (both associates) as well as Scott (a partner) are members of the firm's IP and technology transaction group, where they frequently advise clients on AI, NewSpace, and other emerging technologies. Curt (senior of counsel) is a member of the corporate department and has served for more than 10 years in executive leadership roles at the forefront of the NewSpace revolution.*

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