ASCEND

2020 SPACE TRAFFIC MANAGEMENT

DIVERSE DOZEN

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There are a growing number of state actors and new satellites in space, as well as an accelerating drive for space commerce and exploration. On a recent trip to Alaska, Moriba Jah, an astrodynamicist and space environmentalist, experienced an inner shift in perspective on sustainability and recognized how the indigenous peoples of our world have important lessons and tenets to share that may serve as a basis for us to thrive in space, while doing so in a sustainable way. What seems to be missing from the space community writ large is an inclusive conversation about how best to go about doing these things as one humanity. In an effort to address this, and coming from a space of honoring and respecting the relationships and relatedness among all things, as well as of acting with compassion, Moriba Jah has partnered with ASCEND to create a first-of-kind annual event that invokes 12 diverse and unique voices from humanity to tell the world about salient issues in space safety, security, and sustainability. The ASCEND Diverse Dozen represent a profile of human constituents with thoughts worth sharing!

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Michael Byers // CANADA

Professor, University of British Columbia

A Tragedy of the Commons in Low Earth Orbit

SpaceX is launching rockets with unprecedented frequency as it builds a megaconstellation of thousands of Starlink communications satellites in low Earth orbit (LEO). Other companies have similar plans. The astronomical community has objected to the effects of the resulting light pollution on ground-based telescopes. But megaconstellations pose threats that extend beyond astronomy. They are an extension of a problem that has been building for decades, namely the pollution of LEO. It is a problem that results, in large part, from the absence of binding multilateral rules.

Light pollution from Starlink satellites is already interfering with optical telescopes. A tenfold increase in communications satellites will also require an expansion in the range of frequencies used by them, encroaching on portions of the radio spectrum that are internationally protected for astronomy. Worse yet, these negative effects on astronomy could delay the identification of an asteroid headed toward Earth and thus the time available to mount a deflection mission.

Adding thousands of satellites to LEO also increases the risk of collisions and therefore the risk of runaway space debris. This is because every collision in orbit increases the surface area of the total material, which then increases the risk of further collisions. Known as the Kessler syndrome, this phenomenon is of considerable concern to space agencies, militaries, and commercial satellite operators. Runaway space debris threatens to turn LEO into a "tragedy of the commons," whereby a resource that is open to everyone is destroyed through overuse.

A complete ban on megaconstellations is not an option. National regulators are willing to issue licences, and even if some were not, companies could always obtain licences elsewhere, or even change their country of incorporation. This potential situation – of a "race to the bottom" and even "flags of convenience" – is the result of an absence of binding international rules designed with megaconstellations in mind.

SpaceX intends to actively deorbit its satellites at the end of their operational lives of 5–6 years, much faster than the nonbinding international guideline of 25 years. However, the satellites will still pose a collision risk while operational or in the process of deorbiting. Rather than just deorbiting satellites, we need international rules that limit the number of satellites, requiring companies to invest in quality, capability, and redundancy—essentially, to do more with less objects in space.

Globally accepted right-of-way rules will also be required to avoid potential games of chicken. Although satellite operators have an interest in avoiding collisions, moving a satellite consumes precious thruster fuel and can lead to service interruptions.

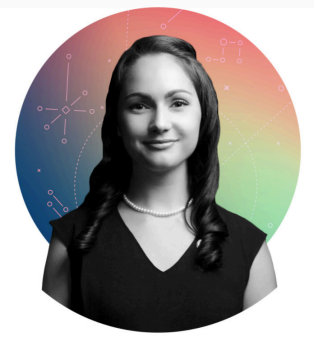
National regulators are presently allowing SpaceX and other satellite companies to externalize costs by failing to adopt a comprehensive approach to the analysis of risks and impacts. The externalization of costs includes the interference caused to astronomy. It also includes space debris and pollution to the Earth's atmosphere and surface.

The externalization of costs also includes the occupation of orbit shells and radio spectrum to the disadvantage of foreign countries and companies, which may be slower to develop the technology or acquire the financing necessary for megaconstellations.

It also, potentially, includes access to space for future generations, in a situation where the Kessler syndrome unfolds in the context of tens of thousands of satellites—an environment with a much higher mass of objects than anything envisaged in LEO before. This last externalization of costs raises important issues of intergenerational equity.

The fact that LEO is an area beyond national jurisdiction makes the self-regulation by private actors less plausible than commons located within nation states. As in other areas beyond national jurisdiction, a multilateral governance regime is needed to provide a form of peer review of proposed actions and the distribution of benefits, and prevent a race to the bottom and flags of convenience.

These days, we are keenly aware of the impact pollution has had on our environment—our lakes and oceans, tundras, deserts, and atmosphere. Although it's a different kind of pollution, we should also pay more attention to what we're doing higher up, in that portion of outer space surrounding our planet. It will have a profound effect on our future.



Alyssa Goessler // UNITED STATES

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The Civics of Space Policy

How might we cultivate a sense of civic duty and custodianship in a policy sphere that has no political boundaries? The term civic duty refers to a responsibility expected from all members of a society. It is based on the principle that citizens have an obligation to serve their society in exchange for certain rights and privileges. Jury duty, taxes, and even volunteer work in one's community are useful examples. Thus, the notion of civic duty is inherently linked to political boundaries—the entity to which you owe this duty traditionally must have borders.

What might this notion contribute to the field of space traffic management? The proliferation of orbital debris is on course to develop into a tragedy of the commons. A notion of civic duty could help to guide the way toward a global norm of space custodianship wherein spacefaring actors abide by certain behavioral obligations in exchange for the crucial benefits we gain from space. Therein lies the challenge: how do we foster a sense of civic duty in a region without boundaries, where every actor—regardless of their national origin— stands to win and lose in equal proportion?

Terrestrial political boundaries have historically developed as a result of material benefits or a defense rationale. The modern Persian Gulf nation-states as we typically conceive of them did not develop until the late twentieth century following the discovery of oil. Prior to this time, the region was predominantly populated by either bedu (meaning nomadic) or hadar (meaning settled) tribes. In an effort to protect vital trade routes and stamp out piracy off the Persian Gulf, Great Britain began entering into agreements with tribal leaders in the 1820s. These Gulf sheikhdoms, which came to be known as trucial states, deferred to Britain on issues of foreign and defense policy, and in exchange received assurances that Britain would defend their sheikhdom from any internal or external threats to their power. These sheikhdoms would develop into the full-fledged Gulf states that exist today, particularly after 1971 when the British withdrew from region. Thus, we see in this instance how both economic and security considerations led to the development of borders in the Gulf.

I've paraphrased roughly 200 years of history here, so forgive my brevity. What I aim to illustrate is how history impacts the modern policies and ethos of states. Many states maintain some variety of a "social contract," which is a notion that originated in the Age of Enlightenment, meaning that states and citizens are both entitled to certain rights and duties—the origin of the notion of civic duty. The Gulf monarchies, given their wealth and shorter term of existence, tend to have a different type of social contract wherein citizens receive generous benefits and social services in return for political acquiescence. Even the Arabic term for citizen—muwaatin—carries a very different connotation than its English counterpart. Its root term—watan— means nation, and the term itself translates to something closer to "national" or "one of the nation." Thus, the concept of civic duty in the Gulf varies greatly from a U.S. view of civic duty, given that the relationship between the citizen and the state is so markedly different.

In space policy, as in all fields of international policy, we also are not operating under the same political assumptions and models. This is further complicated by the presence of non-state actors operating in space, as a notion of a civic duty in their case would be irrelevant.

My recommendations are twofold. First, the field of space policy as a whole must recognize the value and necessity of integrating regional studies into their analyses. Not all nations are operating the same political models, let alone working in the same language. A historical and linguistic perspective is necessary to understand the cultural nuances that will inherently be reflected in a nation's policies. Second, spacefaring nations who are ahead in the game, like the United States, ought to take on a leadership role in crafting and exhibiting a norm of space custodianship. It is a great privilege to have the national means and infrastructure requisite to maintain a space program. We ought to honor that privilege by helping to ensure that space remains a prosperous, global commons for all.

Meshack Kinyua Ndiritu // ETHIOPIA

Space Applications Training Officer, African Union

Will There Be Space Left for Africa and Latecomers After All?

While the Space 4.0 era has birthed breakthroughs for accessing space, it has also led us to the verge of the Donald Kessler threshold of space debris. Nations are worried, but in different dimensions. Spacefaring nations are concerned about continuity of exploration. Emerging nations are perturbed with rising barriers to entering space. Africa and other developing nations have huge concerns about space sustainability. The big questions are:

1. Will there be space left for latecomers to deploy their technologies after all?

2. Is the Outer Space Treaty losing its grip?

In-demand orbits are stretching beyond their carrying capacities. For Africa, the most affordable Low Earth Orbit (LEO) resembles a full dumpsite that needs to be emptied — but emptied to where and by whom?

The lifetime of geosynchronous equatorial orbit (GEO) satellites is predicted by fuel. Defunct spacecrafts are moved to a graveyard orbit. In LEO, the lifetime for many spacecrafts is determined by the failure of components, which is unpredictable and minimizes deorbiting possibilities. The Secure World Foundation reported that 40% of active LEO satellites had not maneuvered in two years, which strongly suggests they cannot be deorbited at end-of-lifetime. As a result, about half of all space debris resides in LEO.

For Africa, access to space is now a necessity and that room needs to be available. This is inevitable due to the growing demand for satellite services, noted by Euroconsult, as the population surges and industries expand.

As reported by Space in Africa, Africa has launched about 41 satellites, too few to serve its population of ~1.3 billion people. Eleven of these are GEO satellites; the rest are in LEO because LEO is relatively affordable. Therefore, any threat to LEO is a threat to African space capability.

The rise of megaconstellations targeting LEO makes the case desperate. Astronomers are voicing their concerns. The megaconstellations pose a threat to the Square Kilometer Array observations, in which Africa has invested. LEO resources are now facing the threat of appropriation. Territorialization is also imminent on the moon.

The Outer Space Treaty is at risk of being violated, begging the question: is the time ripe for its revision or at least its enforcement? This is the only anchor document giving a sense of fairness to developing nations. Even more frustrating is that countries have yet to agree on universal ways to clean up space debris owing to technology protection. **It is time for spacefaring nations to act responsibly and for UNOOSA to enforce accountability of the treaty.**

In addition, because Africa and other developing nations need space to develop themselves, what role can they play in space traffic management to ensure space sustainability? Here are my recommendations.

Use their numbers: There are only a handful of spacefaring nations globally. Many others are either in the stage of developing core technologies or at nascent state. These nations should use their strength of numbers to influence globally responsible space governance.

Africa as a neutralizer: With over $7 billion of annual revenues from space services, projected to reach $10 billion by 2024, Africa is the new El Dorado for space. Africa is strategically located near the equator, making it an attractive hub for strong spacefaring nations. Africa should leverage this opportunity to neutralize the imminent space race and enforce responsible use of space.

One voice of influence: Africa is geopolitically neutral and open to indiscriminate partnerships. The African Union, an intergovernmental body consisting of all 55 countries, has established the African Space Agency as the continental voice in global space matters. Africa should use this seat of influence to voice its concern on space sustainability.

A challenge to Africa and developing nations: By now, developing nations must have learned important lessons, including that unlike the other industries, where the last mover has an advantage over the first, it is not always so in space. The resources are limited and contested. Missing the first move means missing out. Climate change has also taught us that failure to participate does not spare you from universal consequences. The cislunar economy is another open check that Africa and developing nations should not be absent from. They should be in the front line to grab the opportunities. No one is too poor to participate in space activities because we are all users and payers for its derived services after all.

Samantha Le May // AUSTRALIA

Ph.D. Candidate and Fulbright Scholar, RMIT University

The Necessity of Developing an International Sustainability Indicator Framework for Space

The practical applications of space science and technology in sustainable development are countless. Space capabilities are key to our understanding of climate. Communication, navigation, and observation from space enables recovery from a natural disaster. A global food crisis could be avoided with the aid of space-based technologies that offer solutions for agriculture. Soon, satellite technology could enable every person in the world to connect online – enhancing education, lifting economies, and reducing inequalities worldwide.

"Our Common Future," a 1987 report by the World Commission on Environment and Development, defined the concept of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Progress toward this vision has been closely measured and monitored at an international level through the sustainable development goals (SDGs) set by the UN General Assembly. Because of the intrinsic value of space-based technology to achieve these development goals, it is crucial that the same vision for sustainable development is adopted for outer space. Yet, no cohesive international framework exists to measure and monitor our progress toward the sustainable development of the space environment – and meanwhile, the proliferation of man-made waste in space continues to grow.

Sustainability indicators are used widely (by the UN and others) as an approach to measure and monitor progress toward sustainable development. Historically, the idea of sustainability indicators originated among environmentalists with the emergence of biological indicators to quantify ecosystem health as early as the 1970s. This area of environmental research is ongoing, and there have been many published frameworks and methodologies for the development of sustainability indicators in environmental economics literature. When we think of the motivation of environmentalists – to protect the health of ecosystems – perhaps it is challenging to extend this concept to the space environment, which is void of biological life. However, when we consider that more than 17,000 objects tracked in Earth's orbit are essentially pollution that threatens the livelihood of our space-based resources, including the satellites we rely on to measure and monitor pollution in our biosphere, it becomes easier to connect the dots. Developing an international sustainability indicator framework will be necessary to evolve a space environment that promotes economic and social advancement while avoiding environmental degradation, overexploitation, and pollution.

Recent work by the World Economic Forum to develop a space sustainability rating (SSR) system highlights the importance of research in this area. Researchers have also developed space debris indicators to quantify the long-term impact of a spacecraft in orbit on the space environment (criticality index) and the potential impact of hazardous space junk on a space mission. Instead of reinventing the wheel, further progress could be catalyzed by adapting existing methodologies from environmental and sustainable development literature to establish an approach to measure and monitor sustainable development in space.

The overarching purpose of a sustainability indicator framework is to provide a comprehensive and highly scalable information-driven architecture that is relevant to policy. Policy relevance is key, as the main benefit of using sustainability indicators is to improve the basis for political decision making. This is an area where adapting existing frameworks for space would make the most significant impact. Policy, regulation, and guidelines exist to prevent the proliferation of space junk, but it is difficult to identify whether such policies and guidelines are being complied by space participants. It is even more challenging to assess whether current regulations and policy approaches to preserve the space environment are effective.

As a starting point, a sustainable development indicator framework recontextualised for the space sector would require the following:

- International collaboration and participation by stakeholders to inform the development of indicators
- Indicators that capture the essential characteristics of the space environment
- Indicators that are quantifiable and scientifically verifiable
- Indicators that are relevant to space policy, so that they can be used as a basis for decision making
- A methodology for measuring the indicators that is replicable and practical in terms of data collection and cost, so that it can be implemented globally
- The establishment of reference values such as targets, baselines, threshold values, or benchmarks used to measure and monitor our progress

Robust science-based indicators for evaluating the sustainable development of the space environment are necessary to ensure society can benefit from space as a resource for generations to come. As the space sector grows and changes, so too will the ways in which we measure and monitor space sustainability. But given the role of space-based technologies in expanding the richness of human life, sustainability needs to be a priority – and we must start today.

Michael Linden-Vørnle // DENMARK

Chief Advisor, National Space Institute

Safe Access to Space Through Autonomous Infrastructure

Space around Earth is getting crowded. Very crowded. Satellites are being launched into orbit around our planet in rapidly growing numbers. This not only increases the number of functioning satellites, but it also contributes to the creation of growing amounts of space debris.

Satellite operators will be increasingly challenged when trying to manage their space systems in a safe manner. As the number of human-made space objects skyrocket, the time to react is now.

The consequence of this overcrowding is definitively not a comforting one: an ever-increasing risk of collisions – either between functioning satellites or between a functioning and a dead satellite or some other form of space debris. Is this this risk acceptable? The short answer is clearly: No!

Maintaining safe access to space and the uninterrupted use of space-based systems is therefore absolutely necessary to preserve and expand functions and services essential for our societies. Therefore, it is evident that the increasing risk to our space infrastructure has to be effectively mitigated.

The obvious question is: How?

Can legislation do the job? Would it be possible to introduce international rules regulating when and in which numbers we launch satellites into Earth orbit? I believe not. Both political and economic interests will prevent this.

What is the alternative?

Let me introduce you to a concept that could manifest itself as an important tool for securing safe access to space: autonomous infrastructure!

The essence of this concept is an infrastructure of autonomous systems that is collaborative and self-organizing. The concept is currently under development for unmanned autonomous systems in the classical domains of land, sea, and air, but to me, the introduction of the concept in space seems natural.

Before I present my vision for an autonomous infrastructure for space, let me share the key properties of this concept, keeping in mind that the development is presently aimed toward autonomous systems that drive, sail, and fly here on Earth.

As mentioned, we are talking about a collective of individual autonomous systems – either independent or in swarms. The focus here is not on the individual systems, but rather on how they interact. The main property is that the infrastructure is autonomously able to both coordinate and deconflict activities in order to operate in the most efficient, safe, and secure way.

Within the infrastructure, sensor data are shared between individual systems as are capabilities for solving tasks. The infrastructure is open for individual systems to join or leave given the situation at hand. This makes the autonomous infrastructure inherently modular and scalable controlled mainly by its internal self-organizing structure. Similarly, tasks are handled by an internal coordination and deconfliction within the infrastructure. For a given task, the infrastructure identifies and activates the relevant systems to perform the job, whereas the remaining parts of the infrastructure do not interfere. The infrastructure can either be tasked directly or identify tasks by itself.

The final key property is that as a result of its collaborative nature the infrastructure is able to detect and identify anomalous behavior. Systems behaving in a non-collaborative and thus suspicious way will stand out and can be isolated or even neutralized.

Now with these key properties for a terrestrial autonomous infrastructure in mind, how does this translate to a space infrastructure? My vision is that most – if not all – active, functioning satellites will be part of an autonomous infrastructure that shares data to maintain space domain awareness. Given this awareness, the infrastructure will be able to continuously coordinate and deconflict with a fast reaction time, thus effectively limiting the risk of collisions. To but it boldly: our space infrastructure will manage itself and do it significantly better than can ever be expected from operators on the ground!

Now, the big question is: Can this vision be realized? I strongly believe so – at least to a certain level. And the reason why is that in my opinion there is no real alternative.

Will it be difficult? Absolutely! We are talking about the need for global acceptance and appreciation of the concept of an autonomous space infrastructure – with many conflicting interests involved!

Will it be worth the effort? No doubt – for the sake of safe access to space for us and for future generations!

Anastasia Medvedeva // RUSSIA

Co-Founder and Host, Space Pals

Preventing In-Orbit Cluttering

Space is becoming cheaper, faster, and simpler – which has always been a dream. It has never been easier to send something into space, commercially, and with all the grey zones provided by space law, almost anything can be legally sent up there unless proven to be a weapon (but even then there is not a definition for a weapon). Should this be worrying or alarming?

Imagine if a company were to send constellations of small satellites into low Earth orbit to create huge illuminated orbital advertisements. Coca-Cola once signed a contract with a company developing such technology, but they were stopped by public opinion. This was only the first attempt, however, and it will not be the last.

The business model today is pretty clear: you think of it, you pay for it, you send it to space. For example, people want to send human ashes to space – to make a couple of spins around our planet and then burn in the atmosphere. It sounds like a great send-off for one or two people, but what happens if there are hundreds? How do we calculate how many CubeSats containing the ashes and photos of loved ones can fit in orbit?

Who is to blame when space is all cluttered with this space junk? This could be worse than the Kessler effect – it would be a complete orbital mess, posing an actual threat to the future of a human presence in orbit.

China, Russia, and the United States are the main polluters now. However, almost any country can have a startup providing different kinds of launch or service packages – promising to send anything you want into orbit. And while it makes sense that the three biggest polluters should be accountable for the already existing space debris – who will be accountable for future commercial orbital cluttering? And what happens while the best legal minds in the world ponder how to regulate end-of-life rules for space objects? If legislation takes another 15 years, it might be too late – just like climate change and the Arctic meltdown.

And let's think ahead – there are people and startups looking at sending things to the moon. The moon and Mars are already small museums of human-made technology with all the landers and rovers sent there over the years. There is no talk about how to clean that up or regulate the amount of technology dumped on the surface of other celestial bodies. Are scientific missions pollution? And let's not forget about asteroid mining because there is a lot of talk about technology, but none about how to maintain the asteroid's integrity after drilling.

The way out is threefold:

- Public awareness: Earth's orbital environment should be respected as any land here on Earth. Our planet is facing a waste disposal catastrophe caused by reckless behavior and business concepts. The plastic island in the Pacific, animal deaths due to plastic intoxication, the Amazon jungle disappearing – this has all been neglected for far too long and serves as an example of what may become of our planet's orbital environment in no time. We need a Greenpeace or World Wildlife Fund for space.

- Business ethics: Companies who wish to clutter the orbital environment and celestial bodies should be carefully reviewed, and their payloads approved by a governmental/intergovernmental panel of decision makers. Businesses should be wary of the orbital environment and understand their responsibility before sending questionable payloads into orbit.

- Government control: Each state space agency should have an ethics jury containing officials and members of the general public who could evaluate and rate the necessity of questionable business services. Companies with no clear guidelines or cause for launching objects should be denied launch. All cases should be evaluated from several standpoints: scientific value, necessity of launch, and environmental damages to the orbital environment.

If we follow through on these three steps, we would be able to control overall pollution – atmospheric, orbital, and on other celestial bodies – and that would allow a safe orbital future for humankind.

Susmita Mohanty // INDIA

CEO, EARTH2ORBIT

Outer Space, the New Wild West

Outer space, humanity's shared resource, is fast turning into the next Wild West.

The 21st century, unlike the 20th, will not be a race between nations, but rather a race between private companies seeking to exploit space assets, mine space resources, ferry tourists, and, eventually, miners, terraformers, construction workers, settlers, and others.

Let's take stock of some happenings in recent years that are symptomatic of the maladies that will need addressing through appropriate legislation and governance.

In November 2015, during the Obama administration, the U.S. Congress passed legislation that unilaterally gave American companies the rights to own and sell natural resources they mine from bodies in space, including asteroids.

In July 2017, the Luxembourg parliament voted in favor of an asteroid mining law, similar to that of the United States, that gives mining companies the right to keep their loot. In the absence of binding international treaties, unilateral and unfettered commercial exploitation of outer space resources is almost certain.

In 2017, commercial companies, governments, and amateurs launched more than 400 satellites into orbit, over four times the yearly average for 2000–2010.

In February 2018, SpaceX billionaire Elon Musk tossed a red roadster into space. Some consider this a nerd-baiting publicity stunt and others see it as an obscene act of megalomania. It sets a worrisome precedent for mindless littering of outer space with personal effects to generate press buzz.

In March 2019, India's Prime Minister Modi ordered India's first anti-satellite technology (ASAT) demonstration in low Earth orbit (LEO), raising debris concerns for the crewed International Space Station. India joined the United States, Russia, and China in the ASAT club. Others are bound to follow.

In August 2019, Musk reiterated his idea of nuking and vaporizing Mars' ice caps to warm the planet and make it habitable for human colonists. It is fashionable to talk about colonizing Mars and mass extract resources from the moon and asteroids.

Sustainability is a token buzzword that never quite makes it to the mental radar of those obsessed with monetizing everything. The vocabulary of conquest, control, and domination conveniently ignores the human and environmental cost of colonial adventures here on Earth.

In October 2019, Virgin Galactic went public on the New York Stock Exchange. Casual passenger spaceflight is about to take off. In addition to Branson, Bezos and Musk have now publicly expressed their intention to ferry people into space.

In November 2019, Planet declared it had reached a milestone of 400 satellites. As of September 2020, SpaceX had launched 715 out of the planned 42,000 satellites for its internet satellite constellation Starlink. There are concerns about space debris and the impact on Earth-based astronomy.

The other problem I see with constellations like Starlink is a takeover of a shared public resource that has all the hallmarks of a land grab by a single private enterprise. In the absence of farsighted and enforceable space laws, such a takeover of low Earth orbit will become a fait accompli, as thousands of satellites – not equipped to be monitored or controlled by regulatory oversight – take to the skies.

If all of the proposed constellations go up, they will equal roughly the number of satellites that humanity has launched in the history of spaceflight. We already have around 20,000 human-made objects in low Earth orbit, from working satellites to small shards of solar panels and rocket pieces. Such extreme satellite and debris traffic will certainly lead to a catastrophe of scale similar to what we have now started to witness with the domino effect of anthropogenic climate collapse.

The behavior, as demonstrated by individuals, companies and governments, is nothing but a classic rendition of the "he who dares wins" or "he who has the money can get away with murder" philosophy of the Wild West. Altruistic principles treating space as a shared resource found in the Outer Space Treaty of 1967 and the Moon Agreement of 1979 have been rendered obsolete.

21st-century space governance needs farsighted and enforceable laws, traditional wisdom, planetary ethics, and real-time, reliable data about orbital traffic if we are to ensure the safety, security, and sustainability of space operations with the growing number of space actors, space objects, space debris, and adverse space weather phenomena.

Aquib Moin // UNITED ARAB EMIRATES

Professor, United Arab Emirates University

Finding Windows in the Sky: Looking at the Universe Through A Growing Multitude of Anthropogenic Space Objects

Humankind has been looking up to the sky since time immemorial to find the meaning of existence, establish some sort of connection, and understand the purpose. Humans across all cultures and civilizations have been doing it, giving different names to the practices, but the underlying motivation, which is often misunderstood, has always been to embark on a journey to search for answers. In most cases, some of the probable and plausible answers led to more questions. So the quest goes on.

In recent times, the search methods and tools are much more efficient and effective, despite the fact there still are more questions than answers. The study of the universe now involves observations and measurements of objects and events using sophisticated instruments all around the globe and in near-Earth space. Due to the limitations of human reach, these instruments and facilities serve as our eyes on the universe and it's imperative that these eyes have a clear vision. Over the years, scientists and technologists have come a long way to enhance this vision to be able to observe and monitor fainter objects and distant events, and they are working hard to get more. The ever-increasing capabilities of these telescopes, sensors, and spectrometers have enabled a number of mind-boggling discoveries such as the direct imaging of a black hole, gravitational waves, and planets beyond our solar system. These discoveries are not only leading humankind to a better understanding of the fascinating elements in the universe, but they are also helping to find effective solutions for human life and teaching us to treat our own planet better. There is still a lot of margin to progress further and to do more to improve our observations and measurements so we can learn and understand more. However, the enhancement of instrumental capability is not the only challenge the universe explorers have to deal with. There is another major obstruction distorting and polluting our vision of the universe. This obstruction is the deployment of rapidly and exponentially increasing number of anthropogenic objects in the near-Earth space.

The frequency and the number of spacecraft that have been launched over the past few years are limiting the capabilities of the telescopes to observe particularly faint and distant astronomical objects and events with accuracy, and this problem is going to become severe as various space companies are planning to launch tens of thousands of commercial satellites. These satellites show up in the data as bright objects and they are hampering effective studies of things that astronomers really want to look at.

So what would be a longer-term solution? Would it be effective to resist and protest the exponential in the number of man-made near-Earth space objects that have commercial stakes attached to them? Or could there be a clever scientifically and technologically sound solution? This leads us to a discussion on the framework, which would allow extensive and continuous monitoring and tracking of these spacecraft so as to find cleaner "windows in the sky" where their presence would have the minimum possible effect on astronomical observations. The predictions of their trajectories, a space traffic management mechanism through a global space situational awareness infrastructure would make it possible to work out time slots, durations, and regions for unpolluted astronomical observations.

Putting together a global space traffic management and space situational awareness network will be a gargantuan task as it would require the acceptance and involvement of a number of stakeholders who could at least find common ground, understand and accept the problem, and come to a reasonable level of agreement to implement a solution in a collaborative fashion. Naturally, the first step is that the stakeholders (astronomers, space companies, agencies) start to listen to each other's concerns, and have productive and science-based discussions on relevant forums and platforms. Once this critical step has been taken, it would then be a matter of data-driven decision making, networking, collaboration, and the pursuit of a common goal of advancing further as an intelligent species, thereby gaining better understanding of existence and connection with the universe as explorers and knowledge seekers.

Regina Peldszus // GERMANY

Senior Policy Officer, DLR Space Administration

We are Constructing a Black Box-of-Black Boxes in Orbit

Operating a satellite is like wrestling with an exquisite, intangible black box. As mission time elapses, the subsystems acquire behavioral blips and quirks that one day result in a minor anomaly. The spacecraft is remote, cannot directly be observed or manipulated, and hurtles through one of the most physically demanding, dynamic, counterintuitive environments we know. On the ground, operations are embedded in the sociotechnical jungle made up of mission control software, launch sites, ground station antennas, with fiber-optic cables, basement servers, diagnostic algorithms – and the personnel and entities that staff, devise, deploy, and govern all these components, with their regulatory provisions, configuration documents, shift plans, export-control requirements, and final acceptance reviews.

All of this makes what we would call a highly complex system. Complex systems – such as nuclear power plants, air traffic control, a tokamak – share a number of common traits. They behave in a nonlinear way. They are made up of interdependent elements with tightly coupled processes. They are somewhat incomprehensible and cannot be represented in their entirety; we can only ever grasp in detail a minute sliver of their state and composition, or an overall perspective at so coarse a level of abstraction that we are liable to oversimplifying.

And they fail.

Failure and system accidents are an inherent possibility of highly complex domains – inevitable, normal even. Theories on Normal Accidents and High Reliability teach us that catastrophic failures occur when we are unable to cope with complexity. When our organizations struggle with joint decision making and communication. When preplanned procedures are eclipsed by novel constraints of an unexpected situation and we don't adapt. When we overestimate the shelf life of approaches to handle what we designed as an ideal system, which now finds itself exposed to the real-world messiness of operations. This is for one satellite or a small fleet.

Now extrapolate to the hundreds, thousands, and ten-thousands of satellites proposed to populate orbit within the next decades. Add their requisite ground infrastructure, aggregating across geographies, jurisdictions, professional cultures, an assemblage of cutting-edge and legacy systems with hitherto unseen idiosyncrasies and nestled layers of relationships.

Essentially, we are constructing an unprecedented black box-of-black boxes – by default and by design with the inbuilt potential for failure.

Of course, it doesn't all have to be incontrovertible degradation and breakdown. In an almost Boolean logic, the absence of the most consequential system failures is achieved through a continuous preoccupation with their potential emergence. Hence operators revisit past events to learn from mishaps and close calls, treble check their command stacks right now, and anticipate and rehearse for future contingencies. As a result, most of the time, complex systems such as space operations do not go wrong, but go right.

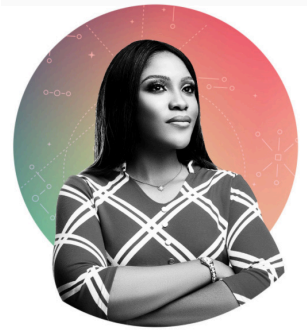
Also, most high-risk domains learn from disturbance and catastrophic disruption, including the space sector. After the most horrific and impactful accidents, new rules are forged, new safety mechanisms implemented. Our orbital environment may not yet have experienced the kind of systemic accident that destroyed significant assets and rendered an entire environment unusable. We did have incidents, both inadvertent and deliberate, that have incapacitated satellites and left lasting marks in the form of debris in certain orbital regimes – and, in turn, ushered in fresh awareness of the risks, or triggered increased transparency about the location of objects in orbit.

Finally, we already have a repertoire of tools at our fingertips to tackle complexity and instill resilience – from multilateral fora to negotiate our goals, to information-sharing schemes and capabilities to foresee and avoid collisions, to predictive models and a prolific community of experts that have been highlighting the pitfalls (and countermeasures) associated with an increased utilization of space for decades.

And yet, one critical attitude does not always appear to be explicit in our collective thinking these days. It's indispensable when staring down complexity – Instead of being affirmative and assuming that we or someone else will be able to fully absorb the extent to which the space domain is evolving, we'd do well to pause and ask ourselves whether we perhaps are succumbing to a sense of hubris. Are we really able to understand, let alone control, this black box-of-black boxes of tomorrow's space situation? I'd argue not yet. Instead, we should cultivate what the most diligent operators bring to their control rooms, even just for one satellite: Humility before an incessantly advancing entropy – because we cannot afford a "normal accident" in orbit.

Ruvimbo Samanga // SOUTH AFRICA

Research Fellow, Open Lunar Foundation



Cislunar Situational Awareness – Coordinating the Edge of Beyond

We all have different masks we wear, different faces depending on how we expect others to perceive us. Conveniently today, you see my space law face, my eager face, the face of a young African curious about what space has to offer a life like mine, like ours. You may also have the opportunity to see my poetic face, my human rights face, my vulnerable face, and the face I wear when I consider the socioeconomic injustices that plague society.

See, we all have different faces; we like to know the different faces people have. Knowing these faces gives us a sense of trust. It fosters dialogue, and it provides us with that sense of confidence of what we can expect. It allows us to understand one another, and ultimately, it promotes peace. Consider how you feel when you can't ascertain the full spectrum of an individual's persona. You feel uncertain, uneasy, and almost distrustful of them. The mystery entices and then quickly disenchants.

So we like to see each other's faces to become more familiar with one another. We are creatures of deep emotions; we continuously seek meaning in relationships, life occurrences, even shapes and lines in the clouds and environment. Yet, what if I told you that there's an entity whose face you've seen almost every night, yet you don't quite know at all. I am talking about that curious white orb that ominously hangs in the midnight sky. Our planet's closest heavenly neighbor, the face of folklore, mythology, religion, and human pareidolic imaginations alike. From our vantage point, we can only ever observe one of the moon's faces. How then, can we be comfortable venturing to a mystery we are yet to comprehend fully?

Humanity has renewed its interest in returning to our celestial companion. This won't just be a proliferation of interest, but a proliferation of actors, diversity of those actors, and diversity of the activities that they will pursue. Add to this the hazards of the occasional comet and asteroid that plunge into our star's vicinity and we have the makings of a space traffic management (STM) conundrum.

The challenge here, of course, is that the farther we are out in the deep back and beyond, the more challenging it will be to ascertain what exactly is going on. We need eyes in the sky that give us information. Yes, of course, NASA has the lunar reconnaissance orbiter, which has done a spectacular job of setting precedent for how we get to know all the faces of our moon. Still, there needs to be more interoperability to foster that deep sense of cooperation and coordination in space. This is where the concept of cislunar situational awareness and registries comes in. Cislunar situational awareness will include not only the on-orbit surveillance of activities, but also surface activities conducted on the lunar terrain, and a registry will act as a window, a transparent view into the actions of another state, and an opportunity to see the many faces of a nation's or entity's space ambition. If we can coordinate and share information on infrastructural capabilities, we can better ascertain who is where doing what and can lend support to our shared desire to explore.

In a nutshell, the legacy space domain awareness (SDA) system is not adequate to track and detect cislunar objects and is hardly comprehensive enough to provide insight into the near-Earth orbital domains. Therefore, heading to the moon requires a new architecture, one that recognizes technological and economic constraints plaguing the existing regime. One that shortens the lengthy chain of custody for registration, one which acknowledges the need for a single canonical registry for the implementation of a successful STM system.

With any expedition toward new settlements, there are always reminders of the atrocious mistakes of the past. As appropriation and overcrowding concerns become prevalent in the near-Earth space domain, they can only be expected to replicate into the cislunar. It is also little comfort that there currently doesn't exist much jurisprudence on the topic of cislunar situational awareness. Still, we can agree that a bit of innovation can go a long way. AI, blockchain, and even robots will have to chip in their fair share of support for this. We won't be able to do this without innovation.

As we try to make sense of the noise and fill the gaps with information, this fundamentally human way will likely not change the further we delve into outer space, taking with us the grand aspirations of millennia. Situational awareness and mostly cislunar situational awareness is a recognition that we need one another more than anything. The dual-pronged approach requiring both space-based observation/verification and an efficient registration mechanism will foster collaboration as opposed to competition because at the end of the day, the cislunar terrain is only more tenuous, owing to the gravitational pull of both the moon and the Earth. It is ultimately in our best interests to band together toward a fully transparent, timely, trustworthy SDA architecture in the interests of all humankind.

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The Democratization of Space: Bridging the Divide Between Established and Emerging Space Nations

In the past 60 years since humankind ventured into space with Sputnik 1 and Yuri Gagarin's first flight, the number of countries that have embarked on space development programs has increased drastically. From a handful of nations in the 1960s, space is slowly being democratized to the point that even developing countries are embarking on national space programs. Emerging space nations understand that a space program is no longer a luxury but a necessity, and is a vital instrument in addressing socioeconomic issues and national development concerns. To date, more and more countries are establishing their own space programs and national space agencies to maximize the benefits that space can provide them.

However, this democratization of space has a hidden negative consequence. With the discussions on space policies and treaties being dominated by established space nations, emerging space nations often find themselves simply following the rules set forth. Oftentimes, these rules are tailored to the interests and capabilities of established space nations and emerging space nations encounter a steep barrier to entry in participating in international discourse. As such, the needs of emerging space nations are significantly ignored and disregarded in the international arena, despite platforms such as the UN Committee on the Peaceful Use of Outer Space.

The divide and disparity are very much evident on space sustainability issues such as debris mitigation and space traffic management. While we all understand the need for sustainability to guarantee our ability to access space, often the rules set forth are difficult for emerging space nations' limited technical capability and budget for satellite development. As one of the youngest national space agencies in the world, the Philippines has tried to deal with these issues even in the early stages of its space program. The Philippines understood the necessity of participating not just on technology transfer partnership programs but also on discussions on space security, debris mitigation, and space traffic management. Active participation in international fora on these issues is crucial to ensure that the needs and interests of emerging space nations are heard and taken into account. Hopefully, more emerging space nations will become vocal and active participants in discussions on space debris mitigation and space traffic management, crucial issues that affect them whether they realize it or not.

At the end of the day, any set of rules, guidelines, regulations, or treaties imposed to ensure space sustainability affect not just the established space nations but also emerging space nations whose space programs are just starting to lift off. Imposing very strict guidelines will further widen the divide between established and emerging space nations. Furthermore, some countries may completely ignore these guidelines because their needs and capabilities were never considered. Even if only a few emerging space nations disregard the guidelines, their actions in space will hinder the progress on everything we have worked on in ensuring space sustainability.

The issue of space security, space sustainability, and space traffic management affect not only established actors but also emerging space nations. Established space nations should serve as role models on the proper norms and behavior in space and, when providing assistance and technology transfer, should not impose steep requirements and regulations that can stifle, development, innovation, and opportunities that may benefit the international space community. On the other hand, emerging space nations should be cognizant of their responsibilities in minimizing congestion of the space environment, voicing their concerns to the space community, and demonstrating their commitment to being a responsible space actor. It is high time that established and emerging space nations work together in this technically and legally challenging endeavor.

Space is said to be the common heritage of humankind. This needs to be demonstrated as a reality and not simply a lip service. The burden, the challenge, and the responsibility of ensuring space sustainability for decades to come rests equally on the shoulders of both established and emerging space nations. Only the keen awareness of this fact can ensure that space will be our legacy to future generations, our key to the protection and sustainability of the space environment, and our guarantee to the survival of humanity.

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Toward a Global Space Management Traffic System

The vast majority of human beings on the planet are dealing with the current pandemic, climate change, and sustainable development, among other social, political, economic, ideological, and religious challenges. Politicians and businessmen and global entities such as the UN Security Council, NATO, G20, OECD, IMF, WB, WEF, and private groups like the Bilderberg and the Club of Rome, are working together on agendas of political and economic interests, and decisions are configured in the purest style of global governance in an increasingly complex context with multiple edges.

While that happens here on the planet, what happens in outer space beyond the Earth's atmosphere? Space debris is an undeniable reality and a serious threat that should concern all the inhabitants of the planet. However, it is mainly addressed by the minority that represents the political, military, and economic interests of the governments and companies that have generated them.

The scientific community has given us a warning about the amount of space debris out there and has demanded greater regulation and the peaceful use of space. The challenge is to control, reduce, and evacuate the debris to avoid the high cost of monitoring. The current soft law initiatives we have do not have enough force — a legally binding instrument and a space traffic management (STM) authority that regulates this activity is urgently needed.

How did this debris accumulate? The answer is found in the internationalization of the geopolitics of spacefaring nations such as the United States, Russia, and China; in the interest of companies as SpaceX, Blue Origin, Virgin Orbit, Airbus, Boeing, Lockheed Martin, Thales AS and Planet, to name a few; and the emerging space powers interests of India, France, the United Arab Emirates, and Luxembourg, among others.

How Do We Solve the Debris Problem in Near-Earth Space?

Multiple and creative technical solutions have been proposed to alleviate the space debris problem, but an effective solution that prevents the aggravation of the problem lies in updating the space law at a multilateral level. In addition, we also need to establish a global authority that monitors transparent compliance with the legislation and regulates the effective evacuation of the waste placed in the low Earth orbit/geosynchronous equatorial orbit regions. This global authority will establish strict and effective regulations for future launches, orbital assignment, and final destination of all objects placed into space.

To start, the global negotiation of a legally binding international convention on the protection of life on Earth should endorse the Committee on the Peaceful Uses of Outer Space's (COPUOS) five treaties and principles, the resolutions of the UN General Assembly on outer space that currently shape international space law, as well as the Space Debris Mitigation Guidelines of COPUOS, IADC space debris mitigation guidelines, and other supporting documents or protocols from the UN Office for Outer Space Affairs and the International Telecommunication Union. Negotiations for this international convention should also consider recognized soft law initiatives on STM standards (national and international), the best practices and insights on space surveillance and tracking networks, and the International Code of Conduct (ICoC) roadmap.

This new international convention must also lay out a global organization for the prevention of risks derived from human activity in space, a specialized authority to verify that governments and companies fully comply with the updated precepts of space law. In addition, this organization needs to acknowledge all the agencies and networks for monitoring space debris, space weather, and near-Earth objects (NEOs) in the world. A network of worldwide entities is important to establish a Global Space Traffic Management System that protects humanity and the planet through global coordination and where information is shared regarding threats from space.

This initiative urges political will and full awareness about the serious situation generated by space debris and the long-term sustainability of human activity in outer space. It will also allow legislation on other issues of space security for the protection of humanity and the planet, including the potential risks from NEOs (more than 17,600 asteroids could become hazardous threats to life on the planet), space weather, the use of nuclear energy in deep space exploration, the reentry to Earth of ships and crew returning from missions to deep space, and other potential activities, such as tourism and space mining.

The international fora and traced path exist, but which government/country or world region will take the challenge to lead this?

The inaugural cohort of the Space Traffic Management Diverse Dozen are influential thinkers and emerging leaders from around the globe. Led by Moriba Jah from the University of Texas at Austin, these 12 authors are also the featured speakers in a series of rapid-fire lightning talks that highlight the most important issues surrounding safety, security, and sustainability in the context of space traffic. What needs to happen in order for space to be more transparent, more predictable, and to have a globally accessible pool of evidence to help people make decisions and hold them accountable for their behaviors in this shared domain? Find out by watching their ASCENDxSummit session at **www.ascend.events/space-traffic-management-diverse-dozen**.

Moriba Jah is an Associate Professor of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin, where he holds the Mrs. Pearlie Dashiell Henderson Centennial Fellowship in Engineering. Prior to this, Jah worked for the Air Force Research Laboratory and NASA Jet Propulsion Laboratory.

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Space Pals

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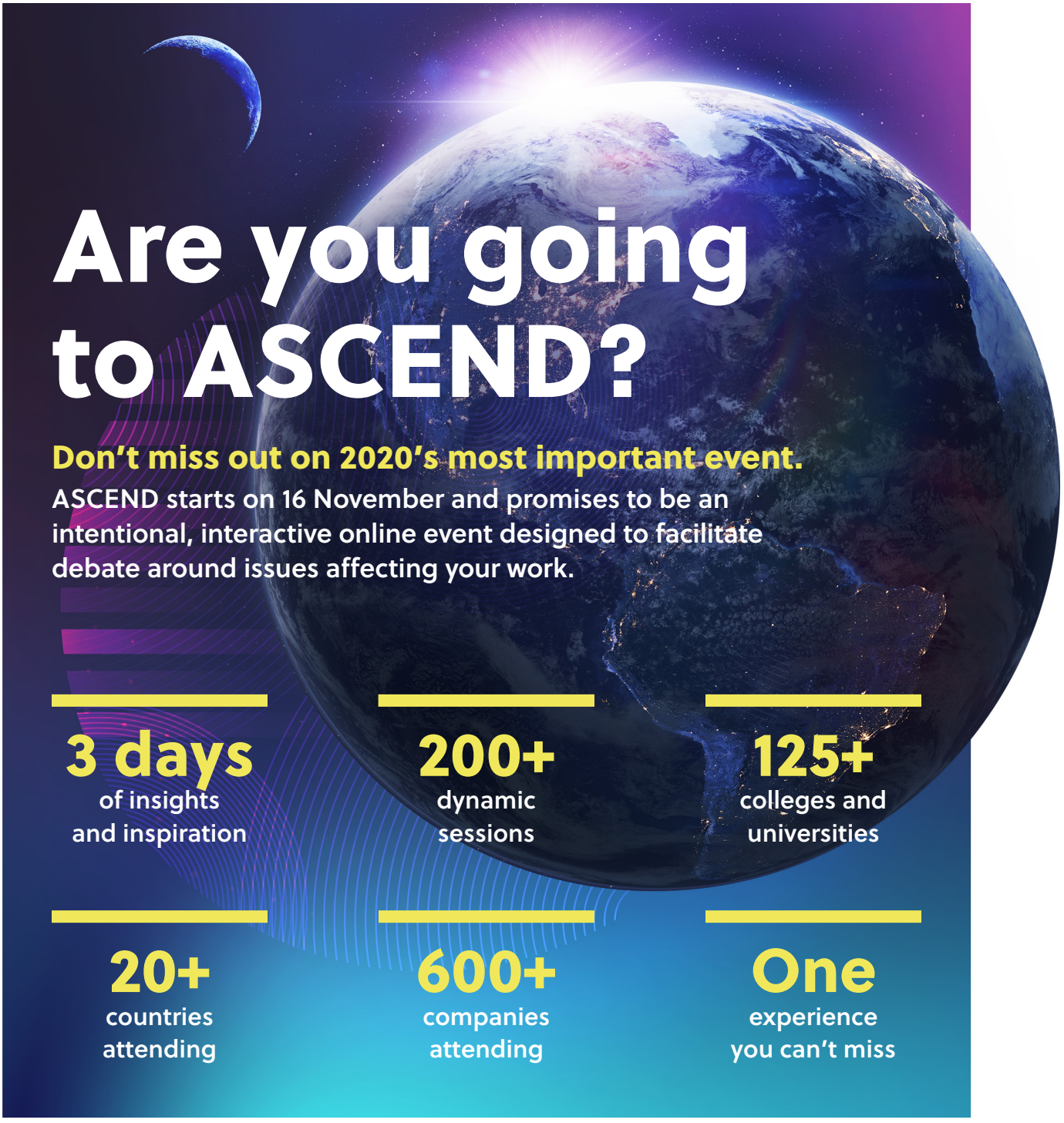

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