THE CONVERSATION

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A giant piece of space junk is hurtling towards Earth. Here's how worried you should be

May 4, 2021 6.45pm AEST

China's Long March 5B rocket, part of which will plummet back to Earth in the coming weeks. Matjaz Tancic/EPA

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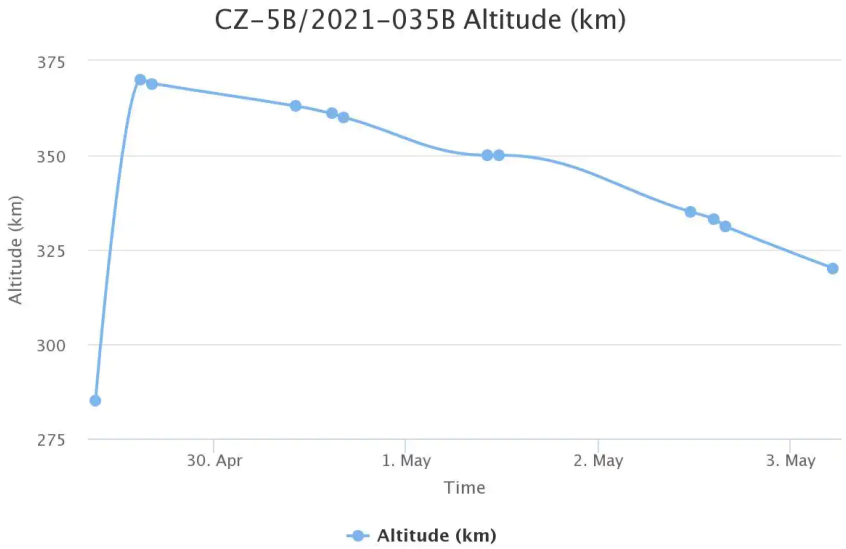
A large piece of space debris, possibly weighing several tonnes, is currently on an uncontrolled reentry phase (that's space speak for "out of control"), and parts of it are expected to crash down to Earth over the next few weeks.

If that isn't worrying enough, it is impossible to predict exactly where the pieces that don't burn up in the atmosphere might land. Given the object's orbit, the possible landing points are anywhere in a band of latitudes "a little farther north than New York, Madrid and Beijing and as far south as southern Chile and Wellington, New Zealand".



Changing altitude of the Long March 5B rocket now in uncontrolled descent back to Earth. orbit.ing-now.com

The debris is part of the Long March 5B rocket that recently successfully launched China's first module for its proposed space station. The incident comes roughly a year after another similar Chinese rocket fell to Earth, landing in the Atlantic Ocean but not before it reportedly left a trail of debris in the African nation of Cote D'Ivoire.

At the time, experts noted this was one of the largest pieces of human-made debris ever to fall to Earth. We cannot say with certainty what fate awaits this latest piece of space junk.

Litter from space

Australia already holds the record in the category of "who can be hit by the biggest piece of space junk". In 1979, the 77-tonne US space station SkyLab disintegrated over Western Australia, peppering the area around the southern coastal town of Esperance with fragments.

At the time, the event was met with with excitement and a sense of lightheartedness, and many pieces were collected by space enthusiasts. Esperance shire council flippantly issued NASA with a fine for littering, and a US radio station later raised enough money to pay the debt.

Pieces of Skylab are now on display in a local museum in regional Western Australia. James Shrimpton/AAP Image

Although there have been no recorded deaths or serious injuries from people being hit by space debris, that's no reason to think it's not dangerous. Just one year before SkyLab's demise, a Soviet

remote sensing (spy) satellite, Cosmos 954, plummeted into a barren region of Canada's Northwest Territories, spreading radioactive debris over several hundred square kilometres.

With the Cold War at its height, the sensitivity of the nuclear technology on board Cosmos 954 led to an unfortunate delay in locating and cleaning up the wreckage, because of the distrust between the Soviet Union and the Canadian/US recovery effort.

The clean-up operation took months but located only a portion of the debris. Canada billed the Soviet Union more than C$6 million, having spent millions more, but was ultimately paid only C$3 million.

Read more: Trash or treasure? A lot of space debris is junk, but some is precious heritage

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Since the late 1970s, pieces of space debris have fallen to Earth regularly and are viewed with increasing concern. Of course, more than 70% of Earth is covered by oceans, and only a minuscule fraction of the remaining 30% is covered by your house. But for anyone falling foul of the extremely long odds, the consequences would be truly disastrous.

It was just a quirk of fate that Cosmos 954 did not land on Toronto or Quebec City, where the radioactive fallout would have necessitated a large-scale evacuation. In 2007, pieces of debris from a Russian satellite narrowly missed a Chilean passenger plane flying between Santiago and Auckland. As we send more objects into space, the chances of a calamitous crash-landing will only increase.

Read more: Two satellites just avoided a head-on smash. How close did they come to disaster?

Who pays to clean up the mess, anyway?

International law sets out a compensation regime that would apply in many circumstances of damage on Earth, as well as when satellites collide in space. The 1972 Liability Convention, a UN treaty, imposes liability on "launching states" for damage caused by their space objects, which includes an absolute liability regime when they crash to Earth as debris.

In the case of the Long March 5B, this would impose potential liability on China. The treaty has only been invoked once before (for the Cosmos 954 incident) and therefore may not be regarded as a powerful disincentive. However, it is likely to come into play in the future in a more crowded space environment, and with more uncontrolled reentries. Of course, this legal framework applies only after the damage occurs.

Read more: It's not how big your laser is, it's how you use it: space law is an important part of the fight against space debris

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Other international guidelines regarding debris mitigation and long-term sustainability of space activities set out voluntary standards intended to limit the probability of collisions in space, and minimise the breakup of satellites either during or after their missions.

Some satellites can be moved into a graveyard orbit at the end of their operational life. While this works well for certain specific orbits at a relatively high altitude, it is impractical and hazardous to start moving the vast majority of satellites around between orbital planes. Most of the millions of pieces of space junk are destined either to orbit in an uncontrollable manner for many years or, if they are in low Earth orbit, to gradually descend towards the Earth, hopefully burning up in the atmosphere before contact with terra firma.

A globally coordinated space traffic management system will be vital to avoid collisions that would result in loss of control of satellites, leaving them to tumble helplessly in orbit or fall back to Earth.

Comprehensively tracking every satellite's movement and functionality is even harder than it sounds, because it would inevitably require countries to be willing to share information they often currently

regard as confidential matters of national security.

But, ultimately, global cooperation is essential if we are to avoid an unsustainable future for our space activities. In the meantime, don't forget to gaze upwards every now and then — you might spot some of the most spectacular litter on the planet.

Space junk Satellites Space debris Chinese Space Station

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It’s not how big your laser is, it’s how you use it: space law is an important part of the fight against space debris

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ESA

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Space is getting crowded. More than 100 million tiny pieces of debris are spinning in Earth orbit, along with tens of thousands of bigger chunks and around 3,300 functioning satellites.

Large satellite constellations such as Starlink are becoming more common, infuriating astronomers and baffling casual skywatchers. In the coming decade, we may see many more satellites launched than in all of history up to now.

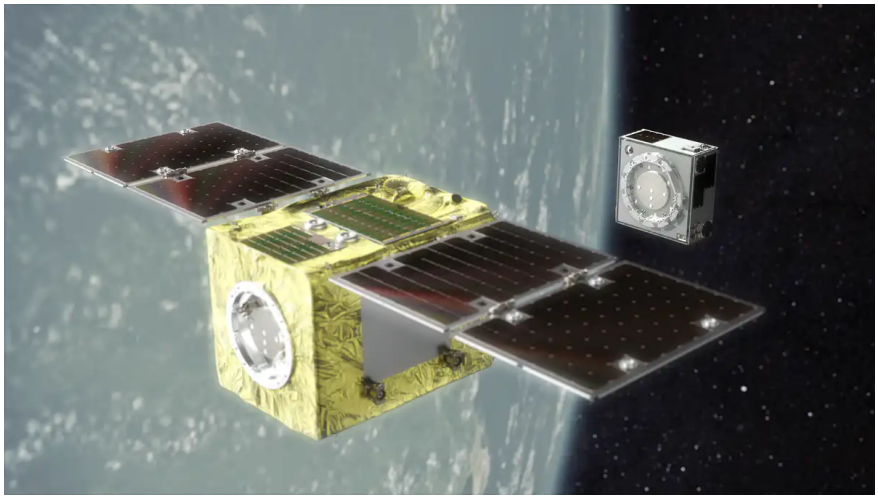
Collisions between objects in orbit are getting harder to avoid. Several technologies for getting space debris out of harm’s way have been proposed, most recently the plan from Australian company Electro Optic Systems (EOS) to use a pair of ground-based lasers to track debris and “nudge” it away from potential collisions or even out of orbit altogether.

Tools like this will be in high demand in coming years. But alongside new technology, we also need to work out the best ways to regulate activity in space and decide who is responsible for what.

Active debris removal

EOS's laser system is just one of a host of "active debris removal" (ADR) technologies proposed over the past decade. Others involve sails, tentacles, nets, claws, harpoons, magnets and foam.

Outside Australia, Japan-based company Astroscale is currently testing its ELSA system for capturing debris with magnets. The British RemoveDEBRIS project has been experimenting with nets and harpoons. The European Space Agency (ESA) is engaged in various debris-related missions including the ClearSpace-1 "space claw", designed to grapple a piece of debris and drag it down to a lower orbit where the claw and its captured prey will end their lives in a fiery embrace.



Astroscale's ELSA system will use magnets to capture space debris. Astroscale

Close calls are becoming more common

Space debris poses a very real threat, and interest in ADR technologies is growing rapidly. The ESA estimates there are currently 128 million pieces of debris smaller than 1cm, about 900,000 pieces of debris 1–10cm in length, and around 34,000 pieces larger than 10cm in Earth orbit.

Given the high speed of objects in space, any collision – with debris or a "live" satellite – could create thousands more pieces of debris. These could create more collisions and more debris, potentially triggering an exponential increase in debris called the "Kessler effect". Eventually we could see a "debris belt" around Earth, making space less accessible.

Read more: Two satellites just avoided a head-on smash. How close did they come to disaster?

In recent times, we have seen several "near collisions" in space. In late January 2020, we all watched helplessly as two much larger "dead" satellites – IRAS and GGSE-4 – passed within metres of each other. NASA often moves the International Space Station when it calculates a higher-than-normal risk of collision with debris.

More satellites, more risk

The problem of space debris is becoming more urgent as more large constellations of small satellites are launched. In 2019, the ESA sent one of its Earth-observing satellites on a small detour to avoid a high possibility of a collision with one of SpaceX's Starlink satellites.

In just the past few days, satellites from One Web and Starlink came perilously close to a collision. If the well-publicised plans of just a few large corporations come to fruition, the number of objects launched into space over the coming years will dwarf by a factor of *up to ten times* the total number launched over the six decades since the first human-made object (Sputnik 1) was sent into orbit in 1957.

Satellites like SpaceX's Starlink constellation will become an increasingly common sight in the night sky in coming years. Mads Claus Rasmussen / EPA

Space law can help

Any feasible technology to alleviate the problem of space debris should be thoroughly explored. At the same time, actively removing debris raises political and legal problems.

Space is an area beyond national jurisdiction. Like the high seas, space is governed through international law. The 1967 Outer Space Treaty and the four other international treaties that followed set out a framework and key principles to guide responsible behaviour.

While the engineers might envisage nets and harpoons, international law is bad news for aspiring space "pirates". Any space object or part of a space object, functional or not, remains under the jurisdiction of a "State of registry".

Under international law, to capture, deflect or interfere with a piece of debris would constitute a "national activity in outer space" – meaning the countries that authorised or agreed to the ADR manoeuvre have an international legal responsibility, even if the action is carried out by a private company. In addition, if something goes wrong (as we know, space is hard), a liability regime applies to the "launching States" under the applicable Treaty, which would include those countries involved in the launch of the ADR vehicle.

The rules of the road

Beyond the legal technicalities, debris removal raises complex policy, geopolitical, economic, and social challenges. Whose responsibility is it to remove debris? Who should pay? What rights do non-spacefaring nations have in discussions? Which debris should be preserved as heritage?

And if a State develops the capability to remove or deflect space debris, how can we be sure they won't use it to remove or deflect another country's "live" satellites?

Read more: Saving space junk, our cultural heritage in orbit

Experts are working to recognise and determine the appropriate regulatory "rules of the road". The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) deals with space governance, and it has had "legal mechanisms relating to space debris mitigation and remediation measures" on its agenda for years. There are already some widely-accepted and practical guidelines for debris mitigation and long-term sustainability of space activities, but each proposed solution brings with it other questions.

In the end, any debris remediation activity will require a negotiated agreement between each of the relevant parties to ensure these legal and other questions are addressed. Eventually, we might see a

standardised process emerge, in coordination with an international system of space traffic management.

The future of humanity is inextricably tied to our ability to ensure a viable long-term future for space activities. Developing new debris removal methods, and the legal frameworks to make them usable, are important steps towards finding ways to co-exist with our planet and promote the ongoing safety, security and sustainability of space.

Space Space junk SpaceX Satellites Space debris Space Law Starlink

THE CONVERSATION

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Cyberspace and outer space are new frontiers for national security, according to an expert report

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CSIRO / AAP

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What do cyberspace and outer space have in common? As we make clear in a new report to the Department of Defence, both are new frontiers for national security that blur traditional ideas about borders, sovereignty and defence strategy.

These “areas” are important elements of Australia’s critical infrastructure and are vital to our ability to defend our nation and keep it secure. They also have a “dual use” character: both areas (and often even individual pieces of equipment) are used for both military and civilian purposes.

What is sovereignty and why is it important?

Sovereignty is a legal and political concept. It generally refers to the authority of a country (nation state) to exercise control over matters within its jurisdiction – including by passing laws and enforcing them.

Historically, this jurisdiction was based primarily on geography. However, cyberspace and outer space are not limited by borders in the same way as territorial spaces.

Sovereignty also includes the power to give up certain sovereign rights, such as when countries agree to limit their own actions so as to cooperate internationally on human rights and national security.

Read more: Star laws: what happens if you commit a crime in space?

Cyberspace and outer space enhance our defence and national security capabilities, but our increasing dependence on continuous access to both also makes us vulnerable. These domains can be a source of unity and vision for humanity, but they can also be a source of tension and discord – and could easily be misused in the conduct of war.

Cyberspace

The world’s dependence on the internet has outpaced efforts at effective cyber security. For every “solution”, another threat arises. This can create serious vulnerabilities for defence and national security.

There is a general understanding that international law applies to cyber activities. However, the details of precisely *how* are not agreed. The debate generally concerns what military cyber activities are “acceptable” or “peaceful”, and which are prohibited or might be considered acts of war.

For example, during peacetime, international law is largely silent on espionage. Nation states can generally engage in cyber espionage without clearly violating their legal obligations to other countries.

Cybersecurity is an increasingly important element of national security. Lukas Koch / AAP

However, it can be hard to tell the difference between a simple espionage cyber operation (which might be permitted) and one carried out to prepare for a more disruptive operation (which might count as an “attack”). Both involve unauthorised access to computer systems and networks within another nation state, but working out who is responsible for such intrusions and their intentions can be an imprecise art.

Different countries have suggested various approaches to the problem. France and Iran say any unauthorised penetration of their cyber systems “automatically” constitutes a violation of sovereignty, irrespective of the reason.

Others, such as the United Kingdom and New Zealand, say a cyber operation must be sufficiently disruptive or destructive to count as a violation of sovereignty principles. These might seem like legal niceties, but they matter – they can determine how the impacted country might retaliate.

Outer space

Outer space is no less challenging. The "militarisation" and possible "weaponisation" of space represent a significant defence and national security challenge for all countries.

Outer space, like the high seas, is often seen as a global commons: it belongs to everyone and is governed by international law. A key tenet of international space law is that space may not be appropriated, which would prevent plans such as colonising the Moon or Mars.

The 1967 Outer Space Treaty, ratified by almost every spacefaring country, provides that the Moon and other celestial bodies are to be used "exclusively for peaceful purposes". It also forbids the placement of weapons of mass destruction in outer space and the militarisation of celestial bodies.

The treaty also imposes international responsibilities and liabilities on the countries themselves – even for transgressions carried out by a private entity. Everything revolves around the imperative to promote responsible behaviour in space and minimise the possibility of conflict.

Read more: Giant leap for corporations? The Trump administration wants to mine resources in space, but is it legal?

Initially, there were different views as to whether the peaceful use of space meant that only "non-military" rather than "non-aggressive" activities were permissible. However, the reality is that outer space has been and continues to be used for terrestrial military activities.

The 1991 Gulf War is often referred to as the first "space war". The use of satellite technology undeniably represents an integral part of modern military strategy and armed conflict for Australia and many other countries.

The situation is made more complex by the increasing interest in possible future mining in space and the potential rise of space tourism. There is also no clear international agreement about where to draw the line between sovereign airspace and outer space, or about what (and whose) criminal law applies in space.

Space sovereignty

At present, some 70-80 countries have some degree of sovereign space capability, including an ability to independently launch or operate their own satellites.

On the other hand, this means nearly two-thirds of the world's countries do not have any national space capability. They are completely dependent on others for access to space infrastructure and to space itself. Their ability to enjoy the benefits of space technology for development and well-being relies on strategic and geopolitical networks and understandings.

Even Australia, which is a sophisticated space participant, currently has relatively limited sovereign capability for space launches, Earth observation, GPS and other critical space activities.

However, it is not economically feasible for Australia to be wholly independent in every aspect of space. For this reason, Australia's twin policy of ensuring access to space through strategic alliances with selected spacefaring nations, while also developing further sovereign space capability in specific areas, is essential to Australia's defence and national security interests.

Looking forward

Addressing the intersection between cyberspace and outer space is vital for Australia's defence and national security policies. Both civilian and military actors participate in these domains, and the range of possible activities is rapidly developing.

We will need to understand the increasingly close intersection between cyberspace and outer space technologies to be in the best possible position to develop effective and integrated defence and national security strategies to meet the challenges of the 21st century.

Your heading here

Space Australia National security Cybersecurity Defence International relations

THE CONVERSATION

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Keen to sign up for space tourism? Here are 6 things to consider (besides the price tag)

July 23, 2021 3.22pm AEST

Blue Origin/AP

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It's been a momentous month for space-faring billionaires. On July 11, British entrepreneur Sir Richard Branson's Unity "rocket-plane" flew him and five fellow passengers about 85 kilometres above Earth. And this week, Amazon founder Jeff Bezos' New Shepard capsule reached an altitude of 106km, carrying Bezos, his brother, and the oldest and youngest people ever to reach such a height. Passengers on both flights experienced several minutes of weightlessness and took in breathtaking views of our beautiful and fragile Earth.

Both flights created an avalanche of media coverage and brand recognition for Branson's Virgin Galactic and Bezos's Blue Origin. There is renewed anticipation of a lucrative commercial space tourism industry that could eventually see thousands of paying passengers journey into space (or not quite into space, depending on your preferred level of pedantry).

This year marks 60 years since Soviet cosmonaut Yuri Gagarin became the first human in space. Since then, almost 600 trained astronauts have gone into outer space, but very few people have become space tourists.

The first, US engineer Dennis Tito, paid a reported US$20 million to spend six days orbiting Earth in the Russian section of the International Space Station in April 2001, after three months' training at

Russia's Star City complex. He was followed by a handful of other very wealthy "orbital tourists", most recently Cirque de Soleil founder Guy Laliberté in 2009, whose ticket reportedly cost US$35 million.

Unlike their predecessors, Branson's and Bezos' flights were suborbital – they didn't reach the velocity needed to orbit Earth. Bezos's entire flight lasted just over 10 minutes. Suborbital flights are much less technically complex, and in theory cheaper (although one seat on the New Shepard flight was auctioned for US$28 million).

You expect a luxurious interior when you pay this much. Michael Craft/Blue Origin/AP

While they might quibble over billionaire bragging rights, there's no denying that suborbital "space" flights have the potential to be less eye-wateringly expensive than going into orbital outer space and beyond.

But before you sign up – assuming you're lucky enough to afford it – here are a few things to consider.

Where does space start, anyway?

Despite assertions to the contrary, there is no legal definition of "outer space", and thus no official boundary where airspace ends and outer space begins. In the past, the International Aeronautical Federation has looked to the von Karman line, but this does not coincide with the boundary of any of the atmosphere's scientifically defined layers, and the UN Committee on the Peaceful Uses of Outer Space, which deals with such issues, has not yet resolved the question.

Conveniently for Branson, 80km has been proposed by some experts as an appropriate boundary.

Outer space is undeniably influenced by Earthly geopolitics. Essentially, the larger space-faring countries see no need to legally define a boundary that would clearly demarcate the upper limits of their sovereignty.

Will you be an 'astronaut'?

The 1967 UN Outer Space Treaty designates astronauts as "envoys of (hu)mankind in outer space". Certainly, that seemed to be the case as the world watched the historic Apollo 11 Moon landing and prayed for a safe return of the stricken Apollo 13 capsule. However, the 1968 UN Rescue Agreement refers to "personnel of a spacecraft", which may imply not everyone on board should be considered a fully fledged astronaut.

Of course, these legal niceties won't deter space tourism companies from awarding "astronaut wings" to their passengers.

Is Richard Branson an 'astronaut'? It's complicated. Virgin Galactic/EPA

What laws apply when things go wrong?

The 1986 Challenger and 2003 Columbia shuttle disasters are stark reminders of the dangers of space travel. Human space travel has always involved determining acceptable levels of risk for trained astronauts. But commercial space tourism is different to state-sponsored space programs, and will need the highest possible safety standards.

Commercial space travel will also require a system of responsibility and liability, for cases in which a space tourist suffers injury, loss or damage.

Space tourists (or their families) can't claim for compensation under the 1972 UN Liability Convention which, in terms of space, applies only to collisions between space objects such as satellites and space debris. While there may be scope to take legal action under national laws, it is likely space tourists will be asked to sign carefully worded waivers of liability.

Read more: Want to become a space tourist? You finally can — if you have $250,000 and a will to sign your life away

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The same is probably true of international air law, which applies to "aircraft" — a designation space tourism operators will understandably be keen to avoid.

Ultimately, we may need to develop a system of "aerospace law" to govern these suborbital flights as well as "transorbital" transport such as the keenly envisaged flights that might one day take passengers from Sydney to London in just a few hours.

What activities should be allowed in space?

The advent of space tourism will give rise to some interesting ethical questions. Should there be advertising billboards in space? What about casinos, or brothels? On what legal basis should these things be restricted?

How does tourism fit with the underlying philosophy of space law: that the exploration and use of outer space "shall be carried out for the benefit and in the interests of all countries"?

Will space tourism harm the environment?

Space tourism will inevitably put pressure on Earth's environment – there are claims that space vehicles may one day become the world's biggest source of carbon dioxide emissions. We will need to manage space traffic carefully to avoid disastrous collisions and steer clear of space debris.

Read more: It's not how big your laser is, it's how you use it: space law is an important part of the fight against space debris

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If tourists go to the Moon, they may cause pollution or damage the heritage of earlier exploration, such as Neil Armstrong's footprints.

Do not disturb. NASA

Will tourism workers have to live in space?

If space tourism does become truly widespread, it will need infrastructure and perhaps even staff. People may end up living permanently in space settlements, perhaps having children who will be born as "space citizens". What legal rights would someone have if they were born at a Moon base? Would they be subject to terrestrial laws, or some version of current international legal rules for outer space?

These are obviously questions for the future. But given the excitement generated by the brief journeys of a couple of wealthy entrepreneurs, we should start contemplating them now. Outer space is the new frontier, but it is not — and must not — be a lawless one.

Sustainability Ethics United Nations Space tourism Jeff Bezos Space debris
Richard Branson Virgin Galactic Space Law Blue Origin Space treaties Suborbital flight

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The limits of law: challenges to the global governance of space activities

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Abstract

The development of space-related technology since the dawn of the 'space age' in 1957 has given rise to many new and exciting possibilities. Humankind is now seeking to embark on a broad range of space activities and the utilization of this technology forms an integral element of the global society, such that the world is dependent upon constant and unimpeded 'access' to space. Yet, the existing international legal and governance framework, largely developed in a very different era of space activities (1960s–1980s), is now under strain to provide the necessary certainty, standards and protections to appropriately address specific uses of space that have emerged due to recently evolving space technologies. This gives rise to a number of significant challenges for the ongoing global governance of the use and exploration of outer space and, in particular, humankind's interaction with, and dependency on space-related technology. Important questions arise as to how to address these challenges in a way that will enable humankind to continue to use space for peaceful purposes and to garner significant benefits through such use for the benefit of the global society. This article highlights some of the major challenges that arise and outlines important factors that must be considered in developing appropriate legal, regulatory and policy frameworks for future space activities, so as best to serve the interests of current and future generations.

The complexity and ubiquity of space

On 4 October 1957, a Soviet space object, Sputnik I, was launched and subsequently orbited the earth over 1,400 times during the following three-month period. This milestone heralded the dawn of the space age, the space race (initially between the Soviet Union and the United States), and the legal regulation of the exploration and use of outer space.[1]

Since then, some fundamental international legal principles have developed that significantly improve the standard of living for all humanity through, for example, the facilitation of public services such as satellite telecommunications, global positioning systems, remote sensing technology for weather forecasting and disaster management, and television broadcast from satellites, coupled with many additional uses of space that are, and will be possible through

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the advent of the miniaturization of satellites.[2]

Furthermore, the scientific and exploratory nature of many space activities further enhances our knowledge of the universe in which we live, as well as the origins of the Earth and of humankind. We are now also looking at the prospect of establishing human settlements in space and further utilising and exploiting the natural resources of space that might ultimately be accessible to us.

Space is vital in terms of the world economy, strategic thinking, terrestrial military strategy, geopolitics, human rights, commercial enterprise, technological innovation and, frankly, the future of humankind. The impact of our use of space and the increasing range of space activities mean that law does and should have an important role to play in ensuring that such activities are carried out in an appropriate manner, with appropriate outcomes and benefits and for appropriate purposes. Moreover, the avoidance of a "tragedy of the commons" scenario[3] is crucial if humankind is to garner the maximum benefit from what space can offer.

Clearly, therefore, the prospects for the future use of outer space offer both tremendous opportunities and challenges for humankind, and law at both the international and national levels will continue to play a crucial part in this regard. It is in this context that this article sets out to briefly outline some of the various challenges ahead for legal regulation in this sphere.

Legal challenges posed by the development of space technology

Given the rapid advance of technology in so many spheres and the clear reality that, in many respects, the world is becoming "smaller" and increasingly "internationalized," there is an imperative to explore the fundamental design elements of supranational legal governance for issues of global concern — for example, the impacts of climate change, world poverty, the global commons and international criminal justice[4] — whilst also retaining a grounded view of their significant practical contemporary relevance.

Since the exploration and use of outer space is so impactful on this ongoing evolution, leading as it does to so many changes in the way that individuals, communities, cities, nations and the world operate and exist, this is equally the case when it comes to the regulatory and policy frameworks for space activities. The sheer pace of change and the broadening of potential activities in outer space dictates that we need to continually monitor the scope and content of this framework, whilst at the same time recognising that, at least from a strictly legal regulatory perspective, it will not (ever) be possible for the law to keep up with these changes.

This is highlighted, for example, by the interaction between space technology and another area of great relevance to future global/international regulation: that of cyber law and cyber security. It is important to recognize that the important issues that arise from the continuing development of

2 See Freeland (2019).

3 See Hardin (1968). For a discussion of the implications of the tragedy of the commons to the use of outer space, see Freeland (2017a).

4 For an example of the interplay between the use of space technology and the promotion of international criminal justice, see Freeland & Jakhu (2018).

cyber technology are increasingly relevant for the regulation of outer space, given the increasing rush towards a "digitization" of space activities. Just as there have been past lessons for space law in considering the legal regime established for air space, so it is important for the future development of space law to understand the complexities — from a jurisdictional, technical, commercial, societal, cultural and security-related perspective — that arise with respect to the use and regulation of cyber space.

There are clear parallels between the two regimes of outer space and cyber space, not only in considerations impacting on the law-making side, but also due to the seemingly endless development of technology that results in the activities of these two realms becoming ever more interdependent. In many respects, they act together in the one ecosystem, each reliant on the other for their respective efficient functioning, development and ongoing operational viability, not to mention the important associated national security considerations.

Indeed, it is increasingly necessary to design space infrastructure with a clear reference to the cyber-related elements associated with the implementation, utilization and application of that infrastructure. In this regard, it is somewhat curious that, in quite of number of countries, Governments have devoted considerable resources towards the establishment of systems designed to protect the cyber capability and operations of that country, but have not perhaps been as cognizant to devise similar protective systems for their space assets.

Instead, a different mantra — one involving the call for defensive space weapons — seems to have been accepted as the most appropriate (and in some cases, only) way in which to protect important space infrastructure. A closer consideration of the interplay between cyber capability and space operations is an equally (and perhaps more compelling) strategy to work out appropriate national security measures to minimize the possibility that space assets might be compromised by the actions of other States.

Bearing in mind the rapid development of space-related technology, and the legal challenges that this represents, it is pertinent to reflect on the fact that, in 2017, we celebrated the 50th anniversary[5] of the first — and most significant — of the United Nations space treaties, which is usually referred to as the Outer Space Treaty.[6] During that celebratory year, this author was invited to give a number of keynote speeches at various events to commemorate that important event. In the course of preparing for those speeches, this author had cause to look at an important collection of essays entitled *Outlook on Space Law over the Next 30 Years*, which was published on the occasion of the 30th anniversary of the Outer Space Treaty in 1997.[7]

It is interesting but perhaps not surprising that, barely two-thirds of the way through the second 30-year period following the finalization of the treaty, virtually all of the "possible"/"maybe"/"perhaps" innovations in space canvassed in that book are already a reality or near reality, with some of

5 The year 2017 was, of course, also another significant anniversary year — the 60th anniversary of the Sputnik 1 mission.

6 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (Outer Space Treaty) 610 UNTS 205.

7 Crowther (1997).

them now part of mainstream space activities.

Another interesting observation is that — again not surprisingly — that book centres around the Outer Space Treaty and the traditional actors involved in space activities. Whilst, of course, both the treaty and the existing space participants will continue to be very significant in the future regulation of space, it is incumbent on us all to take a "holistic" view of how space inter-relates with every aspect of life and what this means in terms of constructing the most appropriate legal and regulatory frameworks going forward.

Indeed, the dream of space, and the desire of humankind to engage with space in more and more ways, has driven the development of space-related technology far more quickly, and in ways that would not have seemed imaginable even a few years ago. And, as typifies much about the development of legal rules in a sphere driven by technological innovation, space law has not, as noted above, kept pace with the multitude of space activities about which we can now marvel, and therefore there might increasingly arise various concerns and uncertainties as to how best address the vast complexities that specific uses of space may give rise to.

Nor, in this author's opinion, *should* law purport to keep pace with this technological change with respect to space, given that the developments are so rapid and fluid. Today's technology is often quite quickly rendered obsolete (or at least insufficient) in tomorrow's world. To assert, therefore, that the legal framework is completely up-to-date in every way is therefore misleading and may even lead to complacency. Conversely, to attempt to provide for every conceivable future development might amount to seeking to regulate for the "unknown," which brings with it another set of inherent risks.[8]

Rather, the most appropriate methodology for addressing these changes is to understand the direction that they are taking and to introduce frameworks with a sufficient degree of flexibility, so as to allow the broader principles to remain applicable to new activities even if the express regulatory provisions for specific "new" space activities are not always comprehensively articulated.

This indeed mirrors the "success" to date of the fundamental principles of space law expressed in the Outer Space Treaty. These remain highly relevant and foundational — perhaps even more so than ever — these five decades later notwithstanding that we are now in a very different space "world." In this author's opinion, those who express the view that the fundamental principles of international space law are somehow outmoded or irrelevant are, in reality, frustrated that they are an "inconvenient" restriction to certain military uses of outer space that violate the essence of the way we are to operate in space. Such views are misguided and demonstrate a lack of understanding of the complex history and geopolitical environment underpinning the development of international space law, as well as the object and purpose of the United Nations space treaties.

The evolution of space activities since the days of Sputnik 1 — and the associated laws and guidelines that regulate those activities — has seen a transformation from an era where, initially, only two States dominated the scene, to one where there are a growing number of space-faring States

8 See Freeland (2017b).

(currently estimated to be around 60–70).[9] This, coupled with the exponential growth of commercial opportunities, has historically seen primarily large and well-funded companies invest heavily in space technology, with a view to reaping significant economic returns.

The beginning of the 1990s saw the commercialization of space really start to expand rapidly. By 1998, the spend on commercial space had caught up to Governmental space expenditure and, whilst both have grown rapidly since then, the commercial sector now significantly exceeds the non-commercial space sector in terms of investment. In overall terms, it has been estimated that the total value of the global commercial space "industry" in 2018 was approximately US$385 billion (representing an annualized growth rate of 7% since 2005), and that this figure is anticipated to grow exponentially to somewhere between US$1–3 trillion by 2040.[10] Whatever the correct upper amount, it is clear that the commercialization of outer space is a powerful factor and a major growth area, rising at a much faster rate than the overall global economy.

The enticement of such significant growth, together with the development of technology that enables and facilitates new and potentially lucrative opportunities in space, appear to be an attractive proposition not only for the established space-related companies, but also for a new breed of space entrepreneurs and smaller (and perhaps nimbler) space entities.

Much has been written about this trend towards the commercialization and privatization of space, and the increasingly important role that non-governmental actors play, not only to serve the needs and demands of civil and commercial end users, but also those of States and even military customers. These trends will, if anything, continue at an increasing scale given the trend towards the "democratization" of space as new actors emerge due to developing technology. This will, undoubtedly, present considerable additional challenges to the overarching 'global commons' legal characterization of space, and the principle of freedom of use of space,[11] that stem from the fundamental roots of space law.[12]

Innovations such as nano/small satellite technology and human aerospace flight will, ultimately, bring "space to more people" in a tangible way: through direct participation and entrepreneurship. This is very important since, perhaps not surprisingly, those involved in the space regulatory "industry" have not "sold" the idea of space, and its significance to the general public, very effectively at all in the past.

As an example, just a few short years ago, this author picked up a copy of the *Wall*

9 Of course, viewed from another perspective, this also means that approximately two-thirds of the world's countries do not have any indigenous space capability whatsoever, placing them at an increasing comparative disadvantage over time and rendering them entirely dependent on others for access to space infrastructure. Obviously, this gives rise to sovereignty and national security concerns for those States.

10 See Higginbotham (2018).

11 Article I of the Outer Space Treaty provides in part as follows: " … 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."

12 See Freeland (2017c).

Street Journal whilst in Canada and was surprised and initially delighted to see that the front page had an article about space law. He was quickly brought down to Earth, so to speak, by the headline — "If a Martian Wrecks Your Rocket Ship, Who is Liable?"[13] Is this really what people think about the scope and importance of space law? Despite everything that space-related technology can and does do to raise the standard of living for the entirety of global humanity, is this the best that can be said about the laws that make this possible?

It seems quite extraordinary in this day and age that one great challenge for space law has often been is to get people to actually take it seriously. Those of us who have discussed with our respective Governments the need to establish rational, practical and appropriate legal and regulatory frameworks for the development of a viable space industry at the national level have in the past sometimes been met with counter-arguments stemming from inertia and conservatism, financial concerns, differing priorities and, unfortunately, a lack of understanding.

This situation has now changed somewhat — although not universally — and the truth of the matter is that space is, of course, very real and not something to be derided or ignored, but rather a vital element for the very future of our life here on Earth (and perhaps beyond). No country can afford to fall behind its friends and neighbours in relation to important aspects of its space development.

As noted, space impacts on every country and must be embraced in the most appropriate way for each nation, irrespective of its economic, political or industrial circumstances. In short, no longer is space a "luxury" just for the space "haves:" it is now an imperative for all countries and represents an essential part of their vital infrastructure. Appropriate "rules of the road" are therefore necessary and the challenge is to ensure that these provide the best possible way forward in the circumstances of an ever-changing technological environment.

How to address the major legal challenges

In view of this evolving situation, each country is, or should be, asking the same questions: what does the development of space technology mean for us? How can we maximise our ability to take advantage of the use of space for our continuous development? Do existing national laws or policies unduly inhibit or restrict the development of a viable and self-sustaining domestic space "industry," or can they be categorized as "enabling"? What regulatory framework is most appropriate for us in terms of our risk profile, capability, needs, culture, economic circumstances, national security situation and strategic alliances? How can this framework be constructed in a way that is adequately "future proofed" (if indeed this is at all possible)?

The answers for each country will be different, but there is no mistaking the need to address the implications of our ongoing development of space-related technology. They pose great opportunities but their management and regulation — both at the international but, even more significantly, the national levels — raise difficult questions for all decision makers and for the creation of legal frameworks.

13 Hope (2015).

As such, we are standing at the dawn of a new era in space activities, which will require very considerable thought as to exactly *how* to adapt, and adopt, appropriate legal frameworks that are able to strike the most appropriate balance between sometimes competing interests. There is an urgent need to comprehensively assess these challenges and to develop and design the structure and content of these frameworks.

In order to be relevant, innovative and sufficiently "forward-thinking" to properly advance the field of space law, the development of these frameworks to meet the challenges of the 21st century must incorporate a comprehensive approach, breaking down the "silo" mentality that has traditionally characterized not only existing legal research, but also the current space "law-making" and regulatory processes.

In essence, the challenge — indeed the imperative — is to develop legal and regulatory frameworks to properly address the demands and inevitability of technological innovation and an increasingly globalized and connected world, not the other way around.

This represents an enticing opportunity for space lawyers to play an even greater role in the context of the so-called "NewSpace" phenomenon, by engaging more actively with new participants in space and therefore advocating for appropriately balanced enabling laws and legislation to allow for the most progressive path forward. It is not the time for detached and overly academic law-making, rather the future space law regimes must be closely integrated with and aligned to the sheer breadth of influence and impact that space technology does and will assume.

There are other examples of legal challenges ahead for space law. In order to systematically approach these challenges, we must first understand the issues that they give rise to: only then are we in a position to construct, through a cooperative and multi-disciplinary approach, the laws and standards that will allow humankind to maximise the benefits to be garnered from the exploration and use of outer space. The position is so fast-moving and fluid, given the speed at which innovation and technology develop, that it is neither possible nor appropriate to any longer attempt to rely *exclusively* on the traditional principles — as important as they will remain — that are to be found in the United Nations space treaties.

Nor can we then rely on a simple "copy/paste" transposition of terrestrial international law principles to somehow fill the gaps in the extra-terrestrial regulation of activities that are clearly beyond the contemplation of the original drafters of the United Nations space treaties. This author has listened with interest to commentators who latch on to article III of the Outer Space Treaty[14] — which provides that activities in outer space shall be carried on in accordance with international law — and who then make a quantum leap to their "eureka" moment, to postulate that laws that were developed on Earth for terrestrial activities can somehow magically fit into the unique environment that is outer space. This is a seductive conclusion, but, in this author's opinion, far too simplistic to adequately

14 Article III of the Outer Space Treaty provides as follows: "States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding."

meet the realities. Square pegs do not seamlessly fit into round holes.

With respect to perhaps two of the most pressing challenges for space law — the long-term sustainability of space, and the potential militarization/weaponization of space — the existing terrestrial environmental principles on the one hand,[15] and the laws of armed conflict on the other,[16] whilst relevant, are certainly not adequate or necessarily appropriate in various respects to meet the complexities that these issues present. Both of these pressing questions require specifically crafted legal rules that, even if they do draw on terrestrial law for some inspiration or comparison, are specifically designed to meet the peculiarities that stem from our legal characterization of outer space, as well as the complex non-legal factors that impact and shape the broad range of space activities.

The attempts to deal with these challenges thus far have largely been exploratory, generalized, and on a non-binding and voluntary basis. Whilst much has been made of the importance of "soft law" instruments[17] in shaping the face of the space regulatory regime, this author has reservations as to whether such an approach serves us well in the longer term, particularly in relation to such important issues in the context of our future uses of outer space and, indeed, in many respects, for the future survival of the human race.[18]

Notwithstanding the legal "value" that some such instruments may have, at their core they are merely guidelines or recommendations that do not necessarily have the force of law, unless they are to be regarded as reflecting rules of customary international law, itself a very difficult assertion to substantiate in the absence of, say, a finding to that effect by the International Court of Justice.[19]

Given our increasing reliance on such non-binding measures in a whole range of space-related matters, do we run the risk that they will work only until they don't? Shouldn't they always be regarded only as interim measures, until traditional international law principles can be agreed and applied? And, indeed, is this approach feasible given the multitude of concerns associated with the continued development of space-related weapons technology, and the environmental (and other) risks that they pose?

Ideally, binding treaty norms should be negotiated, to be adhered to in good faith by all relevant States. Of course, in the absence of a change of approach between, in particular, the major space powers, treaty rules are unlikely to come to fruition in respect of these issues in the short and perhaps medium term. Instead, so-called non-binding Transparency and Confidence Building Measures (TCBMs) are articulated as the way forward and are expressed to be stepping-stones towards a more formally binding agreement. The risk is, of course, that

15 See, for example, Boyle (2013); Bohlmann & Freeland (2013); Freeland & Lawler (2011).

16 See, for example, Freeland & Gruttner (2020).

17 Marboe (2012).

18 Freeland (2011).

19 See a whole range of decisions at the International Court of Justice on the issue of how to establish the existence of a rule of customary international law, beginning with the *North Sea Continental Shelf Cases* (Federal Republic of Germany v. Denmark and Federal Republic of Germany v. The Netherlands) (Judgment) [1969] ICJ Rep 3. See also Jakhu, Freeland & Chen (2018).

these binding arrangements never actually eventuate.

This recourse to TCBMs may well represent a realistic assessment with respect to the difficulties in achieving a significant degree of mutual cooperation and the requisite degree of political (good)will to resolve any impasse in a more comprehensive way but, in this author's opinion, in the end, binding norms that also fashion and regulate responsible behaviour by those engaged in space activities will be crucial.

This represents a major challenge ahead for all who understand the role of law in facilitating the peaceful and sustainable uses of outer space in the future. But it is a goal towards which we must all strive: the fact that we do not have such a comprehensive treaty regime in relation to military uses of outer space as yet does not mean it cannot happen. In the meantime, academia, industry and other experts are engaged in research that seek to articulate, at least in the view of those involved, what they perceive to be the *lex lata* rules relating to the military uses of outer space.[20] These are useful exercises although they can never, of course, represent a binding document to which States must comply for fear of be subject to sanctions under the principles of general international law.

Other significant legal challenges

Apart from the two major challenges to space law in the future that have been referred to above, there are a number of other significant issues that will require careful consideration as to their ongoing regulation. This section poses some questions that arise in respect of each of these, each of which will be relevant for future lawmakers and policy designers.

This article has already made reference to the increasing use of small, nano and micro satellites. This technology may represent an important precursor to the establishment of indigenous and independent space programs in States that previously could not have contemplated undertaking such activities. By eliminating some significant barriers to entry, small satellite technology may facilitate capacity building, broader collaborative opportunities, and education/training programs, as well as bridging (some) technology gaps for hitherto non-space faring States. It will also open up even more diverse commercial opportunities for a much broader range of potential service providers.

It is perhaps appropriate to liken the potential of small satellites for space activities to the way that mobile phones have revolutionized terrestrial communications activities. We simply do not know where this technology might ultimately lead and what it will allow us to do. However, we can confidently expect that it will open the door to an even more expansive array of commercial opportunities.

This inevitably represents some significant challenges to space law. For example, what is the impact of this technology for the space "market"? What forms of legal and regulatory frameworks are necessary to balance the interests of a particular State with the demands of entrepreneurs? How will existing space actors react to the potentially new range of participants that this technol-

20 See, for example, the work undertaken in the 3-year project entitled *Manual on International Law Applicable to Military Uses of Outer Space* (MILAMOS), a research project led by McGill University in Canada, and involving experts from 22 countries of the world: available at https://www.mcgill.ca/milamos/ (accessed 30 March 2020).

ogy will allow for? Should the governing legal regime encourage or discourage this evolution towards a multitude of space actors? What role does/should law have in facilitating the commercial possibilities offered by low-cost satellites? How do we deal with the prospect of so-called "mega-constellations" of small satellites, whose (planned) number will quite quickly dwarf the number of space objects launched in the six decades from the time of Sputnik 1?[21]

As noted earlier, there has developed an important cross-fertilization of activities in outer space with those in cyber space. In this regard, it is no surprise that many of the major digital platform companies have now expressed significant interest, and invested large sums of money, towards an incorporation/expansion of their existing operations with additional space activities. This is sometimes referred to as the "GAFTA phenomenon" (**G**oogle, **A**mazon, **F**acebook, **T**witter, **A**pple).

How should the recent interest shown by major digital platform operators be regulated in the space sector? Will there be a major convergence between digital content and the space industry? How can/should law react to, and properly regulate this rush towards the digitization of commercial space?

Another challenge that arises is the development of aerospace technology and the legal regulation of human aerospace and space flight. Much discussion is required about the future legal regulation of these activities and, equally importantly, about who would take responsibility — and how — for the governance structures and legal principles that will be needed.[22] In this regard, one will need to examine the scope and legal/regulatory implications of, for example, proposals to (re)define the areas of air space and outer space into distinct zones corresponding to differing uses of space-related and high-altitude technology (drones, balloons, other high-altitude platforms, air travel, aerospace flights, suborbital flights, orbital flights, space stations, permanent human settlements etc)?

In the area of geo-politics, strategic space, and transparency and confidence building measures (TCBMs), must we really be required to think of space in terms of that now well-worn mantra — that it is "contested, congested and competitive" — or is there another theme(s) towards which future space law should be directed?[23] How can the regulatory framework minimise/mitigate the threat of conflict involving the space ambitions of States? How can we ensure that *all* 'voices' relating to space are heard, not just those that loudly advocate for its designation as a "war fighting domain"? In this author's opinion, such calls are dangerously self-fulfilling and largely self-defeating: all States, particularly the major space-faring ones, will suffer if activities in space are undertaken in such an irresponsible manner as to cross certain "red lines" of accepted behaviour.[24]

And, of course, no overview of the challenges facing space law would be complete without a consideration of the potential for the commercial exploitation of the natural

21 In this regard, one of the major private entities engaged in proposals to launch many hundreds of small satellites has recently announced significant funding problems that will, at least in the short-medium term, most likely curb its activities somewhat; see Amos (2020).

22 See Freeland (2010).

23 See Freeland (2018a).

24 See Freeland (2018b).

resources of outer space. As is well known, the United States Congress passed the Space Resource Exploration and Utilization Act of 2015. Shortly afterwards, Luxembourg enacted its own national legislative framework[25] that encourages and promotes space resource exploitation and utilization. It seems apparent that other States, such as the UAE,[26] may also follow on this path.

These national law developments have highlighted some thorny legal issues but have also brought to the forefront intense geopolitical disagreement at the United Nations discussion level.[27] Even putting those aside, how will technology ultimately enable this commercial exploitation to take place? Is there a potential legal/regulatory model that will adequately support these activities, particularly in light of the uncertainties that some express with respect to the interpretation of the relevant principles of the treaty regime?[28]

These are but a few of the imposing challenges ahead for space law. The existing regulatory regime has largely served us well and, in many respects, has been remarkably successful. But the "spacescape" is changing very quickly, driven by this bewildering technological maelstrom that, over the last five years or so (and certainly for the next period of time), has far surpassed the already rapid evolution in space-related technology that began at the beginning of the space race.

Two important "takeaways:" principles of humanity and stewardship

We thus find ourselves in "interesting times." The need for a more comprehensive and detailed legal/regulatory framework for outer space represents one of the most politicized and complex challenges ahead for our, and future generations. All stakeholders need to work together to find a path forward, in order to meet the challenges. The existing international regulatory framework, whilst important, cannot alone stand up to the complexities that the ever-increasing range of space activities — and the possibilities that still lie before us — impose.

The opportunity presents for Governments, industry, scientists, entrepreneurs and civil society to work together to develop appropriate future legal frameworks that supplement and compliment the robust foundational principles that underpin how space has "worked."

This leads to probably the two most important considerations this author can offer. How should the societal, community and human impacts of our inexorable march into space be measured? Why has there been so little work done so far as regards

25 See https://spaceresources.public.lu/en.html (accessed 30 March 2020).

26 See UAE Space Law Details Announced to Facilitate Space Sector Development, https://spacewatch.global/2020/02/uae-space-law-details-announced-to-facilitate-space-sector-development/ (accessed 2 April 2020).

27 A current (since 2017) item on the agenda of the Legal Sub-Committee (LSC) of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) is "General exchange of views on potential legal models for activities in exploration, exploitation and utilization of space resources." In addition, in June 2019, UNCOPUOS Member States agreed to convene "scheduled informal discussions" of the exploration, exploitation and utilization of space resources, which were convened for the 2020 LSC session — this has been cancelled due to the current coronavirus situation and most likely will commence in 2021.

28 See, for example, Article II of the Outer Space Treaty, which provides: "Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

the human rights aspects of the exploration and use of outer space?[29] What legal and regulatory regimes best protect the broader interests of society without unduly restricting the development of appropriate space activities in the future? And, indeed, what are the criteria by which we are to determine the priorities as to what constitutes "appropriate" future space activities? What role does law play in fashioning these choices?

Furthermore, as we develop frameworks to address these legal challenges, we must always remain cognizant of the "stewardship" role we, as human beings, have in the way we manage our ongoing relationship with space. Our responsibilities in this regard extend not just to ourselves, but to future generations.[30] It is incumbent on us, and imperative for the future of humanity, that we do not repeat some of the mistakes we have made on Earth that threaten our ability to coexist here into the very long term.

In answering these questions, it is important that, at all times, we are conscious of, and adhere to, the core principles of "humanity" that underpin space law, in order to avoid the possibility of scenarios that do not bear contemplation. In the end, the principle of humanity must be the bedrock of all global legal regimes, including the regulation of the exploration and use of outer space.

In this regard, law will therefore continue to play a crucial role. But lawyers certainly cannot do this on their own. They simply do not have the tools to do so. All relevant stakeholders must exchange ideas, knowledge and expertise, and understand how each can contribute to an appropriate future where space continues to play a vital role in the activities of humankind. In the end, these discussions will be the most important way in which all of the exciting innovations and developments that we all dream about can best be advanced.

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29 See Marboe (2013); Freeland & Ram Jakhu (2014).

30 This obligation is already reflected in Article 4(1) of the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) 1363 UNTS 3, to which Australia is a State Party, although it must also be noted that there are currently only 18 States Parties to this instrument, none of which are considered as "major" space powers; see Hobe et al. (2013).

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