2022 SPACE TRAFFIC MANAGEMENT

DIVERSE DOZEN

25 October 2022

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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.

Several years ago on a trip to Alaska, Moriba Jah, an astrodynamicist and space environmentalist, experienced an inner shift in perspective on environmentalism and sustainability, and recognized how certain indigenous peoples of our world have important lessons and tenets to share in this regard. In essence, we must embrace the belief that all things are interconnected and we must embody stewardship because our lives depend on it. These indigenous peoples live each day in acceptance that they are in an existential crisis and that their way through this is by having a successful conversation with the environment. This perspective may serve as the basis for us to thrive in space in a sustainable way. What still 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 topic, and coming from a place 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 one-of-a-kind annual event that invokes **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!

Uma Shangery Aruldass // MALAYSIA

Manager, Berjaya Corporation Berhad

Emergence of CubeSat Industry Necessitates a Coordinated Space Traffic Management System

The emergence of CubeSats since the early 2000s positively impacts space exploration, especially in non-spacefaring countries. However, these CubeSats are potential deadly hazards to space infrastructure and spacecraft when there is no coordinated space traffic management. How could such tiny satellites be so hazardous? Imagine a bullet. When stationary it is harmless; however, once loaded into a gun and fired, the power and velocity can cause a deadly impact and damage. This is exactly the impact of the CubeSat when it becomes space debris moving at high speeds in orbital space.

CubeSats are a small satellite class that use a standard size and form factor and serve a similar purpose to ordinary large satellites [1–2]. There is a high demand for CubeSats in the New Space era due to their lower cost of manufacturing and lower barrier to access orbital space [3]. Previously there was a high entry barrier due to the high cost and resources needed to build a satellite. CubeSats give opportunities for non-spacefaring countries to participate as global players.

Twenty years ago, countries like Malaysia could not compete in the Space Race. However, in 2022, Malaysia is now building its own Earth station and space technology center in Penang, which will have the capacity to assemble its own CubeSats [4–5]. This scenario also is happening in many other countries and has created a new ecosystem in the market [6–8]. The growth of space education and space entrepreneurship has assisted space policy frameworks for CubeSats to continue to use outer space responsibly. Unfortunately, the effort for a coordinated space traffic management system has still not happened [1].

CubeSats are often considered sustainable alternatives to gigantic satellites in terms of cost, resources, and most importantly the decaying process [9]. Yet, in reality, there are two major concerns:

1) The potential space debris hazards for CubeSats are hard to identify as the currently shared resources from NASA and the ESA on trackable space debris measure from 10 cm in size and above [10–11]. Anything smaller than that is categorized in the "millions of pieces" of space debris and untrackable. These untrackable, and therefore unpredictable, space debris are hazardous and sometimes lethal for CubeSats.

2) Decaying CubeSat trajectories are caused by atmospheric drag. The simulation studies show that the best-case scenario for decaying takes three years and in the worst-case scenario up to 122 years for CubeSats [12]. Failure to address these concerns precisely simply means we are contributing to more space debris and we need to be ready to face a debris-filled space.

The use of CubeSats has rapidly been adopted because of their scientific, commercial, and societal benefits. However, in the long run, the stability of CubeSat operations is at high risk [13]. Since CubeSats are affordable, launching them in a swarm for space missions is common. For example, the CubeSats are deployed simultaneously to map an area for Internet of Things (IoT) connectivity. These swarms are highly interdependent and work as a group. If one CubeSat gets hit by space debris and loses connectivity, what would happen to the entire mission? What if more than 90% of the swarm is lost to space debris? To prevent this scenario we need coordinated space traffic management that will support the advancement of the New Space space exploration.

The United Nations' 18th Sustainable Development Goal (UN SDG 18) promotes the participation of all countries in space exploration [14]. Safe and sustainable use of outer space is equally important and can be achieved with coordinated space traffic management. The launch of CubeSats has exponentially grown from one in 1997 to more than 100 per year in 2021 [15]. In 2032, the number might reach as many as 10,000 CubeSats per year. CubeSats may even overtake the conventional large satellites in 2032, which increases the chances of collision with each other and with other existing space debris.

The acceleration to commercialize and optimize the CubeSats market is already happening today and redefining New Space. It is our responsibility together to provide a safe and sustainable outer space environment by having great space traffic management awareness, tools, technologies, and ecosystem. It is time to channel our resources into the development of coordinated space traffic management systems.

[1] https://core.ac.uk/download/pdf/147641383.pdf

[2] https://www.nasa.gov/content/what-are-smallsats-and-cubesats

[3] KiboCUBE Academy LIVE: Hybrid Event (Tunisia/Virtual)

[4] Big step with small satellites for Malaysia

[5] https://penang2030.com/2022/05/malaysian-made-satellites-launching-soon-in-penang/

[6] https://africanews.space/tag/cubesat/

[7] https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Technology_CubeSats

[8] https://www.borntoengineer.com/india-set-launch-100-satellites-single-mission

[9] https://www.wilsoncenter.org/blog-post/rise-cubesats-shifting-standards-expand-use

[10] https://www.nasa.gov/mission_pages/station/news/orbital_debris.html

[11] https://www.esa.int/Space_Safety/Space_Debris

[12] https://iopscience.iop.org/article/10.1088/1742-6596/641/1/012026/pdf

[13] https://www.wilsoncenter.org/blog-post/rise-cubesats-opportunities-and-challenges

[14] https://www.unoosa.org/documents/pdf/copuos/lsc/2018/tech-04.pdf

[15] https://spacenews.com/exponential-growth-of-cubesats-may-be-tapering-off/

Paul Bauerlé // FRANCE

Flight Dynamics Engineer, Astroscale UK

The Need for a Recovery Service on the Orbital Highway

If your car was broken, you would not leave it on the highway: you would ask for assistance to move the car. We all can imagine that an inert vehicle would lead to congested roads, collision avoidance maneuvers (CAMs), and deadly crashes that spread debris all over the road. For the same reason that cars need to be removed from the road, there must be a plan for satellites to be removed from space when they fail.

Today, space research and technologies have tremendous benefits for humans' everyday lives such as navigation, communication, and weather forecasts, and even more benefits are to come [1]. However, the space business is threatening itself as satellites are launched in massive quantities, and the high conjunction risks are more and more frequent. If a collision occurs, as happened in 2009 between Iridium 33 and Cosmos 2251, the consequences last for years as the debris continues to orbit around Earth at thousands of miles an hour. Therefore, when a satellite dies in a congested orbit, its retrieval is essential to mitigate the risk of collision with its operational neighbors. As you cannot rely on others to clean up your mess; it is everyone's responsibility to keep the orbit as clean as possible: end-of-life servicing should be considered for any project.

Know the risks. Being liable for an accident that could have been avoided is a heavy burden, especially when it jeopardizes the next generations. It is necessary to follow the best practices [2,3] as time cannot go backward. If a cascade of collisions occurs, the entire space sector will be heavily impacted; whoever you are, the consequences of a belt of debris will threaten your research or your business. But it goes beyond the space sector as all the downstream applications will be affected. To lessen the risk of a collision, the sooner a dead satellite is removed from orbit, the better; hence, it is worthwhile having a standardized docking plate that will help the capture and remove the spacecraft.

Space is hard: While effective practices and methods may minimize the risks of failure, an unforeseen loss can happen at any time, including while the satellite is in a heavily congested orbit. With the current and future pace of satellite launches, the number of nonmaneuverable objects will increase exponentially, and in-orbit servicing is being developed, including flying demonstration missions such as ELSA-d (End-of-Life Services by Astroscale-demonstration). The servicer will be ready to remove the space junk, and it will be helped by integrating the servicing possibility into the design of the mission.

We need to **join technology development and sustainability**. If the long-term objective is to develop the best products possible, we must face the technical challenges and continuously improve. We also must avoid putting ourselves at risk by developing space in an unsustainable way. The next generation is faced with a crowded space environment, we must try to provide them with solutions for space traffic management.

How do we guarantee the satellite servicer will not harm the client, or worse, create another piece of debris? Most satellites are able to deorbit themselves, but with so many new satellites, if even a small fraction are unable to it will result in plenty of satellites that need assistance to be removed. If one servicer can remove several defunct satellites, the net impact will be significant and considerably lower the risk of conjunctions, so all the other satellites will not need to perform CAMs.

In a nutshell, in-orbit servicing will become a norm to ensure sustainable use of space, but it will require every stakeholder to work together toward space sustainability. Actions must be taken now: we all know the orbits will be overcrowded in the future, if not already, so it is crucial to prepare the satellites to be serviced for the benefit of all.

[1] Jeff Greenblatt and Al Anzaldua, July 29, 2019, "How Space Technology Benefits the Earth." The Space Review. https://www.thespacereview.com/article/3768/1.

[2] "Best Practices for the Sustainability of Space Operations." Space Safety Coalition, September 16, 2019. https://spacesafety.org/best-practices/.

[3] "Long-Term Sustainability of Outer Space Activities." UN Office for Outer Space Affairs. https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html.

Selene Cannelli // ITALY

Managing Director, Space Is For You

The First Outer Space World Heritage Site: Earth's Orbits

Earth's orbits are a natural resource that are being overused. They contain hundreds of satellites that literally aid in navigating our daily lives. These satellites facilitate our communication systems, help us determine the weather, and provide key information for navigation purposes. Even though these satellites help us map the climate effects of excessive resource use and consumption on Earth, we are paying too little attention to how crowded Earth's orbits are becoming. We need to do more to protect what has given us so much.

To put things in perspective, our four orbits host:

- 4,852 active satellites (2022), the majority in low Earth orbit (LEO)
- More than 30,000 pieces of debris, up from 21,901 in 2021
- There will be around 100,000 satellites in LEO by 2030

The naked-eye view of the night sky may not be affected, but astronomers and our quest to understand the cosmos will be greatly impacted. Satellites reflect sunlight, cluttering astronomical instruments with unwanted detections, or creating a noise that hides the cosmos' weak natural radio signals, which we are trying to detect from Earth. Debris, especially, poses a threat to our safety. On Earth, houses might be damaged by falling debris; in space, debris could permanently damage the International Space Station (ISS). Just in 2021, the ISS performed two maneuvers to avoid debris collisions, of which one threatened the astronauts' lives, and it was discovered that a piece of debris made a small hole in the Canadian robotic arm.

We are again letting future generations solve the problems that we created, as is happening to our polluted oceans, land, and atmosphere. Is this the heritage that we want to leave behind in space?

We saw an incredible and profitable resource in our planet's orbits, and we started to exploit them as no binding multilateral rules regulate orbits' usage and safety. We cannot take action just after a catastrophe happens. We seem to have forgotten the cultural value that space is for us, and here's my proposition—recognize Earth's orbits as UNESCO World Heritage sites to protect and safeguard these precious resources, as well as objects historically important for space exploration.

The UNESCO World Heritage List includes landmarks or areas of historical, cultural, scientific, or other forms of significance to humanity, such as the Statue of Liberty. Created by the collaboration of a sculptor and an engineer, the list is a symbol of human spirit and ideals such as liberty, abolition of slavery, and opportunity.

Vanguard 1 could be the first outer space object in this list. Launched by the United States in 1958, it's the oldest human object in Earth's orbits, and it was made possible thanks to international cooperation, even in the midst of the Cold War. It also involved the first group of citizen scientists.

Recognizing Earth orbits as a UNESCO site will set up a precedent for the protection of the outer space environment and human heritage. This process will be challenging and lengthy, as the Outer Space Treaty will need to be updated for the first time since it was drafted in 1967. To ensure sustainable and safe use of the orbits, most likely we will need to identify the limited carrying capacity of each orbit. New laws will need to be designed taking this into account, and herein lies the challenge.

- Will each company have a limited number of satellites allowed in a given orbit?
- When the maximum number of satellites in an orbit is reached, what will happen? A waiting list?
- Will space become more hostile, closing its doors to emerging space nations?
- Which body will ensure that each satellite complies with international laws? Will there be a need for an international orbital traffic management operational facility?
- Will the Committee on the Peaceful Uses of Outer Space be identified as the authority?

The night skies undoubtedly tick the aforementioned forms of significance, as humans continue to view the stars and imagine the structure of the universe, narrating it through their star tales, cosmologies, and myths. We have always tilted our heads up to find inspiration, guidance, and courage, whether it was to find our way home or to embark on adventures overcoming our own limits.

Federico Di Vruno // UNITED KINGDOM

Spectrum Manager, SKA Observatory

Astronomy and the Night Sky Are Endangered by Large Satellite Constellations

Large satellite constellations (satcons for short) in low Earth orbit (LEO), such as Starlink and OneWeb, are already having a negative effect on the night sky and the science of astronomy, but it could become much worse. By reflecting sunlight or beaming strong radio signals to Earth, these satellites appear as bright strings of pearls in the night sky [1], can "photobomb" amateur astronomers' pictures [2], and can blind telescopes or confuse professional astronomers [3]. Not long ago what scientists thought was the oldest gamma-ray burst ever detected (an extremely rare event) was instead confirmed to be sunlight reflected by a defunct rocket body [4]. These things are happening now with close to 5,000 satellites in orbit, but there are global plans to deploy more than 400,000 satellites counting all the proposed satcons in LEO. If these numbers are realized, it will completely disrupt our view of the night sky and severely cripple many optical and radio telescopes on Earth [5,6,7,8], and also in low orbit like the Hubble Telescope [9].

To understand how professional telescopes can be impacted, imagine that you are in a completely dark room and someone suddenly directs a flashlight straight to your eyes, now imagine if this happens once every few seconds! This is a good analogy to what a telescope will experience if all planned satellites are deployed without proper consideration of their effect on astronomy. Astronomers fear that this situation can reach the point where gazing at the sky will be like looking through a bee swarm. For radio telescopes in particular, the strong signals intended to provide internet connection from satellites are "visible" 24/7 and can produce the same "flashlight effect." Furthermore, the electronics in a satellite can emit faint radio noise in many more frequencies than the intended ones producing a broadband background noise that can also interfere with radio observations.

The unprecedented fast proliferation of bright satellites is not only threatening basic astronomical research; telescopes are also used in vital day-to-day applications like the search for asteroids with collision courses with Earth [9] (like the one that wiped out the dinosaurs), or to look for habitable Earth-like planets, to search for radio signals from extraterrestrial life, and even to refine the accuracy of global navigation satellite systems (this is the navigation system we all rely on every day). All these applications can be negatively affected if we don't act now, just imagine the consequences of failing to detect an asteroid coming our way!

The global astronomy community has been actively working on this problem together with the most advanced satellite operators (Starlink, OneWeb and Amazon Kuiper) for a few years now. Four conferences have been organized since 2020, where mitigations and best practices were proposed [5,6,7,8], Starlink conducted hardware tests to lower satellite brightness [10], and some radio telescopes (like Effelsberg in Germany or the VLA in the United States) have been protected by national laws and by the satellite companies to mitigate the effect on radio observations. This is encouraging, but there is still much more to do, especially considering that there are many more companies than just Starlink, OneWeb, and Amazon Kuiper planning on having a satcon in LEO.

Since 2018 several astronomy organizations have been working with the United Nations Committee for the Peaceful Uses of Outer Space to protect the night sky and astronomy, with dedicated sessions in 2022 and also planned for 2023 to discuss the topic of Dark and Quiet Skies. Unfortunately, international agreements and guidelines can take a very long time; so in parallel, the International Astronomical Union (IAU) has created a Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS) [11]. The aim of the CPS is to bring together all stakeholders to discuss potential solutions and compromises to create a future where the night sky is protected, and astronomy and large satellite constellations can effectively coexist.

There are things you can do: awareness is the first step, spread the word and argue for a sustainable use of space. Space should be for all, these large satellite constellations can bring benefits to society, but it's important that they don't affect our ability to enjoy or study our skies.

[1] https://earthsky.org/space/spacex-starlink-satellites-explained/

[2] https://astronomy.com/news/2022/03/starlink-satellite-streaks-how-big-a-problem-are-they

[3] https://www.nature.com/articles/d41586-022-01420-9

[4] https://www.space.com/oldest-gamma-ray-burst-space-junk-mistake

[5] https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf

[6] https://www.iau.org/static/science/scientific_bodies/working_groups/286/dark-quiet-skies-2-working-groups-reports.pdf

[7] https://aas.org/satellite-constellations-1-workshop-report

[8] https://aas.org/press/satcon2-working-group-reports-released

[9] https://arstechnica.com/tech-policy/2022/02/nasa-says-starlink-gen2-may-cause-problems-for-hubble-and-asteroid-detection/

[10] https://skyandtelescope.org/astronomy-news/starlink-satellites-fainter-but-still-visible/

[11] https://cps.iau.org

Kim Ellis Hayes // AUSTRALIA/USA

Director, International Earth & Space Technology Pty Ltd; and CEO, Hayes Group LLC

Protecting Critical Space Infrastructure with Innovative Global Strategic Space Education

Life on Earth is dependent on the health of the orbital environment so the growth of the orbital economy can continue into the future. It's estimated that over 100 million pieces of space debris and operating spacecraft like satellites currently orbit the Earth just a couple of thousand miles above us. There are plans to launch more than 24,000 spacecraft into space in the next 10 years. The rapid increase of spacecraft and debris on orbit creates an ongoing risk of collisions that could potentially create the much-feared "Kessler syndrome" and damage the critical space infrastructure that humanity utilizes to navigate almost every aspect of life. Global positioning applications like Google Earth help us find where we are going, and meteorological satellites tell us about storms, heatwaves, and daily temperatures. It's easy to receive your paycheck, pay bills, and conduct online banking and shopping 24 hours a day. None of that would happen without the magic of satellite connectivity services that complement terrestrial infrastructure. In fact, space systems form critical infrastructure to support both the space economy and the nonspace economy [1]. Disruption or destruction of these systems would result in significant casualties and economic injury and reduce the ability of nations to deliver national security services.

The Organisation for Economic Cooperation and Development [2] defines the space economy as the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing, and utilizing space. "Space infrastructure is a sociotechnical system with its main component beyond the Karman line, and some components which are intra-atmospheric" [1].

Unfortunately, the past and current legal and geopolitical environment has resulted in the proliferation of large quantities of debris and an exponential growth in the quantity of space traffic [3] that needs to be monitored and tracked on orbit. Most debris currently in orbit is the result of legal and permitted activities in space within existing international and national legal frameworks governing space activities. These frameworks have limited mechanisms to control debris production and instead rely on a patchwork of voluntary guidelines to fill the gaps. This is certainly not a new phenomenon of human behavior. In all the places where humankind has expanded, destruction, debris, and pollution have been left behind on land, sea, air, and now space. Just as sustainable practices on Earth are often an afterthought, sustainable practices in space are only now being considered as the fortunes of wealthy nations, individuals, and companies are threatened.

This is not a question exclusively for the space community, this is a question for all of humanity. Fortunately, the solution lies in thinking outside the box, beyond governments, governance, and operations, toward the next generation of the space workforce. President John Kennedy noted a very important concept within his 1962 Rice University speech where he noted that "space science, like nuclear science and all technology, has no conscience of its own. Whether it will become a force for good or ill depends on man" [4]. That concept of doing the right thing and ensuring that the space environment remains available for this generation and future generations won't just happen. Critical space infrastructure systems consist of both technical, sociotechnical, and geopolitical factors. Better behavior on orbit must be driven by the human component of the sociotechnical space system. It's clear that the current system of space debris control and management is creating a bigger problem as time moves forward. To imagine a different and better world, you must imagine a different and better question. Instead of asking how we reduce or clean up space debris, we should ask how we provide a universal vehicle for eliminating the generation of garbage on orbit. The answer is surprisingly simple and available to us now, that is strategic education available freely in every nation for every student studying space technology, satellite or spacecraft engineering, and international law related to space. Implemented either as MOOCs (massive open online courses) or disseminated through a centralized web platform, sustainability principles, tools like **Crow's Nest** and other important data should be shared. Imagine if all the universities around the world could share and integrate sustainability principles and community tools into undergraduate and postgraduate education. It would mean that the next generation of the space workforce worldwide would be enabled to halt the growth of the debris problem and be empowered to innovate a way to a safe and prosperous low Earth orbit economy.

[1] Georgescu, A. (2020). Critical Space Infrastructures. In: Handbook of Space Security. Springer, Cham. https://doi.org/10.1007/978-3-030-22786-9_129-1

[2] OECD (2019), The Space Economy in Figures: How Space Contributes to the Global Economy, OECD Publishing, Paris, https://doi.org/10.1787/c5996201-en.

[3] International Academy of Astronautics. Cosmic Study on Space Traffic Management (2006, 2018)

[4] https://www.jfklibrary.org/learn/about-jfk/historic-speeches/address-at-rice-university-on-the-nations-space-effort

Jaden (J.J.) Hastings // USA

Director, SENSORIA Program

Enter the Era of Extreme Reusability

The era of disposable spacecraft must end, and there is every indication that significant commercial opportunity exists in the formation of a wholly circular manufacturing and servicing economy in low Earth orbit (LEO) to accompany its irrefutable environmental advantages. The pitch for a thriving civilian commercial space economy currently centers around tourism and contracted R&D once the ISS is decommissioned – developments that can only ever add to an increasingly saturated sky. An accumulation of 9,300 metric tons of space debris encircles our planet – human-made objects serving no function and posing an increasingly catastrophic risk to all active vehicles in space as well as the threat of potential fallout back on our home planet [1].

Disposing of objects by reentry into the Earth's atmosphere, whether under control or unplanned, still produces undesirable environmental effects. As the space object in orbit reenters the atmosphere at a speed of around 28,000 km/h, drag creates enough to partially ablate or fully disintegrate it into by-products like metal oxides with breakup occurring within the range of 75 to 85 km [2]. Very large or dense spacecraft, particularly those made of stainless steel or titanium, are less likely to be fully consumed by atmospheric ablation. Most of these objects are under controlled reentry and pose only a marginal risk to populated areas, but they do still fall somewhere on Earth and still do pose some risk to the environment.

The Oceanic Pole of Inaccessibility – a vast region covering thousands of square kilometers of landless ocean found in the South Pacific where the waters are around 4 kilometers deep – has been the location of choice for spacefaring nations to ditch their defunct spacecraft. Known colloquially within the aerospace industry as the "Spacecraft Cemetery," where hundreds of objects from national space agencies – predominantly Roscosmos, NASA, JAXA, and ESA – and an increasing number of objects from private launch providers like SpaceX are dropped from LEO to the bottom of the ocean. The net result can only ever be a loss – of the cost and labor that went into making the vehicle and even the historical artifact that helps mark our evolution as a spacefaring world.

Of great concern is that most national space programs continue to design spacecraft for demise – anticipating that the final plan for obsolescence of any orbiting technology will be pushing it out of orbit and either further out into space or into the depths of the ocean. The advancement of reusability of launch vehicles and capsules used to ferry satellites, crew, and cargo to orbit has proven to be a wholesale paradigm shift for the space sector [3]. Yet the missions and products planned for launch to orbits across a diversity of altitudes and trajectories in the coming decade have not yet yielded a necessary shift from the continuation of extraction and dependency upon terrestrial materials toward a more evolved, safe, and productive environment in LEO.

Pivoting toward the development of a thriving circular economy on orbit not only clears LEO of this hazardous clutter but ushers in the arrival of a civilian commercial sector dominated by workers with varied expertise – from technicians capable of servicing space hardware within the microgravity environment to engineering teams driving foundries on orbit where old materials can become new vehicles with an ever-decreasing need for terrestrial resources. The astronaut corps of this orbital economy would therefore be more likely composed of machinists and technicians and the personnel required to support the dangerous work they perform in the space environment rather than tourists and scientists.

Moving toward a fully circular economy in LEO clears our skies of clutter to make room for new missions and the next generation of space hardware while also reducing the cost of launching new assets to replace malfunctioning hardware that could have been repaired. Beyond the compelling environmental and cost-saving arguments in favor of this paradigm shift, establishing the capacity for on-orbit maintenance and material recycling offers the opportunity to build structures that are otherwise too large or expensive to launch from Earth. The time has come to shift our expectations in the design and lifecycle of spacecraft and the objects we choose to launch out of our gravity well away from abandonment and toward repair, recycling, or re-use.

[1] Caldwell, Sonja, Ed. "13.1 Deorbit Systems," State of the Art of Small Spacecraft Technology, National Aeronautics and Space Administration.

[2] Park, S.H., Laboulais, J.N., Leyland, P. and Mischler, S., 2021. Re-entry survival analysis and ground risk assessment of space debris considering by-products generation. Acta Astronautica, 179, pp.604-618.

[3] Koch, Frank., 2021. A Business Case for Space Debris, OSIP Open Channel Studies Evaluation Session 2020-02, Orbit Recycling, Version 1.0. Link

Mclee Kerolle // USA

Space Lawyer, Spaceflight, Inc.

Time for Some Action—The Blueprint for Sustainable Outer Space Activities Already Exists

"It ain't about what you got, but it's what you do with what you have." ~ Inside Your Love (Swales' In Detroit Edit)

In terms of solving the most existential problems in the space industry, one of the best tools we have are the sustainable development goals (SDGs). However, at their current iteration, the SDGs are at best suggested guidelines. Implementing the "Space4theSDGs" to become actionable, or even mandated by a UN resolution adopted by the General Assembly via a charter, will help create a framework that identifies specific targets for each goal, along with indicators to help measure progress toward each target that countries in the United Nations can follow. Establishing this Space4theSDGs Resolution will be a game changer. This can be said with confidence because this approach was used for original SDGs via a 2017 United Nations resolution adopted by the General Assembly on 6 July 2017 [1].

By their very nature, the SDGs are designed to be a "shared blueprint for peace and prosperity for people and the planet, now and into the future" [2]. It is important to recognize that the SDGs can provide an additional frame of reference for how the UN Office for Outer Space Affairs, and the space industry in general, can move toward a sustainable future.

Significant benefits from space technologies to SDGs can be seen in such goals as: Climate Action (SDG #13), Sustainable Cities and Communities (SDG #11), and "Industry Innovation and Infrastructure (SDG #9), to name a few.

It is no secret that the world's average surface temperature is projected to rise over 3°C this century. According to the Intergovernmental Panel on Climate Change (IPCC), this change will result in more common and intense extreme heat events and similarly more frequent and intense downpours. With extreme weather events increasing, this change will affect the poorest and most vulnerable people (and regions) the most. While the United Nations and many global organizations have dedicated forums to respond to the issues of climate change, space technologies have been playing a central role in many aspects of climate action, such as climate change monitoring, weather forecasting, disaster management, etc. Because of the contributions from Earth observation (EO) technology, the Global Climate Observing System (GCOS) developed the essential climate variables (ECVs) to provide reliable, traceable, observation-based evidence to monitor, mitigate, and attribute changes in climatic conditions, as well as understanding past, current, and possible future climate variability [3]. Fast forward to today, and with the use of Copernicus, the Copernicus Climate Change Services (C3S) will cover up to 30 ECVs out of 50 by 2030 and provide access to several climate indicators and climate indices to identify climate drivers and the expected climate impacts [3].

A charter should be implemented in a UN resolution that will encapsulate the SDGs for space industry and culture. Globally this promotes mechanisms for raising capacity and awareness for effective space-related planning and management. Those familiar with the United Nations and the Committee on the Peaceful Uses of Outer Space (COPUOS), may note two things: 1) the UN Resolution for the original SDGs was created with the UN's 2030 goal in mind, and 2) since 2010 there's been a working group in COPUOS on Long-Term Sustainability of Outer Space Activities to study and formulate best practices in the form of guidelines [4]. However, the working group is not charged specifically with drafting rules. As a UN resolution, creating the SDGs space-centric charter can place the responsibility on the states to "conduct the outer space affairs in a safe and responsible manner" and to assess all risks to the long-term sustainability of outer space activities. Whether the timeline for the steps after UN2030 focus on 2050 or not, here the action and implementation is more important than the deadline.

[1] Resolution adopted by the General Assembly on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development, 71/313, General Assembly, 2017

[2] https://sdgs.un.org/goals

[3] European Global Navigation Satellite System and Copernicus: Supporting the Sustainable Development Goals. BUILDING BLOCKS TOWARDS THE 2030 AGENDA (unoosa.org)

[4] Paul B. Larsen, Space Traffic Management Standards, 83 J.Air L & Com. 359 (2018)

Ashley Kosak // USA

CEO, Green Aero

Space Is Our Vision for the Future, Make It Green

The way we approach space is how we indicate our vision for the future. Space is what we see as the "final frontier," and it sets the bar for what can be imagined, yet lies on the edge of impossible. Space sets the threshold and asks us to imagine a new solution for what can be achieved.

Take the cell phone, for example. What was once used as a Star Trek prop has become a staple in our everyday lives. Something that was a distant invention in the 1960s—a device that could only be possible in a world where we would sail the vast galaxy to explore the planets of the Milky Way—is now a device I keep in my back pocket without a case because, well, I think it's prettier that way. "The Communicator" influenced the portability, accessibility, and opportunity that has become the fundamental way information is shared.

What is the impossibility of space now? What is this new goal we are seeking to aim for as scientists and spacefarers?

Space has propelled itself on a course toward privatization. And while this means there is a wealth of opportunity, it also places the power to shape the future in the hands of people who decide their own priorities to chase. For those of us who contribute toward the mission of making space a powerful tool for the advancement of technological innovation, we have a collective obligation to ensure the best interests of humanity are being met. And as many have emphasized for far too long, the most important priority in our work is a future with sustainability at the forefront.

A shift in the ethos of the space industry is possible—one that values reducing dependency on fossil fuels, accepts responsibility for waste outputs from manufacturing, and emphasizes reusability. But these are technical requirements. They don't necessarily address what is needed for a truly sustainable future.

A future that recognizes the circular economy as our golden standard is key. The beginning of a product's lifecycle does not start when at T-0: Liftoff and it doesn't end at mission completion, when the satellite is in orbit. The lifecycle of a launch is the mining of materials for manufacturing, the machines that shape and form the materials, fueling the tanks, sending them into space, and bringing the rocket and satellite back to Earth. The carbon emissions of a rocket are rooted in their manufacturing and testing—not just in their exhaust system. This is why examination of the economic, cultural, environmental, and social impacts of the full production process is necessary.

Setting carbon emissions targets is a first step, but it doesn't address the root cause. Resource extraction is our root cause, and it currently permeates every step of the design, test, build process. It has created a supply chain that encourages depletion, burnout, scarcity, and wealth concentration. It is a system that leaves no room for empathy, rest, comfort, nor love. A way of life that will ultimately lead us to an interplanetary future with the same colonial practices that currently exist in this world.

An industry that can see its engineers, technicians, students, and admirers as more than just their potential for profit is one that truly cares about the humanity it seeks to inspire. The space community is full of people who are looking to the stars, and who are working to create a solution for tomorrow. Incorporating sustainability as a key ethical principle is intersectional, it is cooperative. In essence, sustainable and circular manufacturing are an investment in the many generations who will follow on the path we build.

Competition drives innovation, I will be the first one to admit this. As someone who has always been competitive in every space I entered, and who has been explicitly told, "Ashley, please stop making this a contest, we're really just supposed to be having fun," I can see why competition is alluring and winning feels **good**. I think there are ways where healthy competition from a technical standpoint can exist while collaboration from a social perspective can be beneficial on a large scale.

In my opinion, collaboration on creating a space industry that supports zero-carbon emissions, prioritizes diversity, and promotes a safe working environment creates a keystone habit that will influence the future of the planet. There are people all over the world who will write "ad astra" because it's an understood message. It translates to "to the stars" but the message means so much more. It means **there is inspiration to be found in the future of space, in the stars above us, and the vastness of what can be accomplished when people believe together in the possibility of a mission**. A sustainable future is possible, and that is my primary mission.

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Is Space Cool or Useful? Reflections on Communication Language in the Space Domain

Space communication is about channeling and presenting the space environment, its complexity, and its importance to the rest of the world. But how to do it? To communicate to the rest of the world, the rest of the world has to be involved, and this implies the need to create a language that can include, reach out, and make people feel "part of it."

One of the most successful ways to create inclusivity is the use of influencers as science communicators, people who can — with their popularity, broad audience, and down-to-earth approach — create a sense of involvement and belonging to the space community. Traditionally, albeit not always, key characteristics of influencers are their youth, cultural diversity, non-jargon, colloquial language, and a general noninstitutional approach to communication. If we judge the phenomena of influencers by the numbers of clicks and followers, it is not possible to deny its effectiveness. However, are the numbers of followers a good index to measure effective communication for the space sector?

Is Space Cool or Cold?
There is nothing wrong with presenting the entertaining side of space exploration. Undoubtedly, it has the power to bring people in. But is relying solely on such language the right approach to bring diversity to the community? First, "Space is Cool '' is for those who had the privilege or the luck to choose a job not because they needed it, but because they were passionate about it. There is nothing wrong with that, but not everyone sees employment as a path to fulfill a dream. Second, it's a slogan that works well for those who don't need to be convinced, since it doesn't elaborate on the concept. Third, it works very well with children, who get passionate about hearing about the stars, but might not be so effective on adults who feel that space is a glorified, money-wasting machine. Coolness can be too cold to warm the hearts of those not really convinced that space is useful. Maybe we should be less worried about appearing cool, and more interested in being useful?

#SpaceIsUseful
We should aim to build communication campaigns based on "Space for Earth," and create a language that can clarify why space is useful. We should shift from comparisons such as "These satellites will allow us to drive a boat in the middle of the ocean" to "These satellites will allow families of any economic background to live in better areas." We should use a language that can create engagement that goes beyond naive enthusiasm. But how to do so if we all come from the same background?

Socioeconomic Inclusivity: A First Step Forward
The largest part of the scientific and engineering working force in the Western world is composed of better-off individuals educated at elite institutions. In the UK only 15% of students coming from a working-class background end up with a Ph.D., and in the United States only 40% of students from lower-income households proceed to graduate studies [1]. This is reflected in the language of space communication. Doors must be opened to all types of students, and the recruiting campaign cannot be based only on concepts like "Join us, space is cool." Inclusion must come from transmitting a sense of belonging to the global community and doing something worthwhile and useful, a sense of purpose.

The list of biases that comes into play when one turns their attention to the field of communication is vast and cannot be resolved in one essay. These are just starting points to reflect on what can be done to move beyond the rhetoric of the followers and the oversimplified language. In conclusion, an influencer style of communication can be narrowly focused and often oversimplified, and sometimes more useful to the influencer's ego than to the general goal of inclusivity. In the long term, the number of followers and fame might not be good indexes to assess the effectiveness of a communication campaign to generate diversity. We believe a more honest and yet critical approach could bring more benefits and people in. It's up to the domain to decide whether to stay cool, or to become warm and useful.

[1] Is Science only for the rich? Nature 537, 466-470 (2016).

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Applying a Polycentric Form of Governance in the Space Environment

Empathy and inclusion are the buzzwords we hear while discussing space sustainability solutions. However, there is a huge synergistic gap among different proposed governance solutions/ideas. Empathy and inclusion will only remain buzzwords until a form of governance that includes empathy and inclusion as fundamental values is incorporated into the space environment. After studying different forms of governance, I found the polycentric form most suitable for the space environment primarily because of its decentralized nature. Polycentricity, as presented by Vincent and Elinor Ostrom, connotes a sophisticated form of governance with multiple centers of semiautonomous decision making. The concept emerges from the common's scholarship, a sophisticated framework that has tried to address the tragedy of the common [1].

Fundamentally, space operations' highly dynamic and decentralized nature mandates a polycentric model for safe and efficient operations, primarily because the stewardship of the respective anthropogenic space objects lies with different owners/operating bodies. Hypothetically, a polycentric space governance system will be characterized by decentralized operations, autonomous decision making, overlapping jurisdiction, mutual adjustment of decentral decision centers, standardization (norms, values), and effective coordination.

Multiple, Overlapping Decision-Making Centers with Some Degree of Autonomy: The dynamic nature of space operations by all owners/operators makes it an arena of numerous decision centers. The decision centers are drawn from public, private, and voluntary sectors. However, there exists a clear lack of cooperation between these centers. In polycentricity, the existence of these centers is vital. However, their functionality may be rendered useless if overlapping jurisdictions are lacking. Most anthropogenic space objects (ASOs) are unmaneuverable, posing an immediate collision risk to objects from another decision center. Unmaneuverable objects from the Russian anti-satellite test came directly into the path of the ISS, thus involving multiple decision centers in an overlapping jurisdiction [2].

Currently, there is no agreement among the active stakeholders on the definition of a possible conjunction. The probabilities of collision thresholds are not mutually agreed upon nor is no consensus. There is no clear boundary beyond which no-action would lead to a catastrophic collision. The 2009 Iridium-Cosmos collision did appear in the list of possible conjunctions of that day based on the ephemeris data of objects available with the respective decision centers [3] [4]. However, for reasons unknown to common man, the probability of collision was not either computed, or was ascertained to be of less risk and not acted upon. We all know the end result: a significantly polluted LEO environment. In this collision, the American object (Iridium) came from the commercial sector while the Russian object (Cosmos) was military owned. Due to a lack of actionable legal bindings from existing space treaties/laws, a commercial owner/operator cannot be forced to execute a maneuver in case of a probability of conjunction. The owner/operator can argue a different probability of collision based on his own algorithms, since there is no overarching agreement. Therefore, such a situation can only be mitigated if different decision-making centers (e.g., U.S. Space Surveillance Network, Iridium Communications, Russian ISON, etc.) develop an overlapping jurisdiction that mandates harmony and action to avoid future collisions.

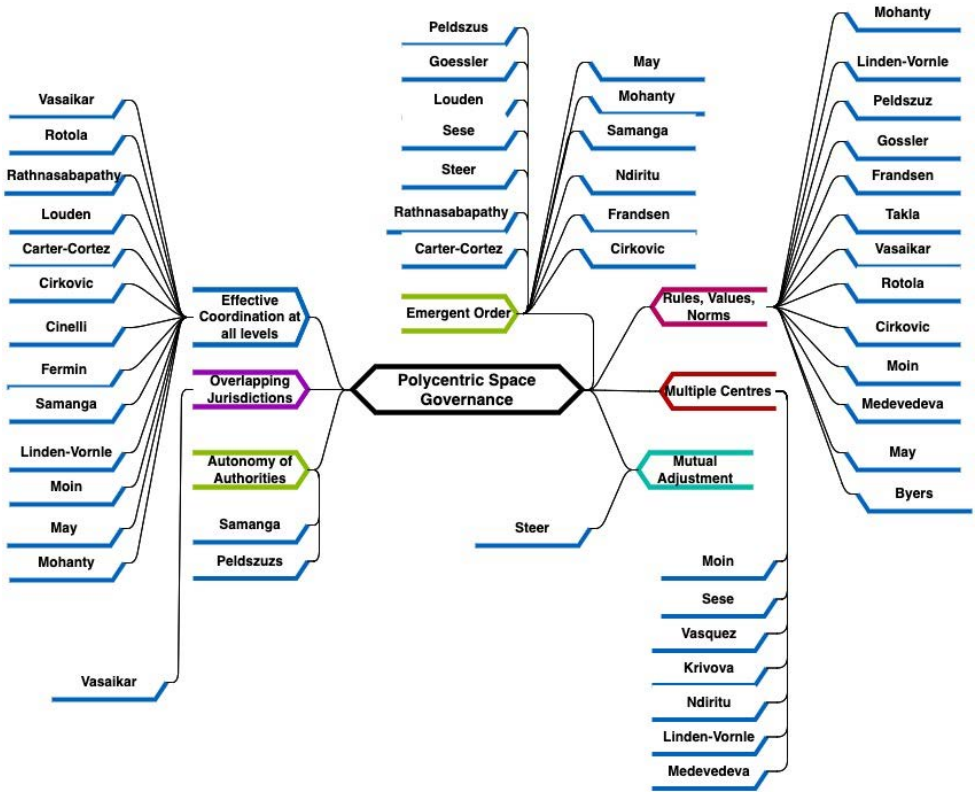

Figure 1: Mapping Polycentricity with 2020 and 2021 Diverse Dozen Op-eds [6–7].

Any ASO under astrometric/photometric observation through the sensory network of one decision center will be under observation of a neighboring network within minutes. This dynamicity of ASOs can only be accurately accounted for when a framework enhances an overlapping sense of action, autonomy, and mitigation between different polycentric centers. A polycentric governance model with legally overlapping jurisdictions in case of possible conjunction (under the agreed threshold of all decision centers) will promote a safer and more sustainable space environment.

Mutual Adjustment, Existence of Overarching RVMs (Rules, Values, Norms): Astrodynamically, the orbit determination models and accuracy of force fields that affect the orbital trajectories are constantly improving. The correct conjunction analyses and probability of conjunctions also enhance human understanding of the actual space environment vs. the simulated or perceived one. In a polycentric space governance model, the decision centers could adjust their modus operandi based on the latest verified information from academia/research. Under the multiple overlapping decision centers polycentric model, a mutual adjustment based on the correct/real understanding of the orbits and space environment would continually improve the algorithms that will make the space safer and more sustainable [5].

No matter how decentralized the global space traffic management system evolves, there has to be a framework of overarching rules that govern the system from an operational perspective. At present, different decision centers have different algorithms, concepts of operation, agreed accuracy levels, decision calculus, and collision thresholds. There has to be an agreed set of RVNs, such as an agreed level of collision thresholds, actionable CDMs (conjunction data messages), sustainability ratings, and legal bindings. With a common RVNs framework, the decision center will diverge at the times of conflict instead of converging/synergizing toward a solution. Moreover, polycentricity also promotes existence of means for effective coordination at all levels. The different levels we already know in space governance are of satellite owners/operators, regional networks, national agencies, and international organizations [5].

To qualitatively check my hypothesis, I used a mind mapping tool and assigned one or more of the previous D12 ideas to different facets of polycentricity.

Polycentricity of polycentric governance addresses maximum (if not all) issues the current space environment is facing. It fundamentally practices empathy and inclusion through an institutional arrangement involving a diversity of decision centers acting independently but under the constraints of an overarching set of RVNs. This restricts externalities and creates an environment for the emergence of an outcome at the entire system level [8].

[1] Critical Commons Scholarship: A Typology

[2] Russian ASAT debris imperils DoD, NRO sats, while ISS risks increase: COMSPOC

[3] How and Why Did Two Satellites Collide This Week?, Nancy Atkinson, Universe Today

[4] 2009 Iridium-Cosmos Collision Fact Sheet, 10 Nov 2010

[5] Polycentric Systems of Governance: A Theoretical Model for the Commons, Keith M. Carlisle

[6] 2020 AIAA ASCEND Diverse Dozen Op-eds

[7] 2021 AIAA ASCEND Diverse Dozen Op-eds

[8] Co-Production, Polycentricity, and Value Heterogeneity, Paul Dragos Aligica and Vlad Tarko

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Openness and Inclusivity: The Approach to the Space Debris Pollusion Problem

The satellite industry accounted for 72% of the USD 386 billion global space economy revenues in 2021. Together with the upsurge in related services this has incrementally impacted the number of satellites released into orbits per year, with about 1,854 satellites in 2021 alone [1,2]. More so, financing for start-up space ventures have been growing year-on-year, with 2021 attaining over USD 15 billion in investments (twice as much as 2020) [3]. These economic growth metrics with their likelihood to increase productivity and affordability, as well as new technological capabilities, must be comparatively scaled with the resultant tens of thousands of space debris larger than 10 cm: a consequential by-product of our advances in space science and technology. However, there seems to be a gap regarding our everyday dependence on satellite services vis a vis the global awareness of the space debris pollution problem. The preservation of safety and security of Earth and space, as well as their sustainability, should interest all humankind. One way to generate this interest is to foster a sense of individual ownership of responsibility with respect to Earth and space safety.

Proliferation of space debris could be reasonably regarded as an activity in continuum even if no more satellites are released into Earth's orbit. Noncollision mechanisms such as material degradation and subsequent fragmentation induced by the harsh space environment could create new debris. This accumulation may increase the risk of collision events among active satellites, debris, and between satellite and debris, which could potentially disrupt new satellite missions and interrupt everyday services on Earth. Any of the estimated hundreds of millions millimeter-sized debris has the potential to catastrophically damage a satellite and abruptly end its mission life. This is exemplified by JAXA's Advanced Earth Observing Satellite-II (ADEOS-II) [4], which became nonoperational after experiencing a severe power failure due to a debris impact on a power harness. Should such an event occur with a communications or a weather satellite, it may disrupt communication/ internet services, social networks platform usage, weather forecasting, and even transportation services [5]. The question then is: how well informed is the individual global citizen and what is the level of awareness regarding the catastrophic effects of space debris? If discussions on the space debris problem and the quest for solutions capable of mitigating debris risks is perceived to be the purview of a select "few constituents," then a sense of responsibility of ownership from the global market would be scarce, implying difficulty in experimenting with and/or implementing proposed solutions. Hence, there is the need for a global awareness campaign.

Most of the proposed space debris removal techniques are at the conceptual development phase and have not attained high technology readiness level. These techniques require advanced guidance/navigation software and hardware, making their demonstrative studies expensive. Hence, it is difficult to attract investments compared with financing for satellite development and related services. Advances in AI, computational models, and new materials could address the concerns. Implemented and proposed solutions to the debris problem include identification, tracking and cataloging that can provide warnings to satellites for collision avoidance maneuvers. These are achieved by using ground-based radar systems and a combination of space-based laser ranging and optical tracking, as well as in situ impact sensors. Yalcin et al. implemented a classification based on energy transfer mechanism between remover satellite/chaser and the targeted debris [6]. The removal systems were classified as potential and impact energy dissipation, neutral energy balance, and destructive energy absorption. In addition, radar observations that are already implemented and capable of measuring the environment of millimeter-sized debris should be continually studied and improved. Also, real-time orbital environment measurement of submillimeter debris [7] using both impact sensors and collision flux models is promising and worthy of research focus.

One way to ensure individual ownership of responsibility regarding the debris pollution problem is by promoting awareness via ample information dissemination. This is attainable by making the necessary information available on social network platforms through the leverage of platform owners and influential users alike. Both technological and political information should be made available to enhance debates and discussions. More so, honest and open discussions must be encouraged with censorship of dissenting opinions reduced to the barest minimum. This would ensure that the process of future policy framework formulation is objectively based on reasonable evidence.

[1] BryceTech: SIA - State of the Satellite Industry Report, (2022).

[2] BryceTech: Smallsats by the Numbers, (2022).

[3] BryceTech: Start-Up Space, (2022).

[4] ADEOS-II, https://www.eoportal.org/satellite-missions/adeos-ii#spacecraft.

[5] Aglietti, G. S.: From Space Debris to NEO, Some of the Major Challenges for the Space Sector, Front. Sp. Technol., 1 (2020), pp. 1–3.

[6] Yalçın, B. C., Martinez, C., Hubert Delisle, M., Rodriguez, G., Zheng, J. and Olivares-Mendez, M.: ET-Class: An Energy Transfer-Based Classification of Space Debris Removal Methods and Missions, Front. Sp. Technol., 3 (2022), pp. 1–23.

[7] Hanada, T., Fujita, K. and Yoshimura, Y.: Estimation of Orbital Parameters of Broken-up Objects from In-Situ Debris Measurement, Front. Appl. Plasma Technol., 3 (2022), pp. 1–10.

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Art: A Medium of Expression for Space Safety, Security, and Sustainability

"Sciences provide an understanding of a universal experience whereas arts are a universal understanding of a personal experience. They are both a part of us and a manifestation of the same thing. The arts and sciences are avatars of human creativity." – Mae Jemison

The problems of space safety, security, and sustainability can be explored by having humanity writ large view space exploration through the lense of the arts. Those domains span across technical, legal, socioeconomic, and political fields, and yet there is a lack of resource allocation to deal with space debris. To develop solutions to tackle this problem, we must first highlight the dangers of space debris directly to the public. Attracting public attention to the daunting problem of space debris will initiate and drive policy and industry changes toward space safety and sustainability.

The arts have played an important role in promoting space exploration through media and literature. Visual arts can stimulate human emotions, deepening emotional perception of the human environment by means of creating artworks and installations [1]. Art can influence the very notion of reality, and as such, give us an understanding of the space debris problem to create a safer future for humanity. Art, created through an interdisciplinary approach of artists, engineers, and scientists, can send a profound message about the infinite vastness that surrounds us. Space and art both address themes of purity, contamination, hybridity, survival, and innovation [2]. The creative collaborations of art and science would be mutually beneficial to addressing the complexity of approaching space debris issues.

One of the very few artistically experimental projects that tried to bring space debris to the public view is "Collision" by artists Richard Clar and Mark Mantel. This is an interdisciplinary site-specific artwork and performance created by using known data from orbiting space debris around Earth to generate musical and visual information through a shared computer program [3]. Subsequently, "Collision II" also was created by artist Richard Clar and composer Marc Battier. "Collision II" is a space sculpture made up of 192 pieces of orbital debris located in the region between 96 and 104 degrees of inclination and an altitude of 450 to 800 km in 2003. A video simulation was created to show the orbit constellation sculpture from the vantage points of low Earth orbit and geosynchronous orbit during a 12-hour period reduced to 12 minutes. This was accompanied by an audio composition created around the debris data. "Collision II" extended the parameter of the Earth-bound art set in motion by the first "Collision" piece with the strong conceptual aspect of the fourth-dimension element of time [4]. Both the "Collision" projects utilized orbital debris that was already in orbit to create art. The problem became part of the solution.

Another project at the intersection of space debris and art, "Adrift" was created by artists Cath Le Couteur and Nick Ryan. It explores the world of space junk through an interactive experience of a sound installation and a documentary. An electromechanical sound instrument was developed to track the positions of 27,000 pieces of space junk, transforming them into sound, in real time, as they pass overhead. This project aimed to engage the audience by having them view, listen, or interact with multiple elements [5]. A wider audience of more than 300 million people worldwide have been reached since it was produced online on easily-accessible virtual platforms.

Currently, there are 131 million space debris objects ranging from the size of 1 mm to 100 mm in orbit [6]. With the demanding concerns of space debris increasing, it is crucial to draw the general public's attention toward what's currently being done to address this and how far we have yet to go to solve this critical problem. In the New Space era, access to space and space knowledge has become easier. Public appeal opens a plethora of communication channels to policymakers to develop initiatives and allocate resources. By creating understanding and awareness, art projects and installations can showcase the interconnectedness of safety, security, and sustainability. Using art as a medium of collaboration, communication, inclusivity, and awareness would accelerate humanity's efforts to address and expedite solutions for solving the space debris concerns.

[1] Malina, F.J. On the visual fine arts in the space age. Leonardo, 3(3), pp. 323-325, 1970.

[2] Greg Hilty. Art, Science and "the True Mistakes of Metaphor"

[3] COLLISION I: An Interdisciplinary Approach to Orbital Debris. Richard Clar and Mark Mantel, Ph.D., Art Technologies, 1992.

[4] COLLISION II: A Colossal Sculpture in Space, 3D Video installation, The Naval Research Laboratory, 2003.

[5] Adrift, http://www.projectadrift.co.uk/

[6] https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

The 2022 cohort of the Space Traffic Management Diverse Dozen are influential thinkers and emerging leaders from around the globe. Led by Moriba Jah from Privateer Space and the University of Texas at Austin, these 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 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 ASCEND session at
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