Future Uses of Space (FUS): Narrative Evidence for Science & Technology Advantage through linking Research and Policy

Synthesis Papers

This document contains seven synthesis papers from academics with narrative expertise. The purpose of the papers is to synthesise the most cutting-edge research in the author's academic field in order to generate evidence in ways that could in turn, and when set alongside scientific and technical evidence, inform decision-making by space policy practitioners. Synthesis authors were provided with a summary of key space policy concerns based on the first steering group meeting in February 2023.

We asked synthesis authors to draw together research and evidence from the relevant discipline, attending to the cognitive value that can be derived from consideration of the functioning of relevant stories. Authors were invited to think specifically about the four cognitive and collective functions of stories outlined in *Storylistening*. These four functions are: offering multiple points of view and new **framings**; providing insights into **collective identities**; functioning as narrative **models** that enable surrogative reasoning about the target system; and informing **anticipations** of the future.

Each paper is prefaced by a short executive summary. All author affiliations are as of time of synthesis paper production.

Contents

SP4 Storymaking Outer Space Otherwise

Juan Francisco Salazar, Professor of Communications, Media and Environment, Western Sydney University

SP5 Regarding Citizenship and Affordances, on Earth and in Space. *Listening to some Stories about Idealism, Identity, and Interoperability in Built Environments Everywhere*

Fred Scharmen, Associate Professor, Morgan State University

SP6 Exploring Space Science Community Engagement with Storylistening Principles

Elizabeth Stanway, Reader in Astronomy and Astrophysics, Centre for Exoplanets and Habitability, Department of Physics, University of Warwick

SP 7 Classic and Contemporary Narratives of Space Exploration

Natalie Trevino, Postdoc at the Space Ethics Group, The Open University

Synthesis Paper 1

Defining sustainability in the international law of outer space: plural actors and new narratives

Elena Cirkovic (Law)

Executive Summary

The advancement of space technologies and applications has significantly contributed to environmental monitoring, resource management, weather forecasting, climate modelling, satellite navigation, communications, and early warning systems for disaster mitigation. At the same time, there are increasing concerns over environmental protection and sustainable use of the outer space environment.

Sustainability in outer space generally refers to the principles, practices, and policies aimed at ensuring the responsible and long-term use of space resources, while minimizing negative impacts on the space environment and preserving the ability of future generations to benefit from space activities. However, there is no precise definition, principle, or rule of space sustainability in the current international legal regime in general, and the outer space regime, in particular. While the majority of space activities are still driven by governments with private industries acting as contractors for public programmes and relying greatly on public funding, there is also a growing investment by private actors in the sector and the emergence of a more business-oriented leadership. In this context, sustainability efforts in outer space are beginning to rely on sustainability value in the private sector. The private commercial sector has linked "sustainability" with the capacity for ongoing use, exploration, and exploitation of space resources. The principle of Corporate Social Responsibility (CSR) implies that public and private socio-technical systems can be managed and improved to make way for economic growth, which would recognise and incorporate ongoing environmental feedback, and aim for more sustainable approaches.

This synthesis paper will provide a non-exhaustive map of the interdisciplinary and diverse narratives surrounding the concepts of "sustainability", "corporate social sustainability", and sustainable value creation in public and private sectors. Mapping different definitions of sustainability and how they might apply to the outer space sector is one of the tools for policy and legal decision-making enabling the identification of sustainability objectives at state, regional, transnational, and international levels. In addition, orbital and planetary sustainability, and the corresponding evolution of domestic, international, and regional regulatory instruments, are taking place in conjunction with the sustainability of the Earth System, where the term “Earth system" refers to Earth´s interacting physical, chemical, and biological processes.

The starting point is the international outer space law and its mechanisms, including primarily the existing norms emanating from the United Nations Office for Outer Space Affairs (UNOOSA) and the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS). UNOOSA is the U.N. Secretariat office that promotes and facilitates peaceful international cooperation in outer space. UN COPUOS is a UN committee whose main task is

to review and foster international cooperation in the peaceful uses of outer space, as well as to consider legal issues arising from the exploration of outer space. The paper considers the evolution of sustainability, first in the outer space sector, and second in the international legal regime, more broadly. Lastly, it situates the role of private corporations and Sustainability Values and CSR in outer space and the Earth System. An example of such an initiative, the Space Sustainability Rating (SSR), seeks to foster voluntary action by satellite operators to reduce the risk of space debris, on-orbit collisions, and unsustainable space operations.

Introduction

The terms “sustainability” and “sustainable development” are prominent legal and policy objectives. There is no clear and unique definition available throughout the various disciplines using these expressions. The most often quoted definition comes from the World Commission on Environment and Development’s 1987 Brundtland report "Our Common Future" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"(Brundtland Report 1987, pg.16). Chapter 10 para 80 of the report refers to space debris regulation as “clearly overdue”. This synthesis paper will address some evolving and/or competing definitions of sustainability and how they apply to outer space activities. The objective is to create a non-exhaustive map which will delineate some of the most prominent narratives of outer space sustainability and sustainable uses of outer space. Different fields and disciplines require some clarity surrounding the concepts of "sustainability" (S), "corporate sustainability" (CS), and "corporate social responsibility" (CSR) (Beckers 2015, WBCSD 2000). The private commercial sector operating in outer space, has linked "sustainability" with the capacity for ongoing use, exploration, and exploitation of space resources.

With no clear global consensus on the definition of sustainability, what are the prospects for the short-medium-and long-term future of sustainability in outer space? The UN has based its guidelines on a broad definition of space sustainability: maintaining the conduct of space activities into the future and allowing for continued equitable access. The general meaning of space sustainability entails ensuring the long-term viability of space activities.

The new space economy—sometimes referred to as NewSpace—is the rising commercialization of space exploration including private investors, companies, and start-ups, all of which are investing and contributing to space exploration (OECD Handbook 2022). Rapidly advancing space technologies have allowed for an increasing accessibility of launching products into space. The difference between traditional space exploration and New Space is that the government no longer has to intervene entirely.

This synthesis paper identifies three areas of concern, which will be addressed in three respective sections: A. Sustainable uses of outer space and the concept of "space sustainability"; B. International and plural approaches to "sustainability" in global governance; C. Application of the concept of corporate social responsibility (CSR) in outer space activities and merging tools for the promotion of sustainability such as the voluntary tool for space sustainability rating (SSR). The synthesis paper there provides a general review of existing narratives on sustainability, emerging from different sectors, and their applicability to outer space activities.

A detailed analysis of applicable laws at international, transnational, regional, and/or domestic levels is beyond the scope of this paper and could be proposed as a necessary tool for relevant decision makers and different actors and stakeholders.

Some of the definitions used in this synthesis paper are as follows:

Outer space: “outer space” is referred to here as the region beyond Earth’s atmosphere that begins when an altitude of 100 km above Earth’s sea level is reached (McDowell 2018).

An orbit: “An orbit” is defined as a regular, repeating path that one object in space takes around another one. An object in an orbit is called a “satellite”. A satellite can be natural, like the Earth or the Moon, and many planets have moons that orbit them. A satellite can also be human made, like the International Space Station (ISS).

Earth System Science: The Earth System Science (EES) is the application of systems science to the Earth sciences, to study the Earth as a self-enclosed system. More simply, it involves viewing the Earth’s environment in a holistic fashion.

Earth System: The term “Earth System” refers to the Earth’s interacting physical, chemical, and biological processes. Human social, legal, political, and economic systems are embedded within the Earth System. The Earth’s climate is the average of all the world’s regional climates.

Climate change, therefore, is a change in the typical or average weather of a region and is also a change in Earth’s overall climate.

A. Understanding sustainability and the environment in outer space

The responsible and long-term utilization of space resources generally entails the preservation of the space environment, ensuring continued availability and accessibility of outer space for current and future generations, and minimising potential negative impacts on Earth and space systems. Protecting and preserving the space environment encompasses measures to avoid generating space debris, minimise the release of harmful substances, mitigate collision risks, and properly dispose of space objects at the end of their mission (ESA Space Debris Office 2021). This also entails efficient and responsible utilisation of space resources such as orbital slots, radio frequencies, and celestial bodies, as well as equitable access and avoidance of resource depletion or overexploitation. Maintaining the safety and sustainability of space activities requires regulating and coordinating the increasing number of objects in space, ensuring safe launch and re-entry procedures, and preventing collisions or interference among satellites (Chanoine 2018; ITU 2021; Lemmens & Letizia 2020; Letizia et al 2019; Letizia, Lemmens & Krag 2020; Maury et. al. 2017, 2019, 2020; Newman & Williamson 2018; Slavin, Wood & Jah, 2021). International cooperation plays a vital role in achieving sustainability in outer space. Collaboration and coordination among the international community, including states, international organizations, private companies, and scientific institutions, is essential in addressing common challenges, developing best practices, establishing guidelines and norms, and sharing data and information.

The outer space environment presently depends on a multitude of actors. Governments, represented by states, play a crucial role in developing national space policies and regulations. International organizations such as the United Nations Office for Outer Space Affairs

(UNOOSA), International Telecommunication Union (ITU), and the Committee on the Peaceful Uses of Outer Space (COPUOS) contribute by establishing international norms and facilitating cooperation among states. Private companies, including satellite operators, launch service providers, and space technology companies, are increasingly expected to adhere to sustainability principles and comply with regulations to minimize their environmental footprint and promote responsible space activities. Scientific and research institutions contribute through research, monitoring, and data analysis. They provide valuable insights, develop technologies, and propose mitigation strategies to address environmental and operational challenges in space. Civil society and non-governmental organizations (NGOs) play a role in raising awareness about space sustainability issues, promoting responsible practices, and advocating for the development and implementation of policies and regulations that prioritize the long-term preservation and peaceful use of outer space. This section provides an overview of how the international legal and governance community defines sustainability in outer space and identifies requirements for collective efforts, cooperation, and a shared commitment from multiple actors and plural perspectives.

Outer space governance was established through a series of international treaties, enacted during the Cold War period. The Outer Space Treaty of 1967 (OST) is the most significant piece of legislation in this regard. It establishes an international legal framework for outer space, intended to preserve outer space as free for exploration by all states, and that should not be subject to national appropriation by any means (Article II). At the time of the drafting of these treaties, outer space exploration was primarily an affair of national governments, which was principally undertaken for geopolitical purposes. Today, space activities are increasingly dominated by private actors (Feichtner 2019; Feichtner and Ranganathan 2019). While the geopolitical underpinnings cannot be ignored, these companies are participating in the race for space exploration mostly for commercial reasons (Singh Sadcheva 2018). The dominant debates and narratives in international law as related to ongoing and future human activities in outer space have recently focused on the military and commercial uses of outer space, with international lawyers participating in the delineation of what the public-private, state-commerce nexus of relations should become (Bittencourt Nieto 2020). Overlapping jurisdictions, regime interaction (Krisch, Kingsbury, Stewart 2005) inconsistent doctrinal interpretations, transnationalism and competing worldviews (ILC 2006, Teubner 1997), characterize the contemporary legal terrain. In the context of outer space, national laws on the utilization of space resources are examples of emergent national policies and laws promoting exploration, exploitation, and utilization of space resources (Feichtner 2019). With the intensifying competition in outer space, legal proposals are increasingly bilateral and not global (e.g., Artemis Accords 2020). States continue to be the principal subjects of international space law, and only states can be held responsible and liable.

Sustainability in outer space refers to the principles, practices, and policies aimed at ensuring the responsible and long-term use of space resources, while minimizing negative impacts on the space environment and preserving the ability of future generations to benefit from space activities. The OST establishes the basic principles for space exploration and utilization and does not explicitly use the term "sustainability," it contains provisions that promote the responsible use of space and the protection of celestial bodies. The terms “liability” and “responsibility” are here understood in accordance with the International Law Commission Articles on State Responsibility, generally denoting that “responsibility” only refers to State responsibility and “liability” to State liability (International Law Commission Report, A/56/10

August 2001). In terms of the civil liability systems and Multilateral Environmental Agreements (MEAs), the terms will depend on the form in which they can be found in the regime in question. It is up to the states to regulate via their national legislative systems if and how the financial burden flowing from their international responsibility and liability for a private entity's conduct in space will eventually be shared between them and these private entities.

The requirement of "continuing supervision" stated in Article VI of the OST implies that governments are responsible for overseeing the space activities of private actors, extending to the operational phase of satellites while they are in Earth orbit. The United Nations General Assembly (UNGA) Resolution 68/74 recommends that national regulatory frameworks for space activities cover various aspects such as satellite launches, on-orbit operations, impacts, and end-of-mission procedures. In the context of outer space, this could, for example, involve due diligence in national assessments of the impact of on-orbit satellite operations before launching them and processes ensuring ongoing supervision.

UN COPUOS encourages states and international intergovernmental organizations to voluntarily implement the guidelines to the best of their ability. It is a principal forum for ongoing dialogue on the implementation and review of these guidelines. In June 2016, COPUOS agreed upon the initial set of guidelines for long-term space sustainability, followed by a consensus reached in 2018 on a preamble and nine additional guidelines.

In the context of promoting long-term space sustainability, during its sixty-second session in 2019, COPUOS decided to establish a dedicated working group under the Scientific and Technical Subcommittee. The LTS Guidelines for the Long-term Sustainability of Outer Space Activities (henceforth, the "LTS Guidelines"), which were adopted in June 2019, serve as a comprehensive framework for promoting the long-term sustainability of space activities. They offer comprehensive direction concerning policy and regulatory frameworks for space activities, safety considerations in space operations, international cooperation, and capacity-building endeavours, as well as scientific and technical research and development. The LTS Guidelines encompass several key aspects aimed at fostering responsible and sustainable practices in outer space including the recommendations of GA Resolution 68/74, addressing risks to people, property, public health, and the environment associated with space activities, promoting regulations to minimize the impacts of human activities on Earth and in outer space, and seeking input from affected entities to avoid overly restrictive regulations or conflicts with other legal obligations. Guideline A.3 of the LTS Guidelines emphasizes that entities conducting space activities should develop specific requirements and procedures for safety and reliability, assess risks associated with their activities throughout the mission life cycle, and take steps to mitigate those risks. The report highlights the previous identification of issues and risks associated with large-scale satellite constellations, including light pollution. They emphasize the significance of establishing comprehensive and transparent national policies and regulatory frameworks for space activities; urge states to develop appropriate legal frameworks and licensing processes to ensure responsible and sustainable space operations; prioritize the safety of space operations; recommend the adoption of best practices and standards to ensure the safe and reliable design, operation, and disposal of space objects, thereby reducing the risk of accidents and collisions; highlight the importance of international cooperation, capacity-building, and awareness in achieving long-term space sustainability; emphasize the need for collaboration among states and organizations to share information, enhance capabilities, and build capacity in crucial areas such as space situational awareness,

space debris mitigation, and space weather monitoring; emphasize the significance of raising awareness and promoting education about space sustainability among stakeholders and the general public; underscore the necessity for continued scientific and technical research and development to advance space sustainability; and encourage states and organizations to support research and development activities related to space debris mitigation, space weather prediction, sustainable space utilization, and other relevant areas.

The adoption of the LTS Guidelines reflected the international community's approach to promoting the long-term sustainability of outer space activities through voluntary mechanisms. They serve as a reference for states, space agencies, and industry stakeholders to develop and implement practices that contribute to a sustainable and secure space environment.

An additional consideration is the impact of human activities on both the Earth and outer space environments. For instance, OST Article IX requires state parties to conduct their space activities with due regard to the interests of other parties and to avoid harmful interference. It also stipulates that states engage in international consultations if an activity could potentially cause harmful interference with the activities of other states. States can exercise their rights and freedoms in outer space (Article I) in a manner that avoids harmful interference with the space activities of other states. Due regard implies that space is a shared domain and that the actions of one state should not impede or adversely affect the space activities of other states. It encompasses a range of considerations, including the need to prevent the creation of hazardous space debris, avoid collisions between space objects, and respect the orbits and missions of other satellites. States must take appropriate measures to ensure that their space activities are conducted responsibly and in a manner that minimizes the risks of interference or harm to other space actors. It also extends to the protection of celestial bodies and their environments. It acknowledges the scientific and cultural value of celestial bodies and emphasizes the importance of preserving their integrity and avoiding any activities that could cause harmful contamination or destruction.

Terms such as "due regard" and "harmful interference" draw from international air and telecommunications law. More specifically, the principle of "due regard" obliges states to conduct their space activities not only in their own interest but also considering the interests and rights of other parties. For instance, Article 87 of the UN Convention on the Law of the Sea (UNCLOS) states that freedom of the high seas is to be exercised by all States with due regard for the interests of other States and also with due regard for the rights under UNCLOS. Harmful interference, as defined by the ITU Radio Regulations, refers to interference that endangers or disrupts radio communication services. It is defined in both No. 1.169 of the RR and in No. 1003 of the ITU Constitution, as "interference which endangers the functioning of a radiocommunication service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations". Harmful interference can take place for a wide range of reasons, which can be either accidental or intentional. Both commercial services and critical safety-of-life applications may be degraded and affected.

Other space treaties, such as the Liability Convention (RES 2777 (XXVI)) and the Registration Convention (RES 3235 (XXIX)), indirectly address sustainability concerns by establishing liability regimes for damage caused by space activities and requiring the registration of space

objects, respectively. These conventions contribute to promoting responsible behaviour and accountability in outer space operations.

In addition, international organizations, such as the United Nations Office for Outer Space Affairs (UNOOSA), actively engage in discussions on space sustainability. UNOOSA facilitates international cooperation, promotes best practices, and encourages the development of guidelines and norms for sustainable space activities. With the growing commercialization of space and the increase in space debris, the concept of sustainability in outer space has gained greater attention. Various initiatives and guidelines have been proposed by space agencies, industry stakeholders, and international bodies to address issues such as space debris mitigation, resource utilization, and the preservation of celestial bodies. Overall, the principles and provisions within international space treaties and the ongoing discussions reflect the recognition of the importance of sustainable practices and the long-term viability of outer space activities.

Guided by these comprehensive principles and guidelines, space sustainability focuses on several critical aspects. First, addressing the escalating challenge of space debris is vital. Guidelines in this area advocate measures such as designing satellites for controlled re-entry and mandating satellite deorbiting at the end of their operational lives to curtail debris creation. Second, efficient, and safe STM establishes practices for tracking and cataloguing space objects, coordinating satellite launches, and implementing clear rules and procedures to prevent collisions and congestion. Third, long-term sustainability practices involve adopting mission designs that prioritize sustainability, utilizing fuel-efficient propulsion systems, and minimizing waste and reliance on Earth's resources. Lastly, international cooperation is essential for space sustainability. Guidelines underscore the importance of information sharing, coordination, and harmonization of space policies and regulations among nations to foster responsible space activities. Space agencies, international organizations, and industry stakeholders continuously collaborate to refine guidelines and best practices. Consequently, consulting authoritative sources and engaging with relevant organizations in the field of space policy is crucial for obtaining the latest guidelines and definitions related to space sustainability.

Over the years, the UN COPUOS has undertaken efforts to address various dimensions of long-term space sustainability. In 2010, the Scientific and Technical Subcommittee (STS) initiated deliberations on this topic and established the Working Group on the Long-term Sustainability of Outer Space Activities. The primary objectives of this group were to identify areas of concern, propose measures to enhance sustainability, and develop voluntary guidelines aimed at minimizing risks to long-term space sustainability. The Working Group, along with its expert groups, focused on several thematic areas, including sustainable space utilization, space debris mitigation, space weather, and regulatory regimes for space actors.

UNOOSA has actively engaged in promoting the long-term sustainability of outer space activities with guidelines such as the Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee (IADC), which provides recommendations to minimize space debris creation and limit the growth of the debris population. UNOOSA also operates a voluntary registration system for space objects. The United Nations Register of Objects Launched into Outer Space serves as a repository of information about space objects, facilitating the identification and tracking of satellites and space debris.

B. Global and plural sustainability narratives

Arguably, some of the earliest manifestations of sustainability in international emerged from the realm of environmental law. The United Nations Conference on the Human Environment, held in Stockholm in 1972, marked a significant milestone in recognizing the interconnectedness between environmental protection and sustainable development. The resulting Stockholm Declaration emphasized the need to safeguard the environment for present and future generations, thereby laying the foundation for the concept of sustainability (Stockholm Declaration 1972).

In subsequent years, sustainability gained increasing attention and recognition on the global stage. As mentioned previously, the World Commission on Environment and Development (WCED), established by the United Nations in 1983, released the Brundtland Report in 1987. The report introduced the concept of sustainable development, defining it as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It highlighted the urgent need for integrating environmental, economic, and social considerations into decision-making processes, setting the stage for the development of sustainable development principles in international law.

The United Nations Conference on Environment and Development, also known as the Earth Summit, held in Rio de Janeiro in 1992, further solidified sustainability as a guiding principle in international law. The summit resulted in the adoption of Agenda 21, a comprehensive plan of action for achieving sustainable development at the global, national, and local levels. Agenda 21 called for the integration of economic development, social equity, and environmental protection, emphasizing the importance of international cooperation and the role of law in advancing sustainability (Earth Summit [ST/]DPI/13441).

The Rio Declaration on Environment and Development, which emerged from the Earth Summit, affirmed the right to sustainable development and emphasized the need for the participation of all stakeholders in decision-making processes (The Rio Declaration, UN Doc. A/CONF.151/26 (vol. I), 31 ILM 874 (1992)). The United Nations Framework Convention on Climate Change (UNFCCC), adopted at the same summit, recognized the importance of stabilizing greenhouse gas concentrations in the atmosphere to prevent dangerous anthropogenic interference with the climate system, thus addressing sustainability concerns related to climate change (United Nations Framework Convention on Climate Change, May 9, 1992, S. Treaty Doc No. 102-38, 1771 U.N.T.S. 107). Since the Earth Summit, sustainability has become an integral part of international legal discourse. Numerous international agreements, such as the Convention on Biological Diversity (1760 UNTS 79, 31 ILM 818 (1992)) and the Paris Agreement (Treaty Doc No. 102-38, 1771 U.N.T.S.) reflect a growing recognition of the need to promote sustainability in different areas of global concern. These instruments aim to balance environmental protection, social equity, and economic development, recognizing that sustainable practices are crucial for the well-being of present and future generations.

The concept of sustainability in international law has evolved over time, with its roots in early environmental law developments. Considering that individual regimes in international law (or *'lex specialis'*) do not operate independently but do exist in the complex system of hierarchies, relationships and regime interactions, various existing concepts of sustainability do apply to

outer space activities, just as they apply to activities on Earth (for a detailed report on regime interactions in international law, please see the International Law Commission's 2006 Report, A/CN.4/L.682 and Add.1).The integration of sustainability considerations in international legal instruments reflects the increasing recognition of the interdependence between environmental, social, and economic dimensions of various human activities and corresponding sectors (e.g., satellite activities).

Approved on 25 September 2015 following a two-year global consultation involving civil society organizations, scientists, academics, and citizens worldwide, the 2030 Agenda for Sustainable Development introduced 17 Sustainable Development Goals (SDGs), accompanied by 169 targets and 231 indicators (A/RES/70/1). Anchored on the Leave-no-one-behind principle and the integration of social, environmental, and economic dimensions of sustainability, the agenda promotes a five P-based world: People, Planet, Prosperity, Peace, and Partnership. In contrast to the Millennium Development Goals, the 2030 Agenda incorporates a comprehensive follow-up and review protocol, acknowledging the crucial role of robust, voluntary, effective, participatory, transparent, and integrated progress tracking at global, regional, and national levels. This necessitates robust monitoring, systematic reporting, and data-driven decision-making to identify policy gaps and facilitate SDG implementation. Scientific research assumes a pivotal role in providing data, assessing progress, analysing interlinkages among the SDGs, and informing policymaking. Key research areas include sustainability measurement and the understanding of interdependencies between goals and targets. However, existing ranking methods often overlook interlinkages, despite the significance of harnessing synergies and minimizing trade-offs for SDG achievement. While the political impact of the SDGs on global, national, and local governance remains limited, the goals offer an opportunity to mobilize academic communities, catalysing relational changes and accountability. To operationalize the 2030 Agenda, further research could explore complex system dynamics, contribute to goal reporting, and stimulate transformative change.

Accompanying these developments is also the relatively novel narrative emerging from Earth System Science (ESS). It is more focused on the holistic approach to the Earth System as a whole (IPCC 2022, Steffen 2018). ESS applies systems science to complex interactions and feedback among the Earth’s sub-systems. These sub-systems include the atmosphere, hydrosphere, cryosphere, geosphere, pedosphere, lithosphere, biosphere, and magnetosphere. ESS also examines the impact of human societies on these components. It brings together researchers from various disciplines, such as ecology, economics, geography, geology, glaciology, meteorology, oceanography, climatology, palaeontology, sociology, and space science. Subsets of ESS include systems geology and systems ecology, and aspects of ESS are essential to physical geography and climate science. The ESS approach generally defines sustainability as the capacity of a system to continue indefinitely into the future, while maintaining its essential functions, diversity, and resilience. Seminal representative works include the report "The Planetary Boundaries Framework: Exploring the Safe Operating Space for Humanity" (2009) which identifies and quantifies critical Earth system thresholds beyond which human activities risk causing irreversible environmental changes. The report identifies nine planetary boundaries, such as climate change, biodiversity loss, and freshwater use, providing a scientific basis for sustainable development goals. The article "Planetary Boundaries: Guiding Human Development on a Changing Planet" (2015) discusses the concept of planetary boundaries in the context of sustainable development and suggests a new approach to global governance that integrates social, economic, and environmental

dimensions. The seminal article co-authored by Will Steffen, Jacques Grinevald, Paul Crutzen, John McNeill, and Peter Smith's "The Trajectory of the Anthropocene: The Great Acceleration" (2007) analyses various indicators of human activity and environmental change to demonstrate the unprecedented acceleration of human impacts on the Earth system since the mid-20th century. They argue that these changes signal the need for urgent action to shift towards a more sustainable and resilient future. The 2015 version "The Great Acceleration: An Environmental History of the Anthropocene since 1945" (2015) provides a comprehensive assessment of the environmental changes and highlights the rapid growth of the human population, resource consumption, and greenhouse gas emissions, and their implications for Earth's systems. The paper emphasizes the urgent need for transformative actions to address these challenges.

Application of this narrative to outer space (Magalhães et.al. 2016; Cirkovic 2021, 2022, 2022), entails managing human activities in a way that ensures the long-term health and integrity of both non-human and human systems. It involves recognizing the interconnectedness and interdependence of social, economic, and environmental dimensions and striving for a balance that supports human well-being while preserving the integrity of the outer space and Earth's ecosystems.

Indigenous studies scholarship is a varied and plural field (Graham 1999, Coulthard 2014; Coulthard & Simpson 2016; Wilson and Wilson 2015; Martin 2017; Simpson 2017, Todd 2020), which has already developed theories for extending subjectivities beyond the human species. For those who identify as Indigenous scholars, the struggle is to find a way to enable these ontologies to be recognised and reproduced in their academic work (Smith 2017). They propose a new vocabulary which troubles the familiar language of empiricist or interpretivist social science to open up a space where objects can express their vitality—or, at least, where humans can experience and understand non-human agency. Indigenous studies provide a basis for an ontology which already considers beyond "where we live" to include the known universe (which has different narratives and imaginaries in various parts of the world) (Cirkovic 2022).

Broader scholarly tradition which refers to all that is considered as non-human (sentient and non-sentient) refers to, among others, theories posthumanism (Alaimo, 2016; Braidotti, 2013, Brooks and Philippopoulos-Mihalopoulos 2017, Grear 2020), new materialist philosophy of science (Coole & Frost, 2010; Barad, 2007, 2011) and science and technology studies (STS) (Jasanoff 2012, 2016). Accordingly, 'anything' that has capacity to affect anything else (material or biological) is agentic (Latour 2005). From these perspectives and narratives, traditional regulatory modalities seem bound to lose their traction.

A preliminary conclusion of this synthesis report is that no one "discipline" as a community of specialized knowledge provides a full definition of sustainability. In social sciences, Dietz et al. (2003) articulated the need for "adaptive" governance of Social Ecological Systems (SES) arguing that our knowledge of any system is likely to be wrong or at least incomplete, and the required scale of governance may shift because of changes in the biophysical and social system components. More recent research builds on the hypothesis of discontinuity and the introduction of non-human agency onto the regulatory playing field (Paloniitty 2023, Cirkovic 2022, 2023). The realization that complex systems are vulnerable to big (and sometimes catastrophic) shifts in behaviour stemming from small changes is a critical area of research

(Nobel Prize Committee 2021). Technological innovation, for instance, has the capacity to trigger events and outcomes within the complex social and environmental systems that are hard to predict and manage. Predictability and causality (which are crucial for legal thinking) are specious when one ignores the underlying causes of “disorder”- induced variability. Legal scholarship needs a capacity to see minute errors that increase over time with varied consequences (e.g., global warming and orbital debris). However, anthropogenic consequences are not entirely unpredictable if analysed with rigorous engagement with, and recognition of other expertise (climate science, engineering, astrophysics, etc.). And finally, an understanding of responsibility(Graham 2014) in sciences, social sciences, and humanities, helps to challenge the misuse of “systems” approaches in social science, as self-driven processes (Luhmann 1993). While specific non-human laws might govern the exponential growth of anthropogenic orbital debris, it is still, anthropogenic.

Recognising these complexities and pluralities the following section narrows on the legal sector and specifics of public-private interactions in private commercial activities in outer space, and the potential for corporate social responsibility (CSR). Private actors and non-governmental entities play a significant role in various aspects of society, including the outer space sector and possibilities for the building of sustainability value in outer space activities.

C. Sustainability Value Narratives in the Public-Private Sector Interactions

National space legislation serves as a direct instrument for implementing international legal obligations arising from space treaties and general international law at the domestic level. States, as parties to these treaties, have the duty to authorize and supervise private space activities (1969 Vienna Convention; OST Article VI)). They are also internationally liable for damages caused by their satellites or those belonging to private companies. While CSR does not have a specific legal definition in international law in general, and outer space law, in particular, it has emerged as a concept from various sources, including soft law instruments, guidelines, and voluntary initiatives. Corporations, as legal entities, serve as the primary organizational form for large-scale businesses, ranging from small entrepreneurial ventures to multinational enterprises. The corporation enables the pooling of capital from diverse investors, facilitating the funding of risky business ventures that may otherwise lack financing. Moreover, it allows investors to limit their liability while expecting returns through dividends or share sales. Coordination of capital raising and share trading occurs through stock exchanges, both domestically and internationally.

One notable instrument is the United Nations Guiding Principles on Business and Human Rights (UNGP), which outlines the responsibility of businesses to respect human rights. The UNGP emphasizes that businesses have a responsibility to avoid causing or contributing to adverse human rights impacts and to address such impacts when they occur. While the UNGP does not explicitly use the term "CSR," it provides a framework for businesses to integrate human rights considerations into their operations ([ST/]HR/PUB/11/4).

The International Organization for Standardization's ISO 26000:2010, provides guidance on social responsibility. It outlines principles and core subjects for businesses to consider, including human rights, labour practices, environmental sustainability, fair operating practices, consumer issues, and community involvement. Although ISO 26000 is not legally binding, it serves as a widely recognized international standard for CSR. Other international treaties and conventions address specific aspects related to CSR, such as environmental protection,

labour rights, and anti-corruption. For example, the United Nations Global Compact encourages businesses to adopt and implement ten principles in the areas of human rights, labour, environment, and anti-corruption (United Nations Global Compact 2015; see also: The Draft United Nations Code of Conduct on Transnational Corporations, UN Doc. E/C.10/1982/6, 5 June 1982 (revised UN Doc. E/1983/17/Rev.1); UN Guiding Principles on Business and Human Rights 2011 (A/HRC/17/31) endorsed by the UN Human Rights Council on 6 July 2011 (A/HRC/RES/17/4).

While these instruments and initiatives provide guidance and promote responsible business practices, CSR largely remains a voluntary concept rather than a legally enforceable obligation under international law. Importantly, the legal status and enforcement mechanisms regarding CSR may vary across different jurisdictions, and businesses should be aware of the applicable laws and regulations in the countries where they operate (Braithwaite and Drahos 2000; Wai 2002; Sjajfel 2020).

In corporate governance, there is a difference between "shareholder primacy" and the legal norm of "shareholder value" . Stakeholders are defined as groups or individuals who can affect or are affected by a firm's objectives. Corporate governance encompasses the balancing of interests with stakeholders, going beyond mere compliance with company law rules. It involves intentional and self-organized interactions among governments, private groups, and formal and informal institutions. Voluntary codes of conduct, non-legislated commitments made by companies, play a role in outer space sustainability by considering the principle of CSR (see generally: Berle 1931; Dodd 1932; Berle 1932; Freeman 1984, pg. 46; Gelter 2010; Herrigel 2007; Foster 2000; Siems 2007; Pistor et.al. 2002).

The increasing number of private actors in outer space also necessitates consideration of transnational regulation. Philip Jessup proposed the phrase transnational law "to include all law which regulates actions or events that transcend national frontiers. Both public and private international law are included, as are other rules which do not wholly fit into such standard categories"(Jessup 1956, pg.2). Transnational corporations operate in multiple countries simultaneously and are subject to a public-private hybrid of regulation, which encompasses public and private international law and other relevant rules. Such corporations have headquarters in one country and wholly or partially owned subsidiaries in other countries, reporting to the central headquarters. Thus, the regulatory framework should account for the activities of transnational corporations in outer space.

The concept of CSR further aligns with sustainability objectives, incorporating existing legal and governance structures, environmental protection, and climate governance regimes. The corporation itself is neither inherently sustainable nor unsustainable, and therefore CSR and voluntary codes of conduct can encourage responsible behaviour in outer space activities. CSR contributes to risk management, cost savings, access to capital, customer relationships, human resource management, and innovation capacity (Sjajfel 2020; 2022).

Intensifying discussions about corporate sustainability metrics have shed light on the ESG criteria (environmental, social, and governance), which has, in turn, increased misperceptions associated with the concept. ESG was first mentioned in the 2006 United Nation's Principles for Responsible Investment (PRI) report consisting of the Freshfield Report and "Who Cares Wins" (UN Global Compact, 2004; Freshfields Report UNEPFI 2005). The former UN

Secretary-General called for financial institutions to develop guidelines and recommendations for integrating environmental, social, and corporate governance issues into asset management. The focus was on establishing measurement systems to assess company performance. ESG is closely related to responsible investments or socially responsible investments (SRI), which are based on the concepts of CSR and philanthropy. It was to be incorporated into the financial evaluations of companies. Mapping different definitions of sustainability and how they might apply to outer space activities is one of the tools for policy and legal decision-making enabling the identification of sustainability objectives at state, regional, and international levels. The ESG criteria are therefore increasingly relevant as part of the rapid growth of the space and launch industry. The need for effective legislation and guidelines becomes more evident considering the increasing dependence on space technologies in our daily lives. The environmental ("E") component of ESG focuses on factors such as climate change, pollution, conservation of natural resources, and greenhouse gas emissions. It involves evaluating how a company's activities impact the environment and whether it adopts practices that are environmentally friendly and sustainable. The social aspect ("S") examines the influence of a company's operations on society as a whole. This includes considering the well-being of employees, customers, communities, and supply chains. Evaluating labour practices, diversity and inclusion, human rights, product safety, and community engagement are important factors within the social aspect of ESG. Governance ("G"), the third component, revolves around the structure and practices of a company's leadership and management. It encompasses aspects such as board composition, executive compensation, transparency, accountability, and shareholder rights. Good governance ensures that a company is managed in an ethical and responsible manner.

Corporate governance and addressing ESG issues have become integral to business strategies in order to meet stakeholder expectations. The sustainability debate now revolves around integrating ESG factors into company strategies and operations. Understanding the fundamentals of corporate governance is essential within this context. Corporate governance encompasses the system for directing and controlling a corporation. Key questions arise, such as the purpose of a business, the interests it should prioritize, and how it should be operated. The governance structure should define the rights and responsibilities of stakeholders and the board of directors. Comprehensive corporate discussions involve ethical considerations throughout value chains, human rights, bribery and corruption, and climate change. Governance factors include board independence, dedication, compensation policies, takeover defences, and the effectiveness of internal audit and control mechanisms.

a. **Space Sustainability Rating (SSR) and Voluntary Regulation**

In response to environmental challenges in outer space activities, the Space Sustainability Rating (SSR) tool was established to recognize and reward actors actively pursuing long-term sustainability in the space industry. It was specifically developed to reduce space debris and ensure safe and sustainable space missions. SSR evaluates mission designs and operations based on adherence to internationally recognized standards and guidelines, promoting sustainable and responsible practices. The concept of the SSR emerged during the Global Future Council discussions in 2017 and was later formed in 2019 by a consortium consisting of the European Space Agency (ESA), the University of Texas at Austin, and Bryce Space and Technology. In 2021, the Ecole Polytechnique Federale de Lausanne (EPFL) was chosen as the administrative organization for the rating. The SSR is presently a non-profit association recognized by EPFL and hosted within eSpace – EPFL Space Centre. The primary goal of the

SSR is to bridge the gap between the growing space industry and the lagging legislation, providing recognition and incentives for actors committed to sustainable practices (Rathnasabapathy 2022; Cirkovic, Rathnasabapathy & Wood, 2021, 2022).

Ratings have proven influential in various industries, even in the absence of strict regulations. The SSR aims to motivate actors within the space industry to strive for sustainable practices and maintain a positive reputation. Drawing parallels to rating systems in other sectors, such as the Leadership in Energy and Environmental Design (LEED) for buildings, the SSR assesses the sustainability of satellites and space missions. By recognizing positive behaviour and rewarding exemplary practices, the rating system encourages industry-wide improvement. SSR employs a scoring system based on six different modules. Factors considered include data sharing, information verification capabilities, orbit selection, collision avoidance measures, plans for satellite de-orbiting after mission completion, and the detectability and identification of objects from Earth. The rating primarily focuses on assessing positive behaviour and encouraging sustainable practices (Steindl et.al. 2021; Letizia et. al. 2021; Rathnasabapathy et.al. 2020).

To ensure the inclusivity and relevance of the SSR, stakeholder meetings were organized during the initial stages of its development. Representatives from different sectors of the space industry, including government agencies and commercial entities, were involved in the discussions. This collaborative approach aimed to address diverse priorities and perspectives within the space sector.

Conclusion

The concept of sustainability in outer space bears significance for the future of space exploration and utilization activities. Conducting human activities in a manner that preserves and protects the space environment for present and future generations, also provides greater predictability for both state and non-state and commercial actors in the space sector.
The legal framework surrounding sustainability in outer space is still in its nascent stages, but there have been notable developments in recent years. International treaties, such as the OST, provide a foundation for responsible space activities and emphasize the need for sustainable practices.

The promotion of sustainability in outer space relies on multilateral collaboration among states, international organizations, and private entities. This is increasingly evident in the proposal for the development of guidelines, standards, and best practices that promote the sustainable use of space resources, minimize space debris, and mitigate the environmental impact of space activities.

In addition, the principle of sustainable development has been a guide in shaping the ongoing framework-building for sustainability in outer space. Various actors are proposing careful balancing of economic interests, social equity, and environmental protection as fundamental for efforts to advance sustainability in space.

As the commercial space industry grows and technological advancements continue, prioritisation of sustainability and responsible behaviour in space activities includes addressing issues such as orbital congestion, space debris mitigation, and the protection of celestial bodies.

In conclusion, integrating sustainability principles into the legal framework governing outer space is significant for the sector and especially for the responsible and sustainable use of outer space. Through international cooperation, continued research, and the development of comprehensive legal frameworks, space access, exploration, and utilization can be conducted in a manner that preserves the space environment, and contributes to the well-being of both present and future generations.

REFERENCES

1. Alaimo, S. Bodily Natures: Science, Environment, and the Material Self (Indiana University Press, 2010).
2. Barad, K. Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning (Duke University Press, 2007).
3. Beckers, A. Enforcing Corporate Social Responsibility Codes: On Global Self-Regulation and National Private Law (Hart Publishing, Oxford 2015).
4. Bennett, J. Vibrant Matter (Duke University Press, 2009).
5. Berle, A. "Corporate Powers as Powers in Trust" (1931) 44 *Harvard Law Review* 1049-74. Dodd, E. M. "For Whom Are Corporate Managers Trustees?' 45 Ibid. A. A. Berle, 'For Whom Are Managers Trustees: A Note' 45. Ibid. 1365-72.
6. Bittencourt Neto, O, et.al (eds) Building Blocks for the Development of an International Framework for the Governance of Space Resource Activities: A Commentary (den Haag: Boomuitgevers, 2020).
7. Braithwaite J. and Drahos, P. Global Business Regulation (Cambridge University Press 2000).
8. Chanoine, A. “How to assess the material obsolescence risk related to REACH?” (2018) in ESA Clean Space Industrial Days, ESTEC, Noordwijk.
9. Cirkovic, E "The Next Generation of International Law: Space, Ice, and the Cosmolegal Proposal" (2021) 21 *German law journal* 2, 147 - 167.
10. Cirkovic, E. “International Law beyond the Earth System: Orbital debris and interplanetary pollution" (2022) 13 *Journal of Human Rights and the Environment* 2.
11. Cirkovic, E, Wood, D. and Rathnasabapathy, M. “Sustainable orbit and the Earth System: mitigation and regulation” (2021) Conference Proceedings, European Space Agency ESA/ESOC : 8th European Conference on Space Debris (2021).
12. Cirkovic, E, Rathnasabapathy, M, and Wood, D. (2022) "Promoting Sustainability Value in Outer Space and the Earth System"(IAC International Congress, 2022) https://iac2022.org/
13. Coole D and Frost, S. New Materialisms: Ontology, Agency and Politics (Duke University Press 2010).
14. Coulthard G and Simpson L. B. "Grounded Normativity / Place-Based Solidarity" (2016) 68 *Amerian Quarterly* 2, 249–255.
15. Coulthard G, Red Skin, White Masks: Rejecting the Colonial Politics of Recognition (University of Minnesota Press 2014)
16. Dietz, T, "The Struggle to Govern the Commons" (2003) 302 *Science* 1907
17. Feichtner, I. "Mining for Humanity in the Deep Sea and Outer Space: The Role of Small States in the Extraterritorial Expansion of Extraction"(2019) 32 *Leiden J. Int’l L.* 255

18. Feichtner, I. and Ranganathan, S. 'International Law and Economic Exploitation in the Global Commons: Introduction' (2019) 30 *European Journal of International Law* 541.
19. Foster, N. "Company Law Theory in Comparative Perspective: England and France" (2000) 48 *Amer. J. of Com. L.* 573.
20. Freeman, R.E. Strategic Management: A Stakeholder Approach (Boston: Pitman, 1984).
21. Gelter, M. "Taming or Protecting the Corporation? Shareholder-Stakeholder Debates in a Comparative Light" (2010) 7 *NYU Journal of Law & Business* 641-730, 686.
22. Graham, M. Some Thoughts about the Philosophical Underpinnings of Aboriginal Worldviews (1999) 3 *Worldviews: Global Religions, Culture, and Ecology* 2, 105–18
23. Graham, M. Aboriginal notions of relationality and positionalism: a reply to Weber (2014) 4 *Global Discourse* 1, 17–22
24. Grear A. "Introduction: Staying with the Trouble'—Environmental Justice for the Anthropocene–Capitalocene"in Environmental Justice. International Library of Law and the Environment Series (Cheltenham: Edward Elgar Publishing, 2020).
25. Herrigel, G. "Guest Editor's Introduction: A New Wave in the History of Corporate Governance"(2007) 8 *Enterprise and Soc.* 3 475
26. Jasanoff, S. The Ethics of Invention. Technology and Human Future (WW Norton, 2016).
27. Jasanoff. S. Image and Imagination: The Formation of Global Environmental Consciousness (London: Routledge, 2012).
28. Jessup, P. Transnational Law (New Haven: Yale University Press, 1956).
29. Krisch NB, Kingsbury B, Stewart, "The Emergence of Global Administrative Law" (2005) 68 *Law and Contemporary Problems* 15
30. Latour, B. Reassembling the Social: An Introduction to the Actor-Network Theory (Oxford: Oxford University Press, 2005).
31. Lehmann, V. Bach and M. Finkbeiner "Product Environmental Footprint in Policy and Market Decisions: Applicability and Impact Assessment" (2015) 11 *Integrated Environmental Assessment and Management* 3, 417-424.
32. Lemmens, S., & Letizia, F. "Space traffic management through environment capacity" In K.-U. Schrogl (Ed.), *Handbook of space security* (pp.). Springer (2020) 845–86
33. Letizia, F., Lemmens, S., Bastida Virgili, B., & Krag, H. (2019). Application of a debris index for global evaluation of mitigation strategies. *Acta Astronautica*, *161*, 348–362. https://doi.org/10.1016/j.actaastro.2019.05.003
34. Letizia, F., Lemmens, S., & Krag, H. (2020). Environment capacity as an early mission design driver. *Acta Astronautica*, *173*, 320–332. https://doi.org/10.1016/j.actaastro.2020.04.041
35. Luhmann, N. Law as a Social System (Oxford: Oxford University Press, 1993). Magalhães, P, Steffen, W, Bosselmann, K, Aragão A, and Soromenho-Marques eds. The Safe Operating Space Treaty: A New Approach to Managing Our Use of the Earth System (Cambridge Scholars Publishing 2016).
36. Martin, B. "Methodology is content: Indigenous approaches to research and knowledge" (2017) 49 *Educational Philosophy and Theory*, 1392–1400
37. Maury, T., Loubet, P., Ouziel, J., Saint-Amand, M., Dariol, L., & Sonnemann, G. "Towards the integration of orbital space use in Life Cycle Impact Assessment"(2017) 595 *Science of The Total Environment* 595, 642–650.
38. Maury, T., Loubet, P., Trisolini, M., Gallice, A., Sonnemann, G., & Colombo, C. "Assessing the impact of space debris on orbital resource in life cycle assessment: A

proposed method and case study" (2019) 667 *Science of The Total Environment*, 780–791.
39. Maury, T., Loubet, P., Serrano, S. M., Gallice, A., & Sonnemann, G. (2020). "Application of environmental life cycle assessment (LCA) within the space sector: A state of the art" (2020) 170 *Acta Astronautica* 122–135.
40. McDowell, J. "The Edge of Space: Revisiting the Karman Line" (2018) 151 *Acta Astronautica*, 668–77.
41. Newman, C. J., & Williamson, M. "Space Sustainability: Reframing the Debate"(2018) 46 *Space Policy* 30–37.
42. Paloniitty, T. Law, Ecology, and the Management of Complex Systems (GlassHouse Routledge 2023).
43. Pistor, K, Keinan, Y, Kleinheisterkramp, J and West, M. "The Evolution of Corporate Law: A Cross-Country Comparison" (2002) 23 *U. Pa. J. Int'l. Econ*. *L*. 791.
44. Rathnasabapathy, M. et al, "Space Sustainability Rating: Towards An Assessment Tool To AssuringThe Long-Term Sustainability Of The Space Environment". IAC 2019 198.
45. Rathnasabapathy, M. et al, "Space Sustainability Rating: Designing a Composite Indicator to Incentivise Satellite Operators to Pursue Long-Term Sustainability of Space" 71st International Astronautical Congress (IAC) — The CyberSpace Edition, 12-14 October 2020.
46. Sachdeva, S. G. "Commercial Mining of Celestial Resources: A Case. 2. Study of US Space Laws" (2018) 13 *Astropolitics: The International Journal of Space Politics & Policy* 3
47. Siems, M. "Legal Origins: Reconciling Law & Finance and Comparative Law" (2007) 52 *McGill Law Journal* 55 (2007)
48. Simpson, L. B. As we have always done: Indigenous freedom through radical resistance (Minneapolis: University of Minnesota Press 2017)
49. Sjåfjell, B. "Sustainable Value Creation Within Planetary Boundaries — Reforming Corporate Purpose and Duties of the Corporate Board" (2020) 12 *Sustainability* 15, 6245;
50. Sjåfjell, B., Tsagas, G. and Villiers, C. Sustainable Value Creation in the European Union: Towards Pathways to a Sustainable Future through Crises (Cambridge University Press, 2023).
51. Slavin, M., Wood, D. and Jah, M. . "Use of ASTRIAGraph to Inform Detectability, Identifiability, and Trackability Metrics for Space Sustainability,"AIAA 2021- 4088 (2021) *ASCEND* https://doi.org/10.2514/6.2021-4088
52. Smith, J. L. 'I, River? New materialism, riparian non- human agency and the scale of democratic reform: I, River?' (2017) Asia Pacific Viewpoint 58, 99–111
53. Steindl, Nair, Slavin, Barba, Wood, and Jah, "Developing Detectability, Identifiability, Trackability Analyses for the Space Sustainability Rating," IAA-UT Space Traffic Management Conference, STM 2021, 26-27 January 2021, Austin TX USA.
54. Steffen, W, Grinevald, J, Crutzen, P et al. "The anthropocene: Conceptual and historical perspectives" (2011) 369 *Philosophical Transactions of the Royal Society Series A* 1938, 842-867.
55. Steffen, W, Richardson, K, Rockstrom, J et al. "Planetary boundaries: Guiding human development on a changing planet" (2015) 347 *Science* 6223.
56. Steffen, W, Broadgate, W, Deutsch, L et al. "The trajectory of the Anthropocene: The Great Acceleration" (2015) 2 *The Anthropocene Review* 1, 81-98.

57. Steffen, W. et al., ‘Trajectories of the Earth System in the Anthropocene’ (2018) 115 *PNAS* 8252–9.
58. Teubner, G. Global Law Without a State (Aldershot 1997).
59. Todd, Z. “Chapter 1: What is Ontology? What is Epistemology? Or: how to understand ‘ontology’ and ‘epistemology’ through fish and canals in the heart of Canadian empire”in *Seasonal Sociology*, edited by Dr. Ondine Park and Dr. Tonya Davidson (University of Toronto Press 2020).
60. The Royal Swedish Academy of Sciences. Press release: "The Nobel Prize in Physics 2021" https://www.nobelprize.org/prizes/physics/2021/press-release/.
61. Wai, R. “Transnational Liftoff and Juridical Touchdown: The Regulatory Function of Private International Law in an Era of Globalization” (2002) 40 *Columbia Journal of Transnational Law* 2 209-274.
62. Wilson, P. and Wilson, S. (2015). Indigeogy. Keynote presentation at Chiefs of Ontario, ‘Charting Our Own Path Forward’, Education Symposium, Thunder Bay, Ontario. http://education.chiefs-of-ontario.org/es2015

Primary Sources

1. 2030 Agenda for Sustainable Development introduced 17 Sustainable Development Goals (SDGs), accompanied by 169 targets and 231 indicators (A/RES/70/1).
2. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (resolution 34/68, annex)—adopted on 5 December 1979, opened for signature on 18 December 1979, entered into force on 11 July 1984.
3. Convention on Biological Diversity (1760 UNTS 79, 31 ILM 818 (1992)).
4. Convention on International Liability for Damage Caused by Space Objects (resolution 2777 (XXVI), annex)—adopted on 29 November 1971, opened for signature on 29 March 1972, entered into force on 1 September 1972.
5. Convention on Registration of Objects Launched into Outer Space (resolution 3235 (XXIX), annex)—adopted on 12 November 1974, opened for signature on 14 January 1975, entered into force on 15 September 1976.
6. Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, adopted on 13 December 1963 (resolution 1962 (XVIII)).
7. Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, adopted on 13 December 1996 (resolution 51/122).
8. ESA Space Debris Office. (2021). *ESA’s annual space environment report* (GEN-DB-LOG-00288-OPS-SD,Issue5.0). https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf
9. ILC, Report of the Study Group, Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law, 18 July 2006 (A/CN.4/L.702).
10. International Law Commission Articles on State Responsibility, generally denoting that “responsibility” only refers to State responsibility and “liability” to State liability (International Law Commission Report, A/56/10 August 2001).
11. IPCC, 2022*: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on*

Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926

12. ISO 26000:2010 Guidance on social responsibility
13. ITU, International Telecommunications Union (2021, June 1). *Should space become the 18th SDG?* https://www.itu.int:443/en/myitu/News/2021/06/01/12/14/Space-18th-SDG-sustainable-space- development
14. OECD, OECD Handbook on Measuring the Space Economy, 2nd Edition,(2022), Paris https://doi.org/10.1787/8bfef437-en.
15. Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting, adopted on 10 December 1982 (resolution 37/92)
16. Principles Relating to Remote Sensing of the Earth from Outer Space, adopted on 3 December 1986 (resolution 41/65)
17. Principles Relevant to the Use of Nuclear Power Sources in Outer Space, adopted on 14 December 1992 (resolution 47/68)
18. Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee(IADC), 2020, Issued by IADC Steering Group and Working Group 4.
19. The Artemis Accords: Principles for Cooperation in The Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes. 13 October 2020 NASA. https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf.
20. The Draft United Nations Code of Conduct on Transnational Corporations, UN Doc. E/C.10/1982/6, 5 June 1982 (revised UN Doc. E/1983/17/Rev.1)
21. The Paris Agreement Treaty Doc No. 102-38, 1771 U.N.T.S.
22. The Rio Declaration, UN Doc. A/CONF.151/26 (vol. I), 31 ILM 874 (1992)).
23. The United Nations Conference on Environment and Development, 1992, Agenda 21 (Earth Summit [ST/]DPI/13441).
24. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (General Assembly resolution 2222 (XXI), annex)—adopted on 19 December 1966, opened for signature on 27 January 1967, entered into force on 10 October 1967
25. UNCLOS, UN General Assembly, *Convention on the Law of the Sea*, 10 December 1982
26. UNCOPUOS. (2019). *Guidelines for the Long-term Sustainability of Outer Space Activities*. https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf
27. United Nations Global Compact, The Ten Principles (2015) Available at: https://www.unglobalcompact.org/what-is-gc/mission/principles
28. UN Guiding Principles on Business and Human Rights (UNGP) 2011 (A/HRC/17/31)
29. UN Human Rights Council, Human rights and transnational corporations and other business enterprises, 6 July 2011 (A/HRC/RES/17/4).
30. UN Principles for Responsible Investment (PRI) Impact Investing Market Map (2018) at: https://www.unpri.org/download?ac=5426
31. UN General Assembly, *United Nations Conference on the Human Environment*, (Stockholm Declaration) 15 December 1972, A/RES/2994

32. UNFCCC, United Nations Framework Convention on Climate Change, May 9, 1992, S. Treaty Doc No. 102-38, 1771 U.N.T.S. 107).
33. United Nations, *Vienna Convention on the Law of Treaties*, 23 May 1969, United Nations, Treaty Series, vol. 1155, p. 331
34. WBCSD Corporate Social Responsibility: Making Good Business Sense, World Business Council for Sustainable Development, Geneva, 2000.
35. World Commission on Environment and Development (WCED), “Our common future” [Brundtland report]. (1987) UN. http://digitallibrary.un.org/record/139811

Synthesis Paper 2

Narratives of community, participation and belonging in Space Science

David (Jeeva) Jeevendrampillai (Anthropology)

Executive summary
This report highlights the narratives around the idea of public participation in space science. As a new commercial space age expands towards a trillion-dollar industry by 2030 and space is seen as a resource to be used for 'all humanity' then, as Alan Marshall notes "it is appropriate to inquire about the real and potential participatory mechanisms whereby the global public could be involved in such a grand project." (2023:61).

The report outlines the ways in which space activity has permeated a popular imagination. It outlines the impact of such things as the visual culture that emanated from the Apollo era. The famous images of the Earth as a 'blue marble' (1972) and the Earth rising above the surface of the Moon (1968) are, according to historian Robert Poole, the most circulate images in the history of humanity. Described by environment photographer Galen Rowell as "the most influential environmental photograph(s) ever taken" they have had a profound impact on the way many people situate themselves in relation to others, the planet, and the future, in particular with a regard to human activity in outer space. In an age marked by increasing ecological concern for the planet, high speed communications and heightened cultural exchange then such images and the role of human activity in space takes on a renewed importance as the planetary, as an orientation point for identity, comes into the foreground. This report outlines this key narrative drive to situate the role of the UK and its space activities within a wider popular imagination.

The report outlines that, despite its large and significant contributions to space science the UK's reputation within the public imaginary is marked by (predominantly political) failures such as the bureaucratic wranglings the Galileo satellite project or lack of funding for Virgin Orbit after its launch failure. Whilst the UK has a relatively good spread of education and outreach programs about space there are few ways for citizens to meaningfully engage in the future policy direction of the UK government regarding outer space activity. Citizen engagement has been a key policy of the UK government for the last twenty years culminating in the localism act of 2011. This policy drive has placed an emphasis on participation at the community level. It has placed emphasis on community involvement in things like urban planning and local government. This policy focus has not been matched by meaningful engagement of citizens in policy of large infrastructure investment at national or international level. Given the role of outer space in the popular imagination, its significance as a marker of identity and a personal, national, and planetary level the report argues that new and innovative models of participation and policy consultation should be considered.

Existing models for participation in space science focus on social media campaigns, education and outreach for existing science projects and education centres. Whilst significant this model largely creates engagement with a space science project that are already happening. As such participation at the level of policy formation, science itself and assessment and appraisal are

lacking. The exception may be participation. Citizen science projects, hackathons and open innovation challenges have allowed greater public participation in space science. However, critics have argued that such participation is only a level of involvement with science agendas that are already set out.

The report concludes with a case study of a group of space enthusiasts who have taken it upon themselves to create a 'citizen authored blueprint'. Here the group employ a model like those found in peoples parliament and radical democracy movements. Namely this is consensus-based knowledge building. From this a serious of reports are being made that aim to influence public opinion and policy makers. This methodology shows not only a way forward but the appetite for it. The groups innovation and use of free web-based tools such as google drive and discord show that such citizen engagement is possible. What remains to be seen is if this should remain at the level of self-motivated groups or brought into structured policy initiatives.

Introduction

This report highlights the narratives around the idea of public participation in space science. It highlights the need for a policy focus on participation, situates this within a wider governmental and academic approach to participation in civic life and policy decisions in the UK, and gives ethnographic examples of how a wider public may consider that which constitutes participation in space science. The report argues that this policy focus is vital now as if the UK government are to invest heavily in the burgeoning space industry it is vital that a wider public see this as both timely, relevant and for them. Without public support any investment runs the risk of failing to maintain governmental support at a public level. The report situates such participation within the emerging narrative landscapes of how outer space is informing a sense of planetary, national, and individual sense of identity and how activity in space intersects with other common concerns such as climate change.

The paper is synthesised in line with the guidance set out by the story-listening project. This asked three fundamental guiding questions. First "What are the biggest decisions concerning space policy, in the next ten years?" Secondly "What are the areas of greatest need for evidence, models, and anticipations of the future?" and three "What stories are most influential to key existing and emergent collective identities in the relevant fields?" In line with this brief, I have chosen to address the narratives of community, participation, and identity. This aims to deal with two aspects of the brief guidance. Firstly, that an emerging sense of planetary community is a dominant theme of space science for many people. Further such a relation to the planet ties in with concerns about climate change, national identity, democratic participation, and increased connectivity to others around the globe via internet technologies. This should be considered in the formation and development of public policy regarding UK space science as it has implications for how the UK space policy relates to everyday notions of identity within a wider public. Secondly it aims to address the concern over avenues of participation in space science. The report takes a broad view of participation and again looks at the narrative drives of the notion of participation and how they relate to the landscape of citizenship in the UK as well as within space science more generally. The report outlines the broad public perception of outer space and how one may have personal relationship to space activity as well as talking about more specific UK examples. It will lay out the academic approach to participation in civic life in UK policy before talking about specific forms of participation in space science. The report ends with a case study of a community who are

attempting to write their own 'citizen authored blueprint' containing a community-based manifesto for all the considerations that need attention if humans are to invest significantly in space.

A brief history of the planet as a focal point of identity.

On December 24th 1968, NASA astronaut Bill Anders, aboard Apollo 8, captured NASA image AS08-14-2383, a photograph popularly known as Earthrise. The image shows the ¾ illuminated Earth rising over the moon's surface. It was described by nature photographer Galen Rowell as "the most influential environmental photograph ever taken"[1]. The image is perhaps only matched by NASA image AS17-148-22727, or 'The Blue Marble', an image of the whole earth from 18'000 miles away, captured by the crew of Apollo 17 on December 7th, 1972. These images of Earth are purportedly the most widely circulated and viewed photographic images in history (Poole 2008)[2]. Today they can be found on everything from car adverts to the background screen savour on phones and laptops.

Image 1 (left): NASA's 'Blue Marble' Taken December 7th, 1972. Image Credit: NASA
Image 2 (right): NASA's 'Earthrise' image. Taken by Bill Anders December 24th, 1968. Image credit: NASA

As philosopher Kelly Oliver[3] notes in her 2015 work 'Earth and World: Philosophy after the Apollo Missions' consideration of the Earth, sharing its surface and viewing it, has been an occupation of many philosophers long before these images were produced. From Immanuel Kant's discussions on ethics based on the idea that humans share the limited surface of the Earth - to Hannah Arendt's discussion of the plurality of social worlds within the global world which we all share, such discussions contain pervasive anthropological themes of our social relations, tension between universal and individualist perspectives, ethics, notions of cosmopolitanism, transcendence, and the shared materiality of living. For most people such concerns are relatively academic. However, the Apollo photographs, as a symbol of a space age, marked a moment through which the world gained a new perspective on the Earth through the visual images. Narratives around human activity in space are often forced to deal

[1] Rowell, Galen, "the Earthrise Photograph" Australian Broadcasting Corporation. https://www.abc.net.au/science/moon/earthrise.htm

[2] Poole, Robert. *Earthrise: How man first saw the Earth*. Yale University Press, 2008.

[3] Oliver, Kelly. *Earth and world: Philosophy after the Apollo missions*. Columbia University Press, 2015.

with such issues. The perspective of the Earth from space has lent a new aesthetic to such discussions and brought issues of identity at the planetary scale to the fore. As Anders himself stated of the Apollo missions “we came all this way to explore the moon, and the most important thing is that we discovered the Earth”[4]. These images have now saturated public consciousness to the extent that such imagery has almost become commonplace.

In 1987 author and journalist Frank White published the book ‘The Overview Effect: Space Exploration and Human Evolution’[5]. White’s position within the book is a simple one but one that has profound implications. White argues that the views afforded from outer space elicit a new and profound sense of relation to the Earth, to other humans and to oneself. This is most clearly seen in the initial impact of the Apollo images. White however goes further than to argue that they have a significant cultural impact. White situates the move of humans to outer space as a significant moment in the evolution of the human species, a moment that he claims is so significant that we are not yet fully able to comprehend its impact. In short White argues that the move to space will be seen, at some point in the future, as an epochal moment in the evolution of human consciousness. To make his point White mobilises the metaphor of the ‘explorer fish’. White describes how the ‘explorer fish’ left the ocean and went onto land. In so doing the fish had a new perspective on life and the environment they were in. They now had to deal with the sky, land, air both physically and philosophically. All these things were, before this moment, unknowable, unrelatable and as such unthinkable. Eventually the evolution of the fish into land-based life fundamentally altered life as we know it, gave us new mental and physical concepts through which to understand our lives - to the extent that we have no sense of relation to the life and the perspective fish from who we evolved.

Whilst there are many who would argue against the Lamarckian notions of linear evolution within White’s thesis, it holds true that such notions of evolution, epochal shifts in human history and expansions to new post-earth territories are dominant narratives in the popular imagination of outer space. Whilst White’s thesis makes such claims rather strongly the idea of space as a new territory that brings new social, cultural and philosophical issues to the fore is a key narrative for many. This is seen in popular culture such as films such as Alfonso Cuaron’s Gravity (2013). Here the main character, Dr Ryan Stone undergoers a personal psychological transformation amidst her struggle to return to the Earth from a distressed ISS. The film is marked by the transformation of the main character over her internal fears and doubts, as she returns to the Earth, she climbs out of a swamp back onto land as a transformed character with a new perspective on life and Earth. Similarly, Ridley Scott’s film ‘The Martian’ (based on the novel by Andy Weir) focuses on the survival and resourcefulness of Mark Watney, an astronaut who has been left stranded on Mars. Watney develops technology, innovates with limited resources, and forces those on Earth to collaborate across political divides to ensure the survival of himself, a symbol of humanity, off the Earth. Whilst the former two films concern the enduring character of the American astronaut as a hero of space exploration the film ‘Interstellar’, directed by Christopher Nolan focuses more on humans becoming an off-Earth species. The film sees the main character search for technological and scientific breakthroughs that allow humans to live permanently in outer space. This need is

[4] ’59 Years After ‘Earthrise’ A Christmas Eve Message from its Photographer’ Space.com Anders, Bill (2018) https://www.space.com/42848-earthrise-photo-apollo-8-legacy-bill-anders.html accessed 23.05.2023

[5] White, Frank. "The overview effect- A study of the impact of space exploration on individual and social awareness." *Space manufacturing 6- Nonterrestrial resources, biosciences, and space engineering* (1987): 120-125.

motivated by the ecological breakdown of the Earth. This assessment of humanity's place in the universe sees a techno-utopian vision of the future in outer space countered by an apocalyptic vision of the future of life on Earth. These narrative drives of technology, evolution, space-based utopia, and ecological apocalypse on Earth are common narrative drives for a wider public (Viceiros & Danowski 2017)[6].

Frank White's vision of a future humanity, with settlements in outer space, and the narratives in films like Interstellar both have a common heritage in the work of Gerard K O'Neil. Whilst a Professor of Physics at Stanford university O'Neil held a conference in the summer of 1975 to work through all the issues that humanity may need think about if they were to undergo a large-scale migration to space. His book 'The High Frontier' (1978)[7] is a widely cited source of inspiration for space science narratives and has been a named source of inspiration for leading commercial space figures such as Jeff Bezos, owner of Blue Origin. Inspired by, and in many ways responding to the United Nations 'The Limits to Growth' report, O'Neil lays out a problem. There are, and will be, to many people for the current rate of resource use on the planet. His solution is to propose that humanity move off-Earth, either in terms of large portions of the population or in terms of the major forms of heavy industry. This position of solving the resource problem maintains the ideological narrative of resource extraction-based capitalism as a driver of socio-economic life, and frontierism as a solution to scarcity by simply finding more space, more resource, and more capital, a common drive of the commercial space sector today (Sage 2008)[8]. The dual position of the utopian promise of outer space as a place of salvation is consistently balanced and driven by its counter position that a move to outer space is necessary due to the apocalyptic impending ecological collapse of the Earth (McKibben 2001)[9][10].

Much of O'Neil's book outlines the technical issues involved in building large scale space colonies in space. The conference that O'Neil convened resulted in several artworks by Rick Guidice which interpreted such colonies and space based mega structures (with a proposed 10'000 inhabitants per colony). Such imagery, as seen below, have become a common trope for imaginations of space based human futures. The film Interstellar ends with a scene where humanity has successfully left the ecologically desolate Earth and settled in a space based cylindrical colony. The film's 'cooper base' has a uncoincidental striking similarity to O'Neil's cylinders (see Image 3 & 4).

---

[6] De Castro, Eduardo Viveiros, and Déborah Danowski. *The Ends of the World*. John Wiley & Sons, 2017.

[7] O'Neil, Garard. K. 'High Frontier: Human Colonies in Space' Apogee Books, 1978.

[8] Sage, Daniel. "Framing space: A popular geopolitics of American manifest destiny in outer space." *Geopolitics* 13, no. 1 (2008): 27-53.

[9] McKibben, Bill. *Eaarth: Making a life on a tough new planet*. Vintage Canada, 2011.

[10] Davidson, Joe PL. "Extinctiopolitics: Existential Risk Studies, the Extinctiopolitical Unconscious, and the Billionaires' Exodus From Earth." *New Formations* 107, no. 107-108 (2023): 48-65.

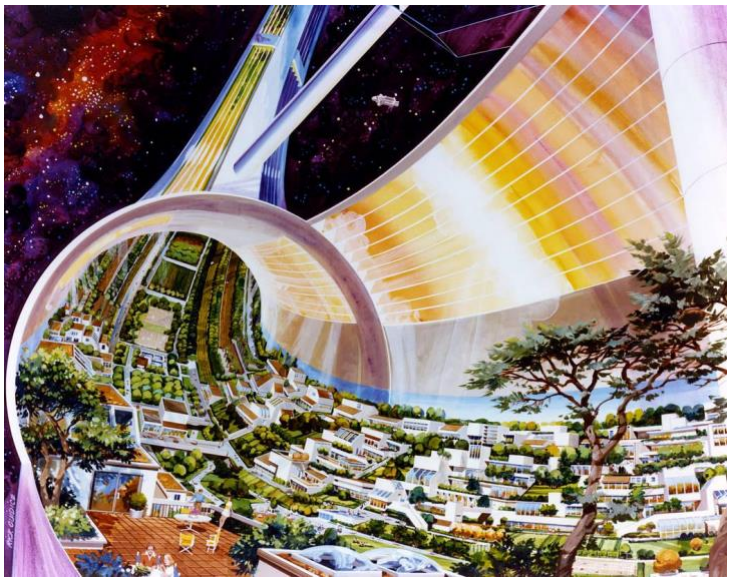

Image 3 (top): Cooper Base from the film Interstellar.

Image 4 (middle) : A Fictional Toroidal (doughnut-shaped) space colony, illustrated by Rick Guidice. *Image Credit: NASA's Ames Research Centre.*

Image 5 (bottom): A space colony imagined through Blue Origin. Image Credit: Blue Origin. An artist rendering of a space colony.

Similarly, the aims and ambitions of one the world's richest persons Jeff Bezos is heavily influenced by O'Neil. Bezos frequently cites O'Neil as a source of inspiration and explicitly aims to follow his call to move heavy industry off the Earth[11]. As one can see from his 'Blue Origin' company images above the resemblance to O'Neil's space colonies is stark (see Image 5). The colonies have also been likened the Frontier imaginary of settler USA and the Californian suburban idealisation of landscape (Sharman 2019[12]). The idea of large-scale space migration for humanity is a strong narrative that is evident in the cultural portrayals of space activity and occupies the imagination of the world's leading commercial space companies.

Returning to White, since the publication of his book he has gone on to publish multiple other books about the impact of a human movement to space. He has gained a significant following and has significant influence over the narratives of the anticipated social and cultural impact of a human movement to space. The term 'overview effect' is now used by NASA, has been cited by Vice President Harris of the USA during her address to the National Space Council meeting 2021[13]. It has become a concept around which a bigger conversation regarding the question of what sort of society we will make in outer space, has emerged.

During the covid pandemic White convened an online discussion group via his organisation 'The Human Space Program'. The online group is a loose affiliation of around 60-80 space enthusiasts who meet weekly over a two to three hour zoom meeting. The meeting was started to create a discussion and support group around a shared interest of space exploration. The aim of the meeting was to think through the issues of a large-scale migration to space. Towards the end of this report, I will use this group as the basis for a case study of how an interested group of citizens took it upon themselves to develop a 'citizen authored blueprint' for the issues to consider if humanity were to move to space. I have chosen this case study as it has a focus on the role of the citizen in addressing the wider social concerns of a perceived move to space. However before examining this case study of how a group of people participate in the development of future space based post-planetary communities, the report will examine some popular narrative drives of space science and why this indicates a need to focus on citizenship. It will look broadly at large narratives and then at UK case studies before looking at participation models and the case study.

Why a citizen led approach - Narratives of elitism in space science.

The space age, in terms of public perception, can be divided into two distinct eras. Space 1 refers to the original space age of the cold war era. This era is characterised by large, government led space agencies such as NASA and ROSCOSMOS. These agencies are highly vertically integrated and lead all development of space science and infrastructure within a locked down and relatively secretive military industrial state complex. Space 1 was marked by nationalist agendas of supremacy and frontier science on behalf of leading nations in the era of the cold war. Space 2 is characterised by a relative openness where public private

[11] https://www.youtube.com/watch?v=GQ98hGUe6FM&t=1127s&ab_channel=BlueOrigin accessed 23.05.2023

[12] Scharmen, Fred. "Space settlements." *Columbia Books.* 2019.

[13] Remarks by Vice President Harris Before the Administrations Inaugural National Space Council Meeting' Whitehouse Briefing room. December 1st, 2021 accessed 23.05.2023 https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/12/01/remarks-by-vice-president-harris-before-the-administrations-inaugural-national-space-council-meeting/

partnerships lead space science developments. This new space era is marked by commercial operators making headlines for innovative rocket developments, tourist trips to space and an increasingly commercial space sector. National agencies have increasing emphasis on international co-operation, public private partnerships and increasing participation from the public.

The space sector is forecast to be a trillion-dollar industry by 2030[14]. In 2021 the era of commercial spaceflight arrived[15]. There were multiple commercial launches of humans into space with companies Virgin Galactic (owned by Sir Richard Branson), Blue Origin (owned by Jeff Bezos) and SpaceX (owned by Elon Musk) all launching humans into space amidst much publicity. The resultant press coverage focused on both the experiences of celebrities who went on these early commercial rides, the possibly for the future but also the seemingly excessive amount of wealth needed to launch to space, and the seemingly frivolous adventures of billionaires who, in the words of former US presidential candidate Bernie Sanders 'take joy rides' in their rocket ships'[16][17].

There was a widespread public perception that the activities of Virgin Galactic, SpaceX, and Blue Origin and those who rode the commercial trips to space were vastly at odds with a public who were experiencing an increasingly difficult financial landscape[18]. The 'joy rides' of such billionaires pits the activities of the new space age against the interests of the general public. It draws attention to those with huge personal wealth who can invest in companies and adventures that most people will never have a chance to experience within their lifetime. There is a counter argument to this narrative. Namely this is that such commercial activity will act as a revenue stream and income generator for companies that will invest heavily in space. This will, in turn, allow infrastructure such as space stations (see the plans of Axiom Space, Blue Origin's Orbital Reef and others) to be commercially viable and as such offer a low-cost research platform to companies who can innovate with product development (at the moment this is predominantly in the fields of material and medical deign) in microgravity environments.

As such there is a key narrative battle to be had here regarding the perception of capital expenditure in space infrastructure and the role of the private and public sector in outer space activity. If the UK government is to invest in space infrastructure, either through publicly funded intuitions such as UK Space or the ESA or through subsidies and regulatory support for the private sector then it must ensure the public are made aware of the benefits such expenditure might bring for a wider public participation in narrative debates is an important way in which to do this.

---

[14] 'To infinity and beyond: the new space age' 02.02.2022. https://www.euronews.com/next/2022/02/02/to-infinity-and-beyond-the-new-space-age. Accessed 01.05.2023

[15] 'Year in Space: Jeff Bezoz and his billionaire rivals finally usher in the age of commercial spaceflight' December 31st 2021 https://www.geekwire.com/2021/year-in-space-jeff-bezos-and-his-billionaire-rivals-finally-usher-in-the-age-of-commercial-spaceflight/

[16] Tutton, Richard. "The unbearable lightness of billionaires in space." *EASST* (2022): 24.

[17] Sauer, Megan. "Sen. Bernie Sanders: Billionaires like Elon Musk and Jeff Bezos are 'off taking joy rides on their rocket ships" April 1st 2022 https://www.cnbc.com/2022/04/01/bernie-sanders-us-billionaires-are-off-taking-joy-rides-in-space.html accessed 01/05/2023

[18] McCarthy, Donnachadh. "the Global super-rich are taking joyrides in space as our precious planet burns" 14th July 2021 https://www.independent.co.uk/climate-change/opinion/richard-branson-space-climate-crisis-b1883256.html accessed 23.05.2023

General perception of UK Participation in Space Science from an international relations perspective.

As the briefing document notes the UK government must contend with a shifting landscape of interdependencies regarding UK involvement in space both through official government agencies such as the relationship between the UK Space Agency and ESA but also between the UK and the emergent commercial space industry. Given the recent shift in relations between the UK and Europe, and shifting tides of alliances of global powers, the relationships that the UK forms through its collaborations within the space industry will be subject to intense public scrutiny and pressures regarding the image that such alliances portray in terms of the UK's position within the sphere of international relations. The public perception of the UKs involvement in outer space should also be considered within the barometer of international relations regarding the upcoming issues of space exploration. To date most space activity has occurred within Low Earth Orbit (LEO). The Apollo missions aside most newsworthy space activity concerns either the revelations of deep space probes that deliver new imaginary of the universe (such as the Cassini probe, Voyager, the James Webb Space Telescope) or human space flight in LEO (such as the activity on the International Space Station). As commercial activity increases in space, issues of the use of space both in LEO, in cislunar space, on the Moon and on other celestial bodies, will be under increasing public focus as contestations and deliberations around the use of the 'ungoverned commons' becomes increasingly newsworthy.

The notion of the 'ungoverned commons' is a key concept, drawn from maritime law, that underlies the Outer Space Treaty of 1967. This led to the Moon treaty of 1979 treaty that established the frameworks for co-operation amongst nations regarding space exploration. However, this treaty has not been ratified by the major space powers such as the USA, Russia, or China and as such it has little to no relevancy in international law[19]. Despite this, it is frequently used as a reference point for the notion of international co-operation in outer space activities (Aliberti et al 2023[20]). Most recently the development of the Artemis accords – a non-binding multilateral agreement between the US government and other world powers in the development of the Artemis program – have made the news[21]. This program aims to return humans to the Moon by 2025 and as such the program and the accords reached mainstream news and a wider public. Notably the accords have fewer signatories than the Moon treaty, which was forged in the heart of the United Nations. What is clear is that who participates in outer space, and how is seen as a fraught issue. How such issues are resolved, or not, is an indication of the position of the UK in a wider global order of international relations. If the UK government is to invest in space, then it will need to understand the narrative drives of a wider public as they seek to form an opinion about what the UK should be doing in terms of outer space activity. It is crucial to the formation of a national identity and the sense that the UK is

[19] Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining.] Jonathan Sydney Koch. "Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining." *Astropolitics*, 16:1, 1-27, 2008. doi:10.1080/14777622.2017.1381824

[20] Aliberti, Marco, Vinicius Guedes Gonçalves de Oliveira, and Rodrigo Praino. "Back to the Moon: Cooperation and Conflict." In *Human Uses of Outer Space: Return to the Moon*, pp. 137-154. Singapore: Springer Nature Singapore, 2023.

[21] Amos, Johnathan "Project Artemis: UK signs up to Nasa's Moon exploration principles' 13th October 2020 https://www.bbc.co.uk/news/science-environment-54530361 accessed 1/5/2023

aligning and working with the right partners. This is demonstrated around the debates regarding the European Space Agency's Galileo project.

The UK, ESA and the Galileo Project.

The Galileo project is a global navigation satellite system that uses satellites to provide geo-positioning capability. This is widely known to the public through its American namesake GPS however GPS is just one of many such systems. Russia, China and since 2016, the European Union have their own systems. Whilst ESA and the EU are distinct entities in terms of political alliance and funding the two are both parts of a European social industrial complex. The EU invested in Galileo primarily for civilian use, but the system would give the EU bloc a military capability free from the reliance on the US system. Given the open access to civilian use the US became concerned that the system would be open to hostile users. This raised tensions between the EU and the US.

Within Europe issues arose as of how to pay for the system. The project ran over budget by over 50% and in 2006 the EU nationalised the project as public private partnership agreements fell through[22]. As of 2018 the UK had provided 12% of the overall costs, at the time estimated to be around 10 billion euros, and it had received around 15% of the work on the project. The UK's involvement came under scrutiny. After an investment of a reported £1.2 billion the UK left, or was excluded from, the Galileo project[23]. This excludes the UK from key contracts, industrial partnerships and leaves the UK without access to top level space-based security resources. Despite the UKs heavy involvement with ESA such a break down in relationship drives a public perception that the UK is no longer linked to major space infrastructure development within the EU bloc. As a polemic OpEd piece about the project in The Guardian newspaper outlined, the failure of Galileo also denotes the ways in which the UK forms strategic alliances or not with other major powers.

"Some entanglement is politically inevitable. Yet the fact remains, in spite of the Brexit vote, that Britain and the EU member states are and will be the closest allies in profound and continuing ways, whether Brexit occurs or not. It is 100% ludicrous to pretend that the UK is a security threat to the EU. And it is 100% absurd that the UK should threaten to develop its own system. The current standoff is infantile and unworthy on both sides. It is high time to grow up and work together for Europe."[24]

Virgin Galactic – failure of launch

One of the leading flagship companies of UK space sector has been Sir Ricard Branson's Virgin group. Whilst Virgin Galactic, based in New Mexico USA has been making headlines for its space tourism ventures the Virgin Orbit satellite launch company, which launched from Cornwall UK, has been making headlines in the UK. In May 2023 the company filed for

[22] Gibbons, Glen (26 March 2009). "European Court of Auditors Lambastes Galileo Satellite Navigation Program". *Wayback Machine*. Archived from the original on 12 January 2014.

[23] Elgot, Jessica. 30th November 2018 https://www.theguardian.com/politics/2018/nov/30/brexit-uk-may-never-recover-12bn-invested-in-eu-galileo-satellite-system accessed 01.05.2023

[24] 3rd May 2018 The Guardian Editorial https://www.theguardian.com/commentisfree/2018/may/03/the-guardian-view-on-the-galileo-project-we-must-be-partners-not-rivals accessed 01.05.2023

bankruptcy after failing to find funding to continue[25]. The company aimed to have low-cost rapid satellite deployment by launching rockets from existing commercially available jumbo jets. The initial tests of the system resulted in failure and loss of confidence. As such the impression of the UK's launch capabilities and its position as an innovator in space satellite technology has been damaged. Despite the failures the strategic and security advantage of such a system is huge. Yet for a wider public this system could appear to be a weaker version of the launch capabilities of major space powers.

What these two examples show is that the narrative of the UKs involvement in space science is one that is largely peripheral and somewhat in the shadow of major space powers. However, the UK has significant contributions to space science that are often underreported and are overshadowed in narratives about the UK's involvement in space science.

A few examples of these are numerous projects through ESA, such as the UK-led Beagle 2 Mars Lander, the only British built spacecraft to have landed on another planet. Contributions to the building of instruments for the Rosetta mission and Philae Lander which made the first ever soft landing on a comet's surface; The UK as a significant partner in the GAIA mission, which aims to create a 3D map of the milky way. Launched in 2013 it has led to significant advances in space science; and the UK contribution to the ESA Soler orbiter mission and has its own 'Skynet 5' military communications satellites. Bringing more attention to these success stories, as well as managing the narratives of the less successful projects, is an important policy consideration for the UK.

So far, I have outlined a public perception to outer space as a socio-economic zone. I have laid out some of the debates surrounding flagship UK involvement in outer space. However, I now wish to change the emphasis. Whereas the previous section of this report outlined an atmosphere of participation in space science from the sense of national identity the next section will look more directly at citizen participation in space science. It will begin by outlining the recent landscape of public participation in UK policy. It will then look at examples of citizen science and public participation from the major space agencies. It will conclude with a case study of the aforementioned 'overviewers' who are creating their own 'citizen authored blueprint' for the future of humanity in outer space.

Active citizenship in the UK

'Active citizenship' is a term frequently found in legislation and policy discourse in the UK. An 'active' citizen is one who engages in public life, particularly at the local level. As Raco (2007)[26] notes the 'active citizenship agenda', has taken various forms under successive governments. The common aim is to mobilise citizens through local volunteering and democratic participation predominantly at the neighbourhood level to encourage community building under a self-help ethos (Seyfang 2003)[27]. The duty of citizens was foregrounded in David Cameron's 2010 election manifesto pledge to kickstart a 'Big Society' based on volunteerism and ground-up community organising in areas previously controlled by the state. Described

[25] "Virgin Orbit ceases operation months after failure of UK space mission" 24th May 2023 https://www.theguardian.com/science/2023/may/24/virgin-orbit-ceases-operations-months-after-failure-of-uk-space-mission accessed 24.05.2023

[26] Raco, Mike. "Building Sustainable Communities." *Spatial Policy and Labour* (2007).

[27] Seyfang, Gill. "Growing cohesive communities one favour at a time: social exclusion, active citizenship and time banks." *International Journal of urban and regional Research* 27, no. 3 (2003): 699-706.

as a 'post-welfare political ideology' (McGuirk and Dowling 2011)[28], active citizenship is intended to encourage citizens to take greater responsibility for their own welfare and that of their communities on the grounds that 'more developed communities and communities with more capacity are safer and healthier places to live' (Kelly, Caputo & Jamieson 2005:308)[29]. Participation in civic life was understood and formulated at a local level. It was premised on a political agenda that asserts that services are delivered best when government is decentralised and when individuals and communities take responsibility for the management of the local area. Policies of localism, which were enacted by the Localism Act of 2011 (Department for Communities and Local Government 2010)[30], were heralded as being more democratic in nature, in that they increased citizens' direct influence on decision making.

The 2003 Sustainable Communities Plan of the New Labour government, which was part of the wider urban renewal agenda in the UK (Raco 2007), reordered the relation between citizens and the state. The policy shift was a rejection of both Thatcherite neoliberal individualism and old Labour's understanding of the welfare state (McGuirk and Dowling 2011) and placed public participation in the centre of a new ideology of state citizen relations. The notion of 'social capital' was fundamental to this agenda (Woodcraft 2019)[31]. The term gained prominence through influential urban theorists such as Jane Jacobs ([1961] 2016)[32] and Robert Putnam (2000)[33] and refers to the connections amongst individuals and social networks that work within an economy of reciprocity, trust, and mutual support. The basic premise is that 'interaction between people builds communities, shared values and virtues, behavioural and social norms and a social fabric in which a society and an economy can function more effectively' (Westwood 2011:692)[34]. As such a policy agenda foregrounds social capital emphasises individual autonomy and citizen-based accountability for government policy (Baron 2004)[35]. Localism was attractive to the Blair, Cameron, and following governments (spanning the years from 1997 to 2016) as a way to counter the widely perceived fragmentation of urban life and rehabilitate the concept of 'society' after Thatcher denied its existence (Imrie and Raco 2003; Putnam 2000) [36].

As Ade Kearns (2003)[37] outlines in 'third way' politics, the roles of the state and the market are combined as the private, voluntary and community sectors are used to deliver services

---

[28] McGuirk, Pauline, and Robyn Dowling. "Governing social reproduction in masterplanned estates: Urban politics and everyday life in Sydney." *Urban Studies* 48, no. 12 (2011): 2611-2628.

[29] Kelly, Katharine D., Tullio Caputo and Wanda Jamieson. 2005. 'Reconsidering sustainability: Some implications for community-based crime prevention.' *Critical Social Policy* 25, no. 3: 306–24. https://doi.org/10.1177%2F0261018305054073.

[30] Department for Communities and Local Government. 2010. *Decentralisation and the Localism Bill: An essential guide*. London: Department for Communities and Local Government.

[31] Woodcraft, Saffron, 'Void potential: Absence, imagination, and the making of community in London's Olympic Park.' PhD Thesis, UCL. 2019.

[32] Jacobs, Jane. [1961] *The Death and Life of Great American Cities*. New York: Vintage Books. 2016.

[33] Putnam, Robert D. *Bowling Alone: The collapse and revival of American community*. New York: Simon and Schuster. 2000.

[34] Westwood, Andy. "Localism, social capital and the 'Big Society'." *Local Economy* 26, no. 8 (2011): 690-701.

[35] Baron, Stephen.. 'Social capital in British politics and policy making.' In Jane Franklin, ed., *Politics, Trust and Networks: Social capital in critical perspective*, pp. 5–16. London: London South Bank University. 2004

[36] Imrie, Rob, and Mike Raco, eds. *Urban renaissance?: New Labour, community and urban policy*. Policy Press, 2003.

[37] Kearns, Ade. "Social capital, regeneration and urban policy." In *Urban renaissance?*, pp. 37-60. Policy Press, 2003.

and partnerships. New relationships are created between the state, businesses, voluntary and public sectors. The responsibilities of both the state and citizen change. 'Third way' or stakeholder politics, places a much stronger emphasis upon the 'responsible and responsive individual – the notion of a developmental self, and the idea that through help and education people can improve' (Richards and Smith 2002:237)[38]. Whilst critics have argued that such policies of participation and inclusion are disingenuous, since they are given on terms dictated by those outside the community (Diamond 2001:277)[39] local participation in public life is now a valued trope of effective and relevant government and ongoing debates about devolution of power attest to the landscape of public participation in public life in the UK. However, as one can tell from the language used above, the notion of participation has focused on the notion of the local person, local community, and local issues at the council neighbourhood level. This fails to account for a sense of participation at a national, international, or planetary level.

As the examples of Galileo, the spaceports and Virgin galactic above demonstrate, if the UK is to invest in space science how and who with the UK invests has implicates for UK citizens senses of identity. The UK can innovate in its participation agenda in space science. But if it is to do so then it needs to both counter some strong existing narratives and find an effective means of public participation in the ethical and social questions that space science raises.

Participation models

This report has focused on the ways in which notions of citizenship and identity are affected through participation in space science. As such there are several areas of participation in space science that are not covered in as much depth as others in this report. This section will outline some key areas for consideration in regard participation where narratives of how space science relates to UK citizenship and identity can be thought through.

Education and Outreach Programs:

A key mode of participation in space science in the UK occurs through engagement in educational institutions such as museums and science centres. Exhibitions deliver history of space exploration and deal with potential future space activity. However, these often focus on the history of the first space era from Sputnik, the Apollo missions and deep space astronomy. Such programs develop a sense of awareness and inspire interest in space. They bring to the fore the role of the UK in the history of space science. Examples in the UK include various university programs; the activities of the National Space Centre in Leicester; the UK Space Agency 'space for all' campaign to promote space related activity in the UK; Science centres and museums such as The Royal Observatory in Greenwich which provides a vital historical overview of the place of the UK in space science; The National Schools Observatory Program which provides free access to remote telescopes for schools across the UK (see also the Faulkes Telescope Project)[40] and AstroCamp – a space camp for 8-17 year olds UK wide.

Public Lectures, Events & Space science communication:

[38] Richards, David, and Martin J. Smith. *Governance and public policy in the United Kingdom*. Oxford University Press, 2002.

[39] Diamond, John. "Managing change or coping with conflict?-Mapping the experience of a local regeneration partnership." *Local Economy* 16, no. 4 (2001): 272-285.

[40] https://www.faulkes.com/faulkes-telescope-project accessed 24.05.2023

Like the above, these events deliver key moments in engineering to a wider public. They have a key role in setting the narrative and can enable a wider public to have a sense of involvement. Examples include TV shows like BBC Horizon, the work of Brain Cox, the Christmas lectures, podcasts, articles, and social media. These all make space accessible to a wider audience.

Stargazing events and Amateur Astronomy:
Such events act as a rare form of live event that enable a public to engage directly with outer space. These are particularly useful around major rare events such as a comet passings. At such times media coverage can highlight the expertise in space science in the UK and deliver a sense of widespread engagement. However, such events also bring to attention the narratives around rights to dark skies. Built up urban areas contribute to high light pollution. Various charities such as National Parks[41] and the Campaign to Protect Rural England[42] have campaigns to protect dark skies.

Space Science Competitions and Challenges:
Several space-related competitions and challenges are organized in the UK to encourage public engagement. For example, the UK Space Agency's "SatelLife" competition 2022[43] invited young people to develop innovative solutions to global challenges using satellite data. These initiatives foster creativity, problem-solving, and interest in space science.

The above are just some of the modes through which a wider public can feel involved in space science. However, these models are largely focused on education or target existing enthusiasts. What I wish to draw attention to in this report is the ways in which the citizen may feel an active part of the development of space science at a policy level. As Kaminski et al (2016)[44] have noted “The notion that individuals should be regarded not only as consumers of science and technology but also as active participants in shaping innovation processes is gaining increasing recognition from government agencies, non-governmental organizations, corporations, and citizens alike” (2016:1). NASA’s latest strategic plan has acknowledged the role of widening participation in its space agenda. Whilst participation isn’t always appropriate, such as when there are security issues in play, NASA has adopted a range of ways to invite the public into their activity. The table from Kaminski et al. (2016) below outlines the various forms of participation.

[41] https://www.darkskiesnationalparks.org.uk/about/dark-skies-organisations accessed 24.05.2023

[42] https://www.cpre.org.uk/what-we-care-about/nature-and-landscapes/dark-skies/ accessed 24.5.2023

[43] https://www.gov.uk/government/publications/satellife-competition-2022-how-to-enter-and-other-resources Accessed 24.05.2023

[44] Kaminski, Amy, Lynn Buquo, Monsi C. Roman, Beth Beck, and Michelle Thaller. "NASA's public participation universe: Why and how the US space agency is democratizing its approaches to innovation." In *AIAA SPACE 2016*, p. 5466. 2016.

METHOD	NEED/PURPOSE	PROJECT EXAMPLE(S)
Crowdsourcing of scientific research (citizen science)	Data collection	GLOBE/GLOBE Observer, JunoCam, Target Asteroids, Aurorasaurus
	Data analysis	Stardust@Home, Disk Detective, Planet Four, Planet Hunters
Challenge/prize competition Hackathon	Data application development	International Space Apps Challenge, Datanauts
	Software/algorithm/ development	International Space Station Food Intake Tracker; Asteroid Data Hunter; Lunar Mapping and Modeling Portal; Planetary Data Systems Cassini Rings
	Hardware prototype development	Centennial Challenges (e.g., Astronaut Glove Challenge); International Space Apps Challenge
	Concept/idea for research/technology advancement	Bioinspired Advanced Exercise Concepts; Mars Space Pioneering: Achieving Earth Independence
	Engineering/Research Project Design	Measurement of Kevlar Strain, Non-invasive Measurement of Intracranial Pressure; Mars Balance Mass Challenge
Citizen input/ deliberation	Collection of external views re: NASA policy/program choices	Asteroid Initiative Citizen Forums

Table 1: 'Open innovation methods used by NASA to achieve various needs and purposes' from Kaminski et al (2016:10)

With this participation agenda NASA have achieved numerous goals. They have spread the risk and increased the depth of innovation in design and engineering whilst simultaneously seemingly opened up to a more commercial and democratic version of space innovation. The European Space Agency has also encouraged citizen participation through the above models. They have engaged in education and outreach, public events and art and culture collaborations. Both agencies have recognised the importance of open access to data, with NASA image database being widely used.

The Challenge prizes and Hackathons have driven innovation for NASA whilst ESA has a strong public engagement agenda. However, for the purposes of this report I wish to focus in on the citizen science aspects of this participation agenda. This is largely as it incorporates the notion of the citizen. ESA has used citizen science in projects such as the flagship GAIA project whilst NASA have used citizen science for things such as planet hunting.

Citizen science is a broad term that relates to scientific research that is in some way inclusive of amateur or non-professional scientists. It is sometimes referred to as participatory action research, public participation science research or any of a wide range of associated terms

(see Hecker et al. 2018[45]; Strasser & Haklay 2018[46]; Follett & Strezov 2015[47]; Leach & Fairhead 2002[48]; Leach & Scoones 2005[49]).

Although participation was the "new orthodoxy" of UK policy (Henkel & Stirrat: 168)[50] of the 1990s, by the late 2000s a more critical review of the agenda was emerging by the mid 2000s with Parfitt (2004)[51] claiming that the idea of participation had become a dogma without meaning. Critical attention focused on the ways in which participation is always structured through existing power relations. That is to say, the forms of data that a public can participate in is already limited by the agendas set out by large organisations such as space agencies, government policies and large companies (see Kapoor 2002)[52]. As Cooke & Kothari (2001)[53] argue, previous approaches to participation had depoliticised the process. In regard to local politics Cooke and Kothari refer to this as the "tyranny" of participation, arguing that such approaches operate as a means to deliver the same top-down initiatives as before in a manner designed to create an appearance of greater democracy (see Hildyard et al. 2001)[54] whilst not really offering the public a stake in the direction of policy and meaningful ways to contribute to large structural issues.

As such, in this final section I wish to draw on a case study of a 'citizen authored blueprint' for space policy that has emerged through the aforementioned 'overviewers' online meet up. This case study outlines another form of much more direct citizen participation. Here citizens are less consumers of knowledge about government or commercial space activities, nor are they citizen scientists in pre structed participation events. The case study is one of a an active, engaged, and motivated community that have self-formed in order to outline their own visions for a socially just and equitable space future.

The Overviewers': A community group looking to increase their participation and influence in space. A case study.

As outlined above the overviewers are a group of people who are grappling with a planetary scale human consciousness. They believe, in line with Frank White's thesis, that the new perspectives on the planet afforded from human activity in space have and will lead to a large-scale shift in human consciences.

---

[45] Haklay, M. E., Hecker, S., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. *Citizen Science* UCL Press. 2018.

[46] Strasser, Bruno, and M. E. Haklay. "Citizen science: Expertise, democracy, and public participation." (2018): 1-92.

[47] Follett, Ria, and Vladimir Strezov. "An analysis of citizen science based research: usage and publication patterns." *PloS one* 10, no. 11 (2015): e0143687.

[48] Leach, Melissa, and James Fairhead. "Manners of contestation:"citizen science" and "indigenous knowledge" in West Africa and the Caribbean." *International Social Science Journal* 54, no. 173 (2002): 299-311.

[49] Leach, Melissa, Ian Scoones, and Brian Wynne, eds. *Science and citizens: Globalization and the challenge of engagement*. Vol. 2. Zed Books, 2005.

[50] Henkel, Heiko, and Roderick Stirrat. "Participation as spiritual duty; empowerment as secular subjection." *Participation: The new tyranny?* (2001): 168-184.

[51] Parfitt, Trevor. "The ambiguity of participation: a qualified defence of participatory development." *Third world quarterly* 25, no. 3 (2004): 537-555.

[52] Kapoor, Ilan. "The devil's in the theory: a critical assessment of Robert Chambers' work on participatory development." *Third world quarterly* 23, no. 1 (2002): 101-117.

[53] Cooke, Bill, and Uma Kothari, eds. *Participation: The new tyranny?*. Zed books, 2001.

[54] Hildyard, Nicholas, Hegde Pandurang, Paul Wolvekamp, and Reddy Somasekhare. "Pluralism, participation and power: joint forest management in India." *Participation: the new tyranny?* (2001): 56-71.

> "Astronauts viewing the Earth from Low Earth Orbit or lunar missions often experience a shift in identity or worldview: The Overview Effect.
> They recognise that, as humans, our commonalities far outweigh our differences. This awe-inspiring perspective reframes our understanding of the cosmos, and our relationship with our home planet and each other. The resulting Overview Perspective plays a vital role in helping us cultivate a future of sustainable peace and prosperity for all of humanity."
>
> www.humanspaceprogram.org

The community have convened each week for over two years since its original formation over two years ago as a response to the Covid-19 pandemic. Each week the group discusses the issues they feel are urgent in dealing with a post-earth sense of human identity, current events in space and how they can work to influence and affect others to think about human life off-earth. In my role as senior research fellow on the ERC funded ETHNO-ISS[55] project at UCL I have been conducting an ethnographic analysis of the group for over two years.

This group believe that the perspectives that human space flight has brought into popular consciousness has had, and will continue to have, a profound impact on human consciences, the way in which we relate to ourselves, others and the planet. As planetary issues such as climate change, global pandemics, the effects of globalisation, global communication, increasingly inform peoples sense of ethics, worldview and anxieties about the future people are forging new attendant planetary forms of social relationships. The planetary, that is the consideration of the materiality of the planet, has now overtaken globalisation as that meta structure by which people theorise a sense of global social relationality. There are two main reasons for this. Firstly, as issues such as climate change, plastic pollution and extreme weather has increasingly come into the consciousness of a wider public people's attention is turned to the dynamic and interrelated nature of the planet as an eco-system of real material forces. Secondly previous forms of social identity at the global level, such as narratives of globalisation, whilst eliciting descriptions of the uneven distribution of wealth and effects of global capital, failed to resonate with people's day to day experiences or give them the ability to relate their actions to that of others. The planet, as an object, has come into focus as a relatable aesthetic through which people can build a sense of empathy and common bond to others at the planetary scale and the 'overviewers' and their narratives, are a prime example of a community motivated by this aesthetics.

The reason for this ethnographically heavy section of primary evidence in this report is simple, there simply isn't much work on participation in space science other than what I have outlined above. Whilst the above focuses on broad perceptions of participation in space science within a population with regard large national projects on the one hand and the participation of interested amateur scientist and hobbyists on the other, this section aims to focus on how it is that an 'active' citizen, as understood within the UK's current frameworks of active citizenship, might participate in creating policy, ethical guidelines and documents that inform the UKs strategic approach to outer space. Further the actions of the group are similar in model to the forms of citizen participation seen in times of radical democracy such as the people's

[55] https://ethnoiss.space/ accessed 23.05.2023

parliaments of Iceland, the communal councils of Venezuela or participatory budgeting processes seen in New York.

Working from the writing of Frank White, in particular his outline of the citizen authored blueprint in his 2019 *The Cosma Hypothesis* book[56]. Here White outlines the work of the Human Space Program (HSP)[57] which hosts these meetings that was formed to carry out this work. He states that the HSP's purpose is to "develop a blueprint for the sustainable, inclusive, and ethical exploration and development of the solar system; and […] to be a focal point for access to, and coordination of, knowledge relevant to all aspects of space exploration and development." The blueprint will be developed by 16 global, de-centralised, task forces that will address the specific subjects of; engineering, education, business and economics, culture and arts, ethics, environment, government, history, legal, medical and public health, military, philosophy, psychology, religion and sociology.

In White's vision each task force would work to develop hypothesis of the key issues in each subject area regarding the human movement to outer space. These hypotheses will be developed through gathering existing literature and questioning experts in each area, including those 'voices that have not yet been heard in discussions of the space enterprise, such as young people, non-spacefaring nations, and Indigenous people'. They would call expert witnesses and gather and record testimony much like a parliamentary committee might. Each task force will conduct their activities in public to be open to scrutiny and the final reports will be open to peer review. The task forces will present specific recommendations within a given timeframe, rather than simply outline academic debates. The task forces would then present the findings to policy makers, media and space agencies and companies. The blueprint would be regularly revised and edited as issues emerge and evolve.

During the online meetings five small task forces were created to test the model. Of the regular attendees around 25 volunteered to form the task forces. People were assigned a group. From there each group would work as a full task force might with literature reviews although expert testimony was not gathered unless it was already publicly available. They co-developed presentations using online tools such as Google Docs, Discord, and other platforms. The groups convened a month later to present their findings to the wider group. The overall aim is to scale this process up and then mount a campaign to raise awareness of the work and influence public opinion and political policy making.

Conclusions

This report has outlined the key narrative drives of the space age from the Apollo images to the more recent commercial space age. It has shown that there is a need to deliver a sense of inclusion in the burgeoning space age as issues of planetary, national, and personal identity are at stake as humans increasingly conduct activity in outer space.

[56] White, Frank. *The cosma hypothesis: Implications of the overview effect*. Hybrid Global Publishing, 2021.

[57] https://www.humanspaceprogram.org/ accessed 23.05.2023

Whilst current participation models such as education, outreach and education can be solidified in their message and funding there is a need for increased citizen involvement. The above case study shows citizen authored a key narrative theme of this process was the openness, inclusiveness and the citizen led aspects of the process. This mirrors a wider trend in policy and socio-political life as outlined above. The process utilised the affordances of high-speed accessible internet, web-based group working tools and open access knowledge and research databases. The model of participation was more thorough in terms of its notions of citizen participation than is usually found in space science and in many ways mirrored models found in public parliaments and radical democracy movements in other areas of life. In an age where there is heightened suspicion of experts, a sense of elites with excessive wealth being detached from the general public and a political realm that is it out of touch with a public is now more vital than ever to have a sense of inclusion in the future direction of space science. The narratives of space tell us that all the public have a stake in space activity beyond an interest in the engineering and the science. Activity in outer space goes to the heart of issues of notions of the future of humanity, the role of technology and science in our collective futures. The narratives of citizenship and modern political life show that there needs to be an increased sense of participation in large scale structural investments in outer space.

Synthesis Paper 3

An 'Issue of Sound Policy': Science Fiction as Evidence to Inform Terraforming Policy

Chris Pak (Literature)

Executive Summary

Science fiction (sf) can be understood as an archive of scenarios that model approaches to terraforming, which can be used to think through key issues in policy and governance. Following Clifford Geertz's (1973) distinction between 'modelling of' and 'modelling for,' this chapter reads sf as constructing models *of* phenomena that enable the generation of further knowledge about pre-existing realities that may be poorly understood or about ones that are yet-to-exist. Assembling works of sf that construct models of terraforming, this chapter provides insights into the implications of transforming other planets for communities on Earth and beyond. Key themes that emerge from the literature include the construction of new collective identities rooted in the work of terraforming and inhabiting other planets, the complexities involved in developing appropriate modes of deliberation and the repercussions of failing to do so, the tensions attending interplanetary relations and the conflicts and opportunities afforded by the establishment of independence for interplanetary colonies, the role of private actors in developing commercial interests on other planets and the possibilities and threats for the economic and cultural growth or decline of colonies.

In the first section, "Modelling Terraforming and Deliberation in Kim Stanley Robinson's Mars Trilogy," Kim Stanley Robinson's landmark *Mars* trilogy (comprising *Red Mars*, 1996c; *Green Mars*, 1996b; and *Blue Mars,* 1996a; along with the companion collection of short stories *The Martians*, 2000) is analysed to establish how sf stories of terraforming construct scenarios for reflection on the social, political, material and scientific dimensions of adapting other planets. The *Mars* trilogy demonstrates the dialogues about identity and governance that sf across the twentieth and twenty-first centuries engage and is used to open up key issues relevant for policy. The fragmentation of collective identities and the development of appropriate modes of representation is a key theme developed across the trilogy. The potential for the emergence of conflict as a response to the narrowing of the value of Mars as a site solely for the extraction of resources highlights differences in how other planets are valued by actors on Earth in contrast to those on Mars. Such conflict is balanced by the opportunities Mars affords to Earth for thinking through and testing solutions to issues related to the effects of climate change for communities on Earth.

The following section, entitled "Interplanetary Relations and Independence," excavates short stories and novels to explore further the interplanetary dynamics that are imagined as emerging between Earth and its colonies. It explores issues related to the persistence of identities imported to interplanetary colonies from Earth and the emergence of new collective identities that depart from those on Earth. These new identities are imagined as essential for the coherence and persistence of interplanetary colonies. Stories addressed in this section include Jack Williamson's (2004) 'Collision Orbit,' Isaac Asimov's (1974) 'The Martian Way,' Arthur C. Clarke's (1976) *The Sands of Mars*, Poul Anderson's (1964) 'To Build a World,' Robert A. Heinlein's (2001) *The Moon is a Harsh Mistress*, Michael Allaby and James

Lovelock's (1984) *The Greening of Mars*, S.C. Sykes' (1991) *Red Genesis*, Mary Robinette Kowal's Lady Astronaut sequence, comprising the novella *The Lady Astronaut of Mars* (2013) and *The Calculating Stars* (2019a), *The Fated Sky* (2019b) and *The Relentless Moon* (2020), and Robinson's (2018) *Red Moon*.

The final section, "The Closure of the Colony," considers the obverse of the growth of interplanetary colonies. These works identify the failure to develop unique and coherent modes of collective identity as critical to the failure of interplanetary colonies. Geopolitical, economic, social and cultural tensions on Earth constrain the development and growth of interplanetary colonies and undermine attempts to establish resilient communities on other planets. The short stories and novels considered in this section include Ray Bradbury's (1958) *The Martian Chronicles*, Frederik Pohl and C.M. Kornbluth's (1974) *The Space Merchants*, Walter M. Miller's (1973) 'Crucifixus Etiam,' Luiza Sauma's (2019) *Everything You Ever Wanted*, Ian McDonald's *Luna* sequence, comprising *Luna: New Moon* (2015), *Luna: Wolf Moon* (2017) and *Luna: Moon Rising* (2019), and Jane Killick's (2021) *In the Shadow of Deimos*.

This chapter concludes by acknowledging how the speculative nature of terraforming and its long timescale can function as an alibi for avoiding the establishment of modes of deliberation that would appropriately acknowledge the interests of all those involved in such a project. Furthermore, the legacy of the unevenness of social structures and the historical and unresolved differences between groups provide a possible foundation for the emergence of conflict on other planets should those differences remain unacknowledged and unresolved. Collective identity is a key theme that will have repercussions for how governance on other planets is conducted. Ultimately, sf imagines terraforming as an expression of collective identities and the values that inhere within a community.

Paper

In *Green Mars* (Robinson, 1996b), the second novel of Kim Stanley Robinson's landmark terraforming trilogy, Art Randolph is recruited by the fictional corporation Praxis to work as a diplomatic liaison to Mars. His recruitment involves days of workshops organised around what CEO William Fort calls "full world-economics" (Robinson, 1996b, p. 101), which seeks global solutions to climate change on this near-future Earth. Recalling R. Buckminster Fuller's development of *The World Game* (1971), these workshops involve modelling scenarios to explore the global repercussions of economic and organisational decisions and to devise strategies to address economic growth within ecological limits on Earth. As the hopeful candidates grapple with scenarios involving "maximum sustainable human populations" (Robinson, 1996b, p. 103) to "Population Reduction" facilitated by an engineered plague (Robinson, 1996b, p. 107), readers are introduced to the assumptions informing each situation. This sequence not only mirrors the kinds of thinking that terraforming demands but it models science fiction's (sf) generation of fictional scenarios, which can be read as evidence to inform policy. The anthropologist Clifford Geertz (1973) distinguishes between two modes of modelling: 'modelling of' and 'modelling for': models can work as a representation *of* an object, which enables exploration of that object to enhance our understanding of how it works, or a model *for* that enables objects to be actualised in accordance with a plan or blueprint. Sf constructs models *of* phenomena that enable the generation of further knowledge about pre-existing realities that may be poorly understood or about ones that are yet-to-exist. This chapter focusses on terraforming and ideas about identity and the organisation, management

and governance of communities on Earth and other worlds. It assembles sf that constructs models of terraforming, which provide insights into the implications of transforming other planets for communities on Earth and beyond.

The sf literature on terraforming is capacious and incorporates reflection on geoengineering, or terraforming on Earth. Terraforming and geoengineering stories—often both at the same time—respond to the political and historic contexts of their contemporary moment but also imagine and speculate on orientations, themes and systems that anticipate future developments. They also respond to the models established by earlier texts and can thus furnish policymakers with a literary archive that assesses the social and political dimensions of terraforming and geoengineering. Key themes related to the construction and maintenance of the material, social and interpersonal infrastructures that sustain the development of new communities in alien environments persist across the theme's history, while speculation on the uses of, risks involved and responsibilities due to earthly and other planetary spaces abound.

Modelling Terraforming and Deliberation in Kim Stanley Robinson's *Mars* Trilogy

Kim Stanley Robinson's *Mars* trilogy, comprising *Red Mars* (1996c), *Green Mars* (1996b) and *Blue Mars* (1996a), along with the short story collection *The Martians* (2000), responds to the sf dialogue about terraforming and explicitly reflects on the changing orientations to planetary adaptation explored by earlier sf. As such it can help to organise the wealth of sf's engagements with terraforming by highlighting key issues and themes that the tradition has explored and to which Robinson responds. Robinson's oeuvre can be read as a summary of debates about terraforming in sf and in popular, speculative and contemporary science, and thus functions as a summation of reflections about terraforming's significance, problems and key considerations regarding issues of identity and governance.

The *Mars* trilogy models the colonisation and terraforming of Mars across two hundred years. The three works correspond to the visibly changing Martian landscape as colonists first settle the red planet in *Red Mars* (Robinson, 1996c), as lichens establish themselves across the planet in *Green Mars* (Robinson, 1996b), and as the planet warms sufficiently for liquid water to persist on its surface in *Blue Mars* (Robinson, 1996a). At each stage the economic, social and political dimensions of the Martian communities undergo a step change as the initial First Hundred colonists, made up of scientists, engineers and technocrats, are joined by succeeding waves of colonists with differing orientations, goals and skills from a number of countries. Throughout the first two instalments the exploitation of Mars is instantiated and challenged such that by *Blue Mars* (Robinson, 1996a) the planet's communities are drawn together to develop a Martian constitution that codifies a system of principles to organise relations and to provide guidelines for how Mars should be terraformed.

Identity and governance on Mars develops in response to the fragmentation of ideas about what Mars is for, why and how it is to be terraformed and which communities terraforming will serve. The initial First Hundred colonists are made up of scientists representing joint American and Russian interests. The trilogy thus acknowledges these two countries' dominance regarding space endeavours and the Cold War context against which the imagination of interplanetary colonisation and terraforming developed. This Cold War context is formative of such fictions and constitutes the backdrop against which works such as Ray Bradbury's *The Martian Chronicles* (1958), Poul Anderson's 'The Big Rain' (2001), *The Snows of Ganymede* (1958) and 'To Build a World' (1964), and Frank Herbert's *Dune* (1965), among many others, respond. The projection of Cold War anxieties and interests into

space forms the initial context for imagining Mars terraformation but, as Robinson demonstrates, this context is inappropriate for thinking about identity and geopolitics in the late twentieth and twenty-first centuries. Although Cold War anxieties texture the initial approach to governance this framework is rapidly exploded as later waves of colonisation greatly diversify the geopolitical claims made of Mars. Compounding this diversification of communities, each bringing their own historic contexts and interests to Mars, is the emergence of new Martian identities that depart from the frameworks of the Earth-born colonists. These emergent community identities are especially marked among the generations born on Mars who have no direct experience of Earth. Their forms of identity are tied to the land and to notions of habitation, and come to represent a fundamental difference in ideological constructions of the new Martian landscape. Yet one of the key issues faced across the trilogy and tackled head-on in *Blue Mars* (Robinson, 1996a) is the question of how best to represent these diverse Martian communities, each of which express different motivations for emigrating to Mars and each of which actualise their identities by practicing different modes of habitation.

These differences emerge spectacularly into conflict in *Red Mars* (Robinson, 1996c) and *Green Mars* (1996b). A key fault line that structures important dimensions of the developing Martian identity is the opposition between Martian and terrestrial modes of governance. In *Red Mars* (Robinson, 1996c) conflict between Earth and Mars results in a failed Martian revolution that develops into an extensive campaign of resistance until Martian independence is achieved in *Green Mars* (1996b). As with stories such as Isaac Asimov's 'The Martian Way' (1974) and Robert A. Heinlein's *The Moon is a Harsh Mistress* (2001), Earth–Mars antinomy, supported by an exploitative sense of Earth ownership over Mars, provides a contrast against which Martian forms of identity are defined. Organising approaches to living on Mars solely in terms of an extractive relationship that measures success by how far the needs of Earth's industries are met overlooks essential dimensions of the Martian community's needs, to which Fort's full-world economics seeks to respond. Moreover, the desire for modes of living specific to the Martian communities' contexts needs to be acknowledged and incorporated into deliberation over how best to govern Mars, as *Blue Mars* (Robinson, 1996a) and the formation of a Martian constitution grounded in principles set out in what comes to be known as the Dorsa Brevia agreement are intended to demonstrate. Mars cannot simply function as an annexe of Earth if the communities living there are to persist and flourish. They must be given the opportunity to exercise autonomy in their deliberations over the future of the colony. These decisions must proceed from those with a lived experience of Mars and of the multiple and fragmented communities that coalesce in these novel environments. What Mars represents for both Mars and Earth will have a crucial bearing on how it will be terraformed and governed. If Mars is simply to be an economic repository and thus terraformed to maximise extraction then the interests of those who see scientific, ecologic and utopian potential will be overlooked, opening up possibilities for differences to crystallise into grievances, which in turn may lead to decline or conflict.

The opposition between Earth and Mars that informs many terraforming stories is addressed by the sequence in *Green Mars* (1996b) where Nirgal, one of the first children born on Mars, travels to Earth to raise awareness of the Martian communities while helping Nirgal to put into broader perspective his thinking about Earth–Mars relations. Nirgal's struggle with the physical demands of Earth's greater gravity and the biological dangers it represents for people born in environments radically absent of the intensified ecological networks that evolved on Earth underscores some of the physical barriers to interchange between those born on different planets. Unlike works of terraforming that establish global identities by homogenising populations on other planets, this sequence and similar sequences on Mars

illustrate the diversity of living conditions, traditions, interests and motivations of the various communities on both planets. Nirgal's view of Earth–Mars relations positions this diversity as Mars' key offering to those on Earth: that Mars functions as Earth's distorted mirror, which condenses and displaces Earth's tensions and problems. Mars magnifies Earth's motivations and interests by distilling key principles and dynamics that are abstractions of the economic and political dimensions that inform Earth's modes of identification, organisation and governance. Terraforming on Mars engages similar challenges that climate change on Earth creates, such as transformations that have reshaped urban and rural landscapes at the coastlines and regions of cultural, ecologic and historic significance. Terraforming Mars is aligned with the physical, social and cultural work of geoengineering Earth in response to climate change.

Nirgal is most concerned with illuminating the shared interests and lessons between Earth and Mars communities, and in doing so showing how possibilities exist for building coalitions between them. This concern underpins the work that many engage when constructing a framework for a Martian constitution. Randolph is a key player in the Dorsa Brevia conference and lends his support to the voices calling for independence and autonomy. Fort's interest in Mars, however, is not solely for access to the new economy Mars offers. More important is how Mars' unique condition, as the site of a new governing body, positions it as a valuable test bed for emergent forms of governance and organisation that could offer models for governance on Earth. The *Mars* trilogy demonstrates how such modelling might look and uses literary strategies such as the proliferation of narrators and subject positions through which the story is told to triangulate multiple perspectives on issues relevant to terraforming. What the humanities offer by way of evidence to support policy are strategies to model affective, ideological and historic dimensions that enable the identification of areas crucial for understanding how these models integrate knowledge of different types to contextualise thinking about terraforming, identity and governance. This broader context implicates knowledge of different orders and offers to deepen consideration of the multiple interests and positions on key issues for terraforming.

If this approach to modelling thought about terraforming and geoengineering threatens to expand the terms in ways that multiply the kinds of phenomena relevant for consideration then the developing sf dialogue about terraforming can constrain understanding so that it can usefully speak to contemporary contexts for policy. Key to the construction of terraforming and geoengineering are the social and political dimensions relevant to these ideas as well as the conceptual broadening of the two terms such that they encompass multiple phenomena. Contemporary scientific discussions of geoengineering often collapse the concept into two modes of planetary adaptation: solar radiation management and carbon dioxide removal. These terms refer to two very different approaches to manipulating planetary environments but they also threaten to narrow discussion about geoengineering such that alternatives to these two methods fail to be recognised as forms of geoengineering. In deliberations over appropriate modes of geoengineering for climate change relevant alternatives are not part of public discussion and are not brought in to contextualise debate about geoengineering. What the literary models constructed in sf can do is to provide this context and to frame specific approaches to terraforming and geoengineering in ways that clarify their social implications and the values that they express.

The risks associated with unilaterial action are addressed in the *Mars* trilogy. In *Red Mars* (Robinson, 1996c) one of the First Hundred, Sax Russell, embarks on several projects to terraform Mars without consulting the rest of the community. He takes this action and avoids deliberation because the opposition represented by his colleague Anne Clayborne threatens

to decelerate terraforming. The two positions represented by each of these influential figures turns on the scientific and philosophic choice to terraform Mars for human habitation and the desire to leave Mars in its unmodified state. These 'Red' and 'Green' positions splinter into a variety of stances that include a militant approach utilising direct action to sabotage terraforming. The ethical dimensions of the debate between the Reds and Greens are crucial aspects of identity formation on Mars and culminate in provisions written into the Dorsa Brevia agreement to set aside regions at high altitudes for the preservation of the original Martian landscape. While this victory fails to placate all of the Red factions this trajectory demonstrates how failures of deliberation establish grievances that have far-reaching implications for governance on Mars. The failure to engage the community in appropriate modes of deliberation creates another fault line in the emerging Martian identity that persists throughout the trilogy. Russell himself modifies his 'strong' stance on terraforming and regrets his earlier infractions after the Martian civil war and seeks a rapprochement with Clayborne in *Blue Mars* (Robinson, 1996a).

Interplanetary Relations and Independence

The relationship between Earth and terraformed worlds is central to the imagination of identity in terraforming stories. This relationship concerns appropriate modes of governance for interplanetary colonies and between Earth and other planets but also contrasts Earth's organisational structures and governance with those of terraformed worlds. Terraforming stories re-contextualise ideas about social and political organisation to address questions about the value and uses of outer and planetary space, how they are invested with value and meaning and how they offer opportunities for developing novel modes of living. Other themes include the continuity of developmentalism and the projection of geopolitical contexts onto other planets, along with Earth's historical systems of governance and economic management. Postulated wars or the threat of resumed conflicts justify the necessity of terraforming while conditioning its success. Such foundations often drive desires for economic and political independence from Earth. Earth's geopolitical contexts are thus of key importance for space policy.

The earliest works of terraforming position the colony or isolated station as part of a wider governmental system against which the colonists define themselves and to which they seek secession. Independence from Earth, centring questions of autonomy and economic, social and political relationships to a governing centre, is a key theme. These questions are framed in relation to values that are defined as American and draw on mythologies of the colonisation of the American west, manifest destiny and the role of science and technology for embodying a national identity conceived as uniquely American. Such framing is a key aspect of the development of the US national space programme but has textured how space is framed by multiple national space agencies, by space advocates globally and in the popular imagination. Terraforming stories reflect on and offer alternatives to conceptions of planetary environments and thus embody how sf can inform policy about the uses of space and the role of terraforming.

Jack Williamson's (2004) 'Collision Orbit,' the short story that coined 'terraforming,' is set on an asteroid made habitable by artificial gravity and atmosphere generators. Positioned at the frontier of space, a scientific research station seeks independence from Interplanet Corp. The story turns on the efforts of scientist-engineers who wish to establish economic and political independence from Earth and other governmentalities of the solar system, and they do so by

creating new ways to generate energy to prevent an asteroid collision. Possibilities for establishing security from exogenous physical threats and the evacuation enacted by Interplanet Corp are economic decisions that are expressive of a lack of care for the colonists. Evacuation would dismantle the station's established ways of living and working and is therefore unacceptable, thus leading the colonists to develop energy technologies to realise an autonomous and independent existence. Key to this construction of identity is how speculative forms of science, technology and engineering are positioned as central to generating new and independent identities and how such developments necessarily reconfigure political and economic relationships to the imperial centre.

Interplanet Corp holds a monopoly on asteroid mining and actively discourages colonies from exploiting these resources. Following an historic war with Interplanet Corp, after which Earth's interplanetary colonies established independence, a High Space Mandate by way of a peace treaty was established to allocate the asteroids' resources to the solar system's governing bodies. The treaty, however, forecloses opportunities for innovation and free enterprise among smaller colonies. To address the immediate threat of collision and to break open the monopoly a new form of energy is developed that promises to disrupt the economic and political systems governing relations in the solar system.

This story draws attention to the division of the solar system's resources and explores how colonies identify themselves in relation to Earth. It raises questions about the possibility and desirability of independence among the colonies and draws attention to the communities that exist at the margins of the solar system's dominant powers. It contrasts free enterprise with a centralised authority and suggests that the most important developments occur at societies' periphery. Autonomy is crucial for these developing communities and to ensure a suitable foundation for the development of new and disruptive technologies. Yet the story's community comprises scientists and engineers led by a charismatic individual who is crucial to the persistence of the outpost. Like stories such as Jack Vance's (2005) 'I'll Build Your Dream Castle,' 'Collision Orbit' privileges the entrepreneurial, autonomous male scientist-hero—a representation that anticipates the image of the entrepreneur constructed around such figures as Elon Musk. The private development of space figures as an early sf trope that informs how terraforming is conceived. Questions about the nature and role of terraforming are answered by positioning space as a field for private development.

The resources offered by asteroids for regenerating stagnant economies is taken up by Vance's (2005) 'I'll Build Your Dream Castle,' Asimov's (1974) 'The Martian Way' and Frederik Pohl's (1992) *Mining the Oort*. 'The Martian Way' focuses on the securing of resources to ensure the continued survival of a Mars colony. Earth's support wanes as political resistance to the economics of the Martian colony and others on Venus and the Moon threatens further investment. The risk to the community created by this threatened withdrawal drives identification with a unique Martian identity that structures how the colonists view their actions and make choices about their own survival. This emerging Martian identity is tied to the work of scavengers who patrol space between Mars and Earth to obtain salvage metal and is contrasted to the Grounders on Earth, who are aligned with exploitation and fraud. This work is framed by one character as "Human progress: the Martian Way; the New Creative Minority" (Asimov, 1974, p. 18). The scavengers' work is hampered by the tensions that prolonged habitation of space generates but their expertise with space enables them to extend their missions beyond the capacities of Earth's astronauts. Water provides energy for propulsion,

which represents a limit that cannot be replaced and thus the colony seeks new sources to achieve economic independence to weather Earth's withdrawal of support and the institution of a water quota which would make scavenging impossible. This story links terraforming to the construction of a distinct Martian identity that is tied to the colony's economic basis and to the unique forms of work that arise on Mars.

Arthur C. Clarke's (1976) *The Sands of Mars* addresses the relationship between Earth and its Martian colony and, like Williamson's (2004), it positions energy as the fundamental lever for establishing full economic independence from Earth. It models the Martian colony's relationship to Earth post-independence in ways that open both worlds to the benefits of exchange. The story's point of view is a key mechanism for providing this situated perspective on what living on Mars might look like. The narrator is a fictionalised sf author who travels to Mars to write a series of magazine articles about the colony. A key theme that would appear in later works is thus portrayed in the novel: how creators use their skills to promote space activity and how images of interplanetary colonisation are fictional constructs that inform relationships to interplanetary communities. As Gibson's experience with the colony deepens he develops greater attachments to Mars and eventually decides to stay and advocate for the Martian colony to audiences on Earth.

Clarke's (1976) portrayal of the Martian colony draws on the same framing of the Martian community as a model Midwestern American town that Ray Bradbury (1958) constructs in *The Martian Chronicles* but it uses Gibson's professional ironic detachment to highlight how analogies for understanding the developing community fail to capture important differences in living and representation. The colony is a highly specialised scientific-engineering community and is organised around the nuclear family. The romanticism of space is highlighted throughout the novel but is ultimately legitimised because the small colony offers opportunities for belonging that are no longer available on Earth. The colony is threatened by Earth's potential withdrawal of support for the colonising project. The community that Gibson bonds with and eventually identifies is dependent on economic and personnel support from Earth. However, the colony has a plan to reignite interest in Mars that turns on the creation of an artificial sun that would provide the colony with a new energy source. It would also initiate the resurgence of an indigenous plant that would terraform the planet by oxygenating its atmosphere. Terraforming, then, promises to make the colony truly independent from Earth while simultaneously making it more attractive to potential settlers. Colonising other planets is thus only widely supported if that planet can be made habitable beyond the domes of the settlement.

Poul Anderson's (1964) 'To Build a World' is a Cold War thriller that focusses on the broader political relations between colonies of the solar system and Earth, through the story of a conspiracy to undermine Lunar terraformation. Venus, Mars and the Moon are totalised such that national identity correlates with the entirety of the planet. These forms of identity emerge from the work undertaken to colonise the planets. Thus the clan-system of governance to which the protagonist identifies developed from the corporations that initially terraformed Venus, reinforced by a relative isolation that is exacerbated by Venus' own planetary parameters: its clouded sky accentuates a separation that facilitates the development of unique and independent cultures and identities. The challenges of terraforming give rise to feuds between clans who compete for territories that require fewer resources to terraform.

The story focusses its attention on an interplanetary effort to terraform the Moon. As with many terraforming stories such as Pamela Sargent's (1989a, 1989b, 2001a, 2001b) *Venus* trilogy, attention to the fractured political relations on Earth and the tensions following multiple World Wars are diverted by the project to conquer space. Widespread public support for Lunar terraformation is presented as unrealistic and unnecessary while criticisms of the project are framed as unreasonable. Such criticisms include fears that the Moon will only be available to the rich, which the protagonist Sevigny rejects by referring to a Moon charter that stipulates adequate and reasonably costed housing for all colonists while codifying the reservation of a quarter of the Moon's surface for recreational purposes. The closure of public deliberation is treated as a reasoned strategy because Earth's unresolved tensions and the lingering threat of nuclear war creates an impasse that would block all attempts to generate widespread support for the project. The threat of nuclear war is cited as one reason for proceeding: humankind's survival increases if societies throughout the solar system can be created, thus spreading the risk that catastrophic planetary failure would result in human extinction.

Public deliberation is vetoed in favour of a privatised approach to terraforming. The avoidance of public deliberation gives rise to an anti-lunar coalition that is presented as fundamentalist and conservative. One anti-lunar criticism concerns the use of resources that could be used to reclaim Earth's ecologically devastated regions—in other words to geoengineer Earth to address anthropogenic environmental deterioration, which the anti-lunarians position as an "issue of sound policy" (1964, Anderson, p. 33). Against arguments that Lunar terraformation would eventually realise greater benefits than Earth could offer, one conspiracist argues that "It will dehumanize us to plan in such terms" (1964, Anderson, p. 34). Another criticism relates to what the Lunar administrator considers to be an overly emotional resistance to the transformation of the Moon's appearance, a theme that is developed in the context of Mars' moon in works such as Jane Killick's (2021) *In the Shadow of Deimos*. By placing these arguments in the mouths of conspiracists who have kidnapped the protagonist the story positions the anti-lunar coalition's arguments as unreasonable. The protagonist's identification as a Venusian clansman and the loyalty to his employer that is fundamental to this identification encourages him to align himself with the lunar coalition. This sense of identity is crucial to ensuring the continued development of the Moon. By the story's conclusion plans are enacted to develop a lunar lobby to rival that established by the anti-lunar coalition, which involves the application of the same strategies used by the anti-lunar coalition: propaganda, the election of sympathetic politicians, political pressure, logrolling and bribery, all of which are framed as essential elements of the political process.

The fragility of colonies to sabotage and Earth's withdrawal of support are key risks which threaten to undermine terraforming projects. While in 'To Build a World' (Anderson, 1964) and the *Mars* trilogy (Robinson, 1996c, 1996b, 1996a) sabotage and Earth's application of force to quell resistance highlight how precarious such colonies are, in Robert A. Heinlein's (2001) *The Moon is a Harsh Mistress* the directionality of violence is inverted. A lunar colony that seeks independence from Earth supports its claim through the threat of violent reprisal in response to Earth's attempted capture of the Moon. By banding together and adapting the systems used to transport food to Earth to enable rocks to be propelled that would impact the Earth's surface with calamitous force, the Lunarians use their unique cosmological position to support their claims to independence. The exploitative relationships established between Earth and the Moon justify the Martian communities' efforts to establish independence from Earth and to secure this independence with force.

From the 1960s onwards ecology and environmentalism become increasingly important aspects of governance and identity for terraforming stories. Works such as Michael Allaby and James Lovelock's (1984) *The Greening of Mars* use ecological ideas and Lovelock's (1987) own theorisation of the Gaia hypothesis to texture the forms of management and transformation applied on Mars. Creating a Martian atmosphere involves repurposing nuclear warheads to bomb Mars, which simultaneously warms the planet and removes a threat to Earth while preparing Mars for the application of ecologically informed approaches to terraforming. Attention to ecology informs conceptions of Martian identity, which in turn provides a foundation for achieving independence from Earth. This distinct Martian identity is central to ensure that the cultures, lifestyles and aesthetics that develop on Mars do not replicate those that have developed on Earth. While such difference could lead to conflict between new arrivals to Mars and those who have inhabited the planet for generations new forms of identity are intentionally cultivated and celebrated to ensure that the Martian colony establishes an appropriate foundation for the development of an independent and self-sustaining community.

If westward expansion across North America patterns the imagination of terraforming, America's and Australia's historic status as penal colonies provides another story that informs how terraforming is conceived. Like Heinlein's (2001) *The Moon is a Harsh Mistress* and Jerry Pournelle's (1992) *Birth of Fire*, terraforming in S.C. Sykes' (1991) *Red Genesis* is conducted by convict-labourers. The story follows chief executive of Sinclair Enterprises, Graham Kuan Sinclair, who is framed for extensive environmental damage that has led to multiple deaths and a legacy of contamination. On Mars Sinclair acclimatises to life in an interplanetary colony and gains first-hand experience with the forms of work that make terraforming Mars possible. *Red Genesis* (Sykes, 1991) positions business management and organisational strategy as essential to terraforming and shows how the rejuvenation and growth of the Martian colonies depends on successfully integrating multiple sites across the planet and utilising the most critical of resources as efficiently as possible. These resources are people, their skills and knowledge and their ability to form self-sustaining communities. Sinclair's capacity to assess the colonies' needs and to develop a knowledge and resource infrastructure to begin the process of achieving economic self-sufficiency as a first step toward independence from Earth helps the Mars communities to define a series of shared goals and to construct an identity that rejects their status as convicts. Under Sinclair's leadership the colonists grow in confidence and harness their abilities to develop and expand their networks across the planet. By the end of the narrative, as evidence of Sinclair's framing comes to light and he is given the opportunity to return to Earth, he decides to remain on Mars with the communities to which he has come to identify to continue the terraforming project.

Mary Robinette Kowal's Lady Astronaut sequence, comprising the novella *The Lady Astronaut of Mars* (2013) and *The Calculating Stars* (2019a), *The Fated Sky* (2019b) and *The Relentless Moon* (2020), develops the relationship between risks to Earth's planetary environment and terraforming. In this alternate history a meteorite collides with the Eastern US coast, killing most of the highest-ranking politicians and causing widespread devastation. Crucially, this impact initiates a runaway climate disaster that functions as an analogue for anthropogenic climate change in the twenty-first century. Missions to colonise the Moon and Mars are undertaken in this alternate 1950s to establish settlements to ensure human survival if Earth becomes uninhabitable. As with Anderson's (1964) 'To Build a World,' a key development is

the emergence of widespread protest groups and dissent, along with saboteurs who campaign for the redirecting of investment to combat the runaway climate crisis on Earth, which is galvanised by the recognition that not only would immigration to these colonies prove impossible for the majority of Earth's population, but that those who leave will be selected from a narrow elite. The sequence reflects on historical prejudice experienced by women, black people and others in the US, which highlights how institutions' historical closure will condition how colonisation and later terraforming will be imagined and planned.

Robinson's (2018) *Red Moon* features sequences set on US and Chinese colonies on the Moon, although other colonies exist, such as the private free colony established by a Chinese businessman to project his vision of an ideal society that operates outside of governmental control. Thus private and national colonies, each with their own systems of governance, are established and operate alongside one another. However, colonies without the support of geopolitical actors on Earth are fragile. Fragmented political interest means that the independence of private colonies cannot be guaranteed. The ties between Earth and the Moon are too strong to sever while possible threats to the stability of geopolitical actors on Earth cannot be overlooked, thus drawing independent colonies into Earth's political conflicts. *Red Moon* (Robinson, 2018) shows how such bases function as annexes of geopolitical entities which extend legal frameworks beyond the Earth. While nominally organised in line with the principles of the Outer Space Treaty (2002), these colonies circumvent these provisions in various ways. While each national colony operates as embassies land claims cannot be asserted. Nevertheless, structures are set up to establish zones of control without prior oversight or knowledge by other national actors on the Moon. As Frederick J. Fredericks and Chan Qi claim sanctuary at a US colony one strategy conducted by the Chinese delegation to negate the rule of inviolability involves appeal to a structure that had been installed across the space later occupied by the US colony. As this scientific monitoring device precedes the US presence on the Moon and as entities are prohibited from interfering with experiments conducted by others the US colony finds itself in violation of Chinese territory. What this example shows is that geopolitical conflict is likely to extend beyond Earth territories to be played out in the spaces of colonised and terraformed planets. Furthermore, while land claims, according to the Outer Space Treaty, cannot be asserted, strategies to effectively claim ownership of the land are likely to test the boundaries of such treaties. The escape from Earth's politics to which interplanetary colonisation is often associated and the independence of such colonies is undermined. Instead, a continuity between Earth and the colonised planets will likely persist, leaving the field a space for the extension of geopolitical conflict.

The Closure of the Colony

If the stories above describe the growth and recuperation of space-dwelling communities then Bradbury's (1958) *The Martian Chronicles* contests the optimism that underlies terraforming and interplanetary colonisation. These stories portray successive waves of colonists who leave Earth, their motivations and the failure of the colonists' attempts to devise a colony expressive of a middle-American way of life tied to the suburban 1950s moment. These stories show how the desire to create hermetically sealed colonies that freeze the values of its moment in American history is doomed to failure because this closure prohibits the emergence of new modes of living and being that life on Mars affords. Martian colonisation is undermined through the economic and national narrowing of the colonists who leave for Mars. Although ostensibly initiated on behalf of all humankind American investment means that the second

wave of colonisation is exclusively American. The threat of nuclear war, a defining theme of post-WWII American sf, means that appropriate demographics for Martian colonisation cannot be mustered, thus underscoring how terrestrial relations circumscribe the effectiveness of colonising missions. Indeed, in 'The Off Season,' two colonists on Mars witness the eruption of nuclear war on Earth. The colony, dependent as it is on successive waves of colonists, cannot survive without Earth's support and so this development closes the potential for regeneration for the already declining Mars colonies.

In 'Way in the Middle of the Air' a black American exodus to Mars is portrayed. Leaving Earth for these would-be colonists is an opportunity to leave the political and governmental structures that have marginalised and exploited non-white bodies in America. In 'The Taxpayer' the eponymous individual craves release from Earth via a trip to Mars to escape the systems of exploitation and the threat of nuclear war that would later erupt on Earth. In 'The Million-Year Picnic' a family arrives to Mars to begin a new life away from Earth failures. In each example Mars functions as a symbolic escape from Earth's systems and an opportunity to begin afresh with a blank slate, to determine independent and autonomous modes of living that might avoid Earth's failures. Yet this view of the value of Mars to Earth is also shown to be short-sighted. In stories such as 'The Off Season,' 'The Green Morning' and 'The Locusts,' the colonists project their own desires onto the planet and thus behave not as if they were living on another planet but as if they were living in a simulated future. They fail to respond to the novelties of the alien planet in ways that recognise their difference and, in stories such as 'The Off Season,' they fail to see the indigenous alien Martians as autonomous individuals with their own needs, interests and desires. Rather, these stories present a series of symbols expressive of how Mars and its inhabitants are understood as sites for the ultimately limited projection of human interests and history. This failure to respond to the new contexts Mars colonisation offers results in the diminishment and eventual failure of the colonies. Coupled with conflict on Earth and the impossibility of sustaining adequate connections with Mars, these stories underscore the difficulties in maintaining colonies on other worlds that require suitable infrastructural connections and influxes of new arrivals. The Martian colony's failure to appropriately respond and adapt to their new environment leads to deterioration and failure.

Frederik Pohl and C.M. Kornbluth's (1974) *The Space Merchants* positions terraforming as the next field for capitalist expansion for a future Earth in which the entirety of the global population works for one of only a handful of corporations that have assimilated all aspects of the global economy into vertically integrated transnational entities. Echoing Clarke's (1976) *The Sands of Mars*, terraforming is the subject of advertising campaigns to inspire workers to take on the task of transforming Venus. Advertising draws attention to how attempts to garner support for terraforming elide the realities of living on and shaping other planets. This is further complicated by the exploitative business practices that form the bulk of the novel. The protagonist Mitch Courtenay, as an advertising executive, brings us into contact with the company's business practices and its marketing strategies, thus casting doubt on how terraforming is presented. The novel ends with an underground opposition of conservationists escaping from the exploitative capitalist world-system on Earth. Terraforming thus represents an escape from the economic closure of Earth even if the outcome of terraforming and the possibilities for the foundation of a new society that does not simply reprise systems on Earth is uncertain.

Another story that expresses anxiety over the possibility that terraforming would enable corporate exploitation is Walter M. Miller's (1973) 'Crucifixus Etiam.' Workers are fitted with a system of hoses that enable them to breathe the thin Martian atmosphere. These body modifications are incredibly painful and foreclose possibilities for a return to Earth. By featuring the Peruvian protagonist Manue Nanti Miller draws attention to how the work of terraforming is placed on the shoulders of labourers made vulnerable by their economic and political plight on Earth. Thus, the economically and nationally vulnerable marginalised are left to bear the brunt of the labour involved in developing Mars for others, generations to come. They only way Nanti can come to terms with his reality on Mars is to sublimate his own desires to the generational goal of a fully terraformed Mars because the only alternative is a meaningless life of pain. One key risk relates to ideas of habitation and of fitting in to the Martian environment. Colonists who journey to Mars under false or mistaken premises risk failing a return and remaining trapped on the new planet, which will have corresponding implications for their life and work.

Luiza Sauma's (2019) *Everything You Ever Wanted* presents a vision of the decline of an interplanetary colony. Attracted to a one-way trip to Nyx to escape the meaninglessness of life on Earth, the trip is part of a reality show about the fictional planet, the popularity of which justifies colonisation. However, the eventual decline in the show's ratings results in a decline in support for the colony, which exacerbates the protagonist's own feelings of alienation. Her motivation for travelling to Nyx reprises the familiar escape from Earth theme illustrated in Bradbury's (1958) *The Martian Chronicles*, though in Sauma's text the circularity and meaninglessness of life on an Earth for which digital media and advertising structure much of the social relationships possible is a key driver exerting a centrifugal pressure on the protagonist. The lack of meaningful communities on Earth motivates colonisation but is matched by the failure to develop a meaningful community on Nyx.

Ian McDonald's *Luna* sequence, comprising *Luna: New Moon* (2015), *Luna: Wolf Moon* (2017) and *Luna: Moon Rising* (2019), explores the contours of the financialisation of the Moon and its use to supply Earth with Helium-3 for clean forms of energy production that would ameliorate anthropogenic climate change on Earth. Echoing Anderson's (1964) 'To Build a World,' governance on the Moon is managed by an oligarchy comprising rival clans, families who have established a monopoly over the Moon's economic and developmental horizons. These oligarchies exercise complete control over the Moon's population. Employment with a family is essential to gain access to the "four essentials": air, carbon, data and water, without which existence on the Moon is fraught. Governance is managed through contracts which outline the scope for employment and legalises all activity, which can include violence and conflict. Antagonism between families is sanctioned provided that suitable contracts are established to govern such conflict. This model for governance illustrates how independent governance on the Moon, linked to family-owned corporations, creates an unstable system that is geared toward ensuring trade with Earth is not disrupted. Much of the population are permanently immiserated. Deprivation on the Moon and on Earth enables the perpetuation of the Lunar colonies, with regular immigration providing a supply of labourers. There is no possibility for deliberation amongst the Lunar population and no power to establish alternatives that would enable them to change their circumstances. It is only through the whims, desires and feuds between the ruling families that any possibility of change is opened, and only when family contracts for Lunar extraction and development are threatened.

While the scope for widening governance is minimal, this does not foreclose possibilities for developing communities on Luna. Identity is primarily linked to the houses that govern relations on Luna but emergent and alternative communities do exist, which function in parallel to these broader forms of identity. Some communities develop novel forms of living that offer resources for support and alliance to mitigate the repercussions of conflicts between the houses while other communities live on the fringes of society, cut off from direct access to the four essentials, the security provided by the houses and from the contracts that establish legal relationships between individuals on Luna. These groups live by salvaging from Luna's infrastructure and illustrate how those who cannot be incorporated into the formal system of governance must and can persist on the margins as an unacknowledged resource. Their role is to function as a warning to those with contracts of the risks involved in failing to find work. Yet for those seeking to escape from oversight they also provide a cover that enables them to circumvent monitoring and detection.

Jane Killick's (2021) *In the Shadow of Deimos* is a story about corporate malfeasance and corruption, the governance of Mars colonies and ideas about belonging and identity. Based on Jacob Fryxelius' (2016) popular board game *Terraforming Mars*, this corporate thriller reflects on the problems related to oversight and accountability, as well as on the relationship between corporations and governing bodies on Mars. *Deimos* suggests crucial problems relating to corporate power will be essential to tackle, but the structures put in place to do so will need to be carefully managed given the distance from central governing bodies on Earth. Corporate espionage, the control of labour and labour rights, legal systems and the governance of territories are key themes.

Deimos' (Killick, 2021) story is told from two perspectives. Luka is a new arrival to Mars. As a migrant labourer, readers are given an insight into the process of orienting oneself in a new system of work and living that is ubiquitous—corporations provide basic necessities but also security and entertainment. Corporate imbrication at every level of the labourers' lives is fundamental. This raises questions about how work, leisure and living should be organised and governed, and whether corporations are best placed to do so. Luka discovers evidence of corporate sabotage, thus providing a narrativised assessment of the problems inherent in ceding governance and control to the very corporate bodies with economic stakes in the Mars colony.

Julie is a high-ranking administrator of the Mars colony and a key official in developing Mars terraformation prior to massive corporate investment. As head of the United Nations Mars Initiative and, during the story, the lead investigator into an asteroid impact that veers off course and destroys a research station, killing its sole occupant, readers are given an insight into how politics unfolds on Mars and how the interests of corporations, labourers, researchers and terraformers are balanced. The story turns on an investigation into the asteroid collision that is initially accounted for as a freak accident but which is revealed to be engineered by one corporation to gain control of land. Issues of security are thus raised, as are the problems inherent in conducting any operations, such as an investigation, on planets undergoing terraforming. Central to this plan is the discovery of alien life, which transpires to be a false alarm. Rather, a modified form of Earth bacteria is used to establish control of the site to prevent investigation and to divert attention from the asteroid collision. This development points to how policies for the preservation and study of alien life may be co-opted to subvert routine investigative processes.

If *Deimos* (Killick, 2021) centres debate about the role of corporations in terraforming it also devotes space to reflect on aspects of identity and belonging. Luka's and Julie's perspectives on their pasts and futures inform much of their reflections on how to orient themselves to their work on Mars and how they conceive of their futures. Given that extended habitation on Mars leads to physiological adaptations that would make a return to Earth increasingly risky colonists much decide whether to return to Earth or remain on Mars indefinitely. This issue is presented as a security risk as one member of the colony is bribed with a promise to buy out her contract in exchange for covering up evidence of sabotage—her homesickness drives her to seek escape from the colony.

Conclusion

Governance is one of the key issues terraforming engages and it is this theme that connects ideas of societal closure, stagnation and collapse to efforts to redirect this trajectory by transforming the material, political and social conditions of the interplanetary colony. Questions about how colonies are managed and how conflict is negotiated can be sublimated by redirecting attention to the future and to transformations that will not be realised within the generation. Terraforming thus becomes an alibi to avoid specific questions about governance and the contemporary contexts that might create the conditions for conflict in the present. Many works of terraforming highlight the limits of such avoidance by showing how the unresolved differences in social structures re-emerge to disrupt the systems in place. Another aspect to this alibi is how the interests of some members of the group are subordinated to the interests of those proselytising for terraforming and how the unresolved tensions of the marginalised group re-merge to trouble terraforming projects. Often the colonists themselves are members of the marginalised group who are subordinated to the designs of a central bureaucracy. Experience on another planet and the dependence upon one another that the demands of terraforming generate create new conditions for the emergence of alternative conceptualisations of identity, which in turn can generate new priorities for the colonists and the ways they organise living and working on other planets.

Identity and its repercussions for governance are key overarching themes of terraforming stories. Earth–colony relations, the communities that coalesce on different planets, the totalisation or fragmentation of identity and how material and economic factors influence identity formation are central. How communities are encouraged and policed, how far community identity coheres with historical models (such as the patterning of space colonisation against the colonisation of North America) and the framing of national, ethnic and cultural identity are also key. Identity is a way for groups to establish kinship bonds and to develop modes of living that condition how terraforming functions as an expression of emerging communities and the futures that enable them to flourish. Sf spatialises identity across colonies or whole worlds to reflect on the possibilities and meanings of community.

References

Allaby, M. and Lovelock, J. (1984) *The greening of Mars*. New York: St. Martin's Press.

Anderson, P. (2001) 'The big rain', in G. Dozois, (ed.) *Worldmakers: Sf adventures in terraforming*. New York: St. Martin's Griffin, pp. 1–49.

Anderson, P. (1958) *The snows of Ganymede*. New York: Ace.

Anderson, P. (1964) 'To build a world', *Galaxy Science Fiction,* 22(5), pp. 7–64.

Asimov, I. (1974) ‘The Martian way’, in B. Bova, (ed.) *The science fiction hall of fame*, vol. 2B. New York: Tom Doherty associates, pp. 1–45.
Bradbury, R. (1958) *The Martian chronicles*. New York: Doubleday.
Clarke, A.C. (1976) *The sands of Mars*. London: Sidgwick & Jackson.
Fryxelius, J. (2016) *Terraforming Mars* [board game]. Asmodee and BraditGamesStudio.
Fuller, R.B. (1971) *The world game: Integrative resource utilization planning tool*. Carbondale, Illnois: Southern Illinois University.
Geertz, C. (1973) ‘Religion as a cultural system’, in *The interpretation of cultures*. New York: Basic, pp. 87–125.
Heinlein, R.A. (2001) *The moon is a harsh mistress*. London: Gollancz.
Herbert, F. (1965) *Dune*. Kent: New English Library.
Killick, J. (2021) In the shadow of Deimos: A terraforming Mars novel. New York: Aconyte.
Kowal, M.R. (2013) *The lady astronaut of Mars*. Available at: https://www.tor.com/2013/09/11/the-lady-astronaut-of-mars/. (Accessed 30 May 2023).
Kowal, M.R. (2019a) *The calculating stars*. Oxford: Solaris.
Kowal, M.R. (2019b) *The fated sky*. Oxford: Solaris.
Kowal, M.R. (2020) *The relentless moon.* Oxford: Solaris.
Lovelock, J. (1987) *Gaia: A new look at life on Earth*. Oxford: Oxford University Press.
McDonald, I. (2019) *Luna: Moon rising*. London: Gollancz.
McDonald, I. (2015) *Luna: New moon*. London: Gollancz.
McDonald, I. (2017) *Luna: Wolf moon*. London: Gollancz.
Miller, W.M. (1973) ‘Crucifixus etiam’, in *The view from the stars*. Hertfordshire: Panther, pp. 58–78.
Pohl, F. (1992) *Mining the Oort*. New York: Ballantine Books.
Pohl, F. and Kornbluth, C.M. (1974) *The space merchants*. New York: Random House.
Pournelle, J. (1992) *Birth of fire*. New York: Baen.
Robinson, K.S. (1996a) *Blue Mars*. London: Voyager.
Robinson, K.S. (1996b) *Green Mars*. London: Voyager.
Robinson, K.S. (1996c) *Red Mars*. London: Voyager.
Robinson, K.S. (2018) *Red moon*. London: Orbit.
Robinson, K.S. (2000) *The Martians*. London: Voyager.
Sargent, P. (2001a) *Child of* Venus. New York: Eos.
Sargent, P. (2001b) ‘Dream of Venus’, in G. Dozois, (ed.) *Worldmakers: Sf adventures in terraforming*. New York: St. Martin’s Griffin, pp. 394–416.
Sargent, P. (1989a) *Venus of dreams*. London: Bantam.
Sargent, P. (1989b) *Venus of shadows*. New York: Doubleday.
Sauma, L. (2019) *Everything you ever wanted*. London: Penguin.
Sykes, S.C. (1991) *Red genesis*. New York: Bantam.
United Nations Office for Outer Space Affairs. (2002). *United Nations treaties and principles on outer space: Text of treaties and principles governing the activities of States in the exploration and use of outer space, adopted by the United Nations General Assembly* (ST/SPACE/11). http://www.unoosa.org/pdf/publications/STSPACE11E.pdf.
Vance, J. (2005) ‘I’ll build your dream castle’, in The world-thinker and other stories. Oakland, CA: The Vance Integral Edition, pp. 37–60.
Williamson, J. (2004) ‘Collision orbit’, in *Seventy-five: The diamond anniversary of a science fiction pioneer*. Michigan: Haffner Press Oak, pp. 216–277.

Synthesis Paper 4

Storymaking Outer Space Otherwise[1]

Juan Francisco Salazar (Media and Communications)

Executive Summary

The value of the space sector relies on collective processes of co-creation that emerge from open forms of discussion, debate and which may inform public reasoning. For these debates to happen it is necessary to widen our repertoire for storymaking and for storylistening otherwise. This synthesis document provides an outline of "other", non-mainstream and counter-narratives of outer space. This is critical for opening up public reasoning at a time when humans reach for the starts with a series of very concrete plans for the next twenty years, when storylistening becomes crucial to resist and rethink normalised narratives of the inevitability of humans becoming a multiplanetary species, as a global corporate manifest destiny takes hold. It is of utmost importance to expand our understanding of what other stories, how storymaking otherwise, constitute forms of "evidence", how they could inform policymaking beyond scientific facts and models, enable novel conversations about the public value of outer space, and spark a deeper dialogue about more diverse future uses of space. The synthesis paper is divided into four short sections or vignettes. The first one starts reference to processes of storymaking and how these relate to theories of storylistening. The next section provides a short critical engagement with what might be called NewSpace narratives and socio-technical imaginaries. The third section moves onto space environmentalism and the critique of the enclosure of outer space futures; and the fourth section delves into Black and Indigenous futurisms and narratives of outer space.

Paper

Outer space has never been just out there, as an inert, unchanging backdrop to the drama of human affairs. Today as a site of political, scientific, commercial, environmental, and social interest, it has also become a legal predicament and a contested cultural landscape. Outer space is a diverse domain of activities, and there is no single collective vision about it. Doreen Massey (2005) evocatively offered an invitation to imagine space as "a simultaneity of stories-so-far". And Thom Van Dooren and Deborah Bird Rose understood that places are always "co-constituted in processes of overlapping and entangled 'storying'" (van Dooren and Rose 2012: 3). Outer space, as co-constituted place, as stories so far, is no different. For millennia, storytelling has been the primordial way of knowing outer space.

Imagination is the cornerstone of science, Albert Eisntein once said. Roman Frigg (2010: 109) asserts that "the core of the fiction view of model-systems is the claim that model-systems are akin to places and characters in literary fiction". In the European scientific imagination of the 17th century, as the historian of science and literature and theatre director Frédérique Aït-Touati (2011) eloquently demonstrates in her book *Fictions of the Cosmos*, literary fiction and astronomical authority were intimately intertwined, and the value of fiction as narrative evidence in science was significant. Aït-Touati also describes how modern science became gradually defined in the seventeenth century according to the narrative frames of exploration,

[1] This synthesis paper reworks previously published work. See Salazar 2017; Salazar and Castaño 2022; Salazar 2023; and Salazar and Gorman 2023.

invention, and discovery. She has traced the motto “Plus Ultra: Always Further”, said to have been originally coined by Emperor Charles V, and which Francis Bacon gave to modern science as a programmatic wayfinding maxim. Today it illustrates how contemporary scientific imaginaries of space exploration, discovery, and exploration are still imbued in narratives of conquest and appropriation where “progress, arrow of time and conquest of new territories go hand in hand” (Aït-Touati 2019: 7).

Author Ceridwen Dovey (2021) conveys it brilliantly when she writes about how outer space,

> “has always been irresistible as an ethical imaginarium for humans, the site of moral wish fulfillment, a place in which to ask who humans might be if we could tilt towards our better rather than baser tendencies. In narratives about outer space, there is a fetishization of perfection; the technologies to get us there are always celebrated as perfectly ingenious. What about perfecting other forms of knowledge, helped along by a subtle shift in descriptive language? We must learn to approach nature as a co-participant in its future, seeing space-nature not as a simple repository of raw materials or cosmically irradiated rocks with which we can do what we like, as possessions and property, but as our kin”.

Despite this diversity of stories, narratives and imaginaries of outer space that have been created, told, listened to, and informed policy since the 1950’s, have largely focused on a small number of frames. Stories of human exceptionalism and scientific discovery; of the cosmos as the last human frontier to conquer; of the expanse of the solar system as a new resources frontier to exploit; of the hunt for alien life; of colonization and settlement of new worlds. Or narratives of a space race among rivals competing for national prestige and geopolitical supremacy; for the mastery of human over nature, and the ascendancy of men over women. And, also, stories of unimaginable technological prowess, ingenuity and disruptive innovations that have changed the way people live in the early 21st century. Indeed, the value of space, as evidence indicates, is in that it has become indispensable for the functioning of all aspects of the contemporary economic system. From financial operations, to travel, to shipping, to insurance, to mining, to agriculture, to online navigation and telecommunications, to monitoring weather, climate change and food security, and of course national security.

A main frame today is that, in the 21st century, as the thorny question of governance regimes beyond Earth continues to unfold, new actors, new industries and new technologies are dramatically changing the expediency of the low-Earth orbit, the Moon, Mars and asteroids, as sites that can be accessed and sourced for commercial purposes. The private sector has become a critical stakeholder in the entire value chain of the space economy, enabling and boosting a thriving commercial presence in space. In effect, the value of the space economy in the early 2020’s has been calculated at around US$400 billion. Several independent reports by Goldman Sachs, by Morgan Stanley, or by Bank of America Merrill Lynch, project that the space economy could reach between US$ 1 trillion and as high as $2.7 trillion by 2040. This current phase into outer space is notably being fuelled not only by scientific discovery and the political rivalry of the Cold War era, but most significantly by a range of business opportunities and disruptive innovations.

These narratives might also be understood as socio-technical imaginaries, a concept developed in the late 2000s by sociologists of science and technology Sheila Jasanoff and Sang-Hyun Kim (2015) as an approach to understanding the relations between scientific and technological projects (such as space activities for instance) and political institutions, policymaking, and power (for example space agencies or space law). The concept has been applied to understand institutions from the perspective of cultural meanings, specifically, how technoscientific projects are imbued with implicit understandings of what is desirable, where collective social values influence the design of space activities which in turn reflect normative

commitments and convey particular understandings of space, and investments in space. Most importantly, as Ruja Benjamin asserts “visions of development and progress are too often built upon forms of social and political subjugation that require upgrading in the form of novel techniques of classification and control. When scholars set out to study the values, assumptions, and desires that shape science and technology, we must also remain attentive to the racial anxieties and fears that shape the design of technoscience” (Benjamin 2016: 149).

But imagination “is a contested field of action” Ruha Benjamin (2020) observes. These mainstream frames in stories and imaginaries that evidence a modern space age have been developed and reproduced, in effect, against other, older, vibrant, vital, collective stories of outer space, which have rarely been considered in the provision of expert evidence and which are crucial for enhancing public debate and reasoning about the contemporary NewSpace environment. Today, a vast and diverse body of work by First Nations scholars for instance, is showing how Indigenous storytelling is a process of decolonisation (Mita 2000), of “assertive self-determination” (Behrendt 2019), of “truth-telling” (Bodkin-Andrews et al. 2022), of “survivance”, where storytelling, as “narratives of Native presence” (Vizenor 2008), becomes a way of overcoming the lived experience of tragedy, dominance, and victimhood.

The purpose of this synthesis document is to map an outline of some of these “other”, non-mainstream and counter-narratives of outer space, to experiment with imagining otherwise as to paraphrase Lola Olufemi (2021). This is critical for opening up public reasoning at a time when humans reach for the starts with a series of very concrete plans for the next twenty years, when storylistening becomes crucial to resist and rethink normalised narratives of the inevitability of humans becoming a multiplanetary species, not only as an American manifest destiny in outer space (Sage 2008), but now a global corporate manifest destiny. It is of utmost importance to expand our understanding of what other stories, how storymaking otherwise, constitute forms of “evidence”, how they could inform policymaking beyond scientific facts and models, enable novel conversations about the public value of outer space, and spark a deeper dialogue about more diverse future uses of space.

The value of storymaking is contemplating at things from different angles. Indeed, as Barney and Vemuri contend “stories are tools of immense possibility that provide powerful means of creating different worlds and making new futures, and of seeing the present in new ways (2022: n.p). For Mariana Mazzucato, it is understood that value emerges from the interaction of the public and private sectors and civil society (Mazzucato 2021: 165). A starting premise for this synthesis paper is therefore that the value of the space sector in the UK, and indeed internationally, ought to be co-created as a collective process that emerges from open forms of discussion and debate. From widening our repertoire for storymaking and storylistening.

The synthesis paper is divided into five short sections. The first one starts reference to processes of storymaking and how these relate to theories of storylistening. The next section provides a short critical engagement with what might be called NewSpace narratives and socio-technical imaginaries. The third section moves onto space environmentalism and the critique of the enclosure of outer space futures; and the fourth section delves into Black and Indigenous futurisms and narratives of outer space.

Storymaking outer space: a poetics of tomorrowing

In a short essay from 1986 titled “The Carrier Bag Theory of Fiction”, author Ursula K. Le Guin speculates on the very origins of storymaking in Palaeolithic cave walls to argue that stories of hunting became more important than those of gathering and harvesting because they not only had action, but also heroes. She complains that “we've all heard all about all the sticks spears and swords, the things to bash and poke and hit with, the long, hard things, but we have not heard about the thing to put things in, the container for the thing contained. That is a

new story". Le Guin proposes that we consider how "long before the useful knife and ax; right along with the indispensable whacker, grinder, and digger- with or before the tool that forces energy outward, we made the tool that brings energy home". The carrier bag.

Evidence of science fiction that has inspired real space exploration projects is abundant (Vertesi 2019). Mainstream TV shows such as Star Trek have influenced and inspired many space scientists and engineers, as well as space entrepreneurs. For Vertesi, these fictions "enable embedded commentary on the socio-political circumstances of technoscientific work: in essence, a form of lay social theorizing. Such fiction references therefore allow scientists and engineers to openly yet elliptically discuss their social, political, and interactional environment, all the while maintaining face as credible, impartial, technical experts" (2019: 135).

However, the kind of science fiction inspiring real-world space exploration endeavours is precisely the kind that Ursula K. Le Guin's speculative fiction theory goes against. It questions the phallic logic of the arrow, the spear (or the space rocket), to insist on a focus on "the carrier bag, the sling, the shell, or the gourd" as Siobhan Leddy (2019) observes. For Leddy "not only is the carrier bag theory plausible, it also does meaningful ideological work — shifting the way we look at humanity's foundations from a narrative of domination to one of gathering, holding, and sharing" (2019, n.p). Le Guin's theory of fiction is an invitation to practice storylistening, as a framework that concerns "the collective and the cognitive, rather than the individual and the empathetic, and recognises that stories are a form of sense-making in the face of complexity and uncertainty" (Dillon and Craig 2022: 22). For Dillon and Craig, a storylistening framework explains the core functions of stories: creating new points of view; understanding different collective identities; extending the range of models available for reasoning; and enabling new anticipations of the future. In previous work I have used the notion of "poetics of tomorrowing" (Salazar 2017; Salazar 2023) to refer to the processes of storymaking futures through re-storying and counterimagining. Poetics understood as a process of making (poiesis) and storying futures and integral for raising questions about the prospects of collective futuring practices as a process of reclaiming imagination, at a time when reciprocity in research relations has come under well-deserved scrutiny or even plain refusal.

Therefore, storylistening otherwise is of critical importance for when new stories of outer space need to be told and be listened to, and when older deeper, more vibrant stories must be recognised and brought to the fore. They are important and needed to provide an alternative to those prevalent stories which only focus on heroes and their actions of exploring, thrusting, hunting, colonizing, extracting, and killing.

In effect, as Lou Cornum warns, "**n**ot all encounters with the other must end in conquest, genocide or violence… We so not travel to the distant reaches of space in order to plant our flags or act under the assumption that every planet in our sights is terra nullius waiting for the first human footprint to mark its surface". For Le Guin it is ultimately necessary to avoid the "linear, progressive, Time's- (killing)-arrow mode of the Techno-Heroic" to redefine technology and science as a "primarily cultural carrier bag rather than weapon of domination".

In dominant, popular, Western narratives, whether in science, cinema, literature, or NewSpace, the story of outer space is one of colonisation. One needn't look too far for examples. Take for instance the US alternative history and science fiction TV series *For All Mankind* (Apple TV), whose title is inspired by the lunar plaque left on the moon by the astronauts of Apollo 11. In this alt-history story, the US built in 1983 a moon base named Jamestown. The literal reference here is to the Jamestown settlement in the Colony of Virginia in the early 1600s, which was the first permanent English settlement in today's US —an obvious embracing of the spirit of settler-colonialism now exported into outer space.

Astronomer Lucianne Walkowicz puts it so eloquently:

> "Human imaginings of outer space are stories told by shadow puppets: in the foreground, our material present is held up to the light as is or bent into the many shapes of hope and desire. Space, its infinite depths flattened by our perspective from Earth, functions as the projection screen onto which these long shadows are cast. Thus, while imaginings of our space futures might seem insubstantial, we must remember that they take their shape from the very concrete project of world-building in the here and now, which in turn has its roots in history" (Walkowicz 2023: xv).

This is further strengthened by narrative evidence from Kimberley Mckinson reflecting on NewSpace narratives of space glory, during the SpaceX Crew Dragon launch in May 2020 days after the killing of George Floyd, where she recalls a strangely familiar juxtaposition of images she felt at Cape Cañaveral, when Americans "were being ushered to look to the stars to imagine the utopic future of humankind in space, while in the streets, they were confronting the country's dystopic underbelly of anti-Black racism". This is echoed by narrative evidence from others for whom the Black Lives Matter protests in 2020, which took place while NASA celebrated a historic achievement, were reminiscent of the Apollo era, when in 1969, civil rights protesters marched outside the Kennedy Space Center the day before Apollo 11 launched to the moon (Werner and Henry 2020).

NewSpace Narratives

NewSpace is a term that emerged in the late 1990's and was arguably first used by US-based Space Frontier Foundation founder Rick Tumlinson (Berinstein 2002), who was also *founder of SpaceFund, Earthlight Foundation, and New Worlds Institute.* Tumlinson has described this new current era of space endeavours in the 2020's as a "NewSpace Age" (Tumlinson 2023), which is often characterised by a shift from an industry heavily dependent on government agencies competing for technological prowess and prestige, to an arguably more agile private sector driven by innovation, commercialisation, operations optimization, and market disruptions. This is further described by lowering the barriers to space industries, providing cheaper access to space, and data from space for the benefit of scientists, venture capital start-ups, and, arguably, the general public. However, they also entail detailed plans for space mining, space tourism and private space stations and gateways. NewSpace narratives also embody an approach that focuses on the 'democratisation of space' characterised by the rise of public-private partnerships, and the intensification of global competition from new space-faring countries.

David Valentine (2012) observed in his genealogy of NewSpace how despite the industry's diversity, they are united by a common—and apparently extreme—vision of the future and of capitalism: that entrepreneurial activity will radically and positively transform the future evolution of society and of our species itself by establishing human settlements in the solar system and beyond. (p. 1047). For Valentine (2012) beyond the possibilities for new forms of capital investment and profit enabled by NewSpace commercial space enterprise, it is the narrative of the promise of a radically transformed human social future that underwrites NewSpace discourses and activities (p. 1049).

In a recent Op-Ed, Tumlinson (2023) writes:

> "without exaggeration, I am talking about something even more transformative than the first airplanes, cars, trucks, railroads, or steamships. It sounds a bit frothy for me to say so, but if SpaceX or someone else perfects 100 percent clean, fully reusable spaceships, it will be like combining all those breakthroughs with the first fish to climb

> onto dry land and survive. The breakout of humanity and life into the universe will have begun".

As Lisa Messeri posited in her landmark book *Placing Outer Space*, we seek to understand "what the cosmos can tell us about ourselves" (2016: 16). But this 'ourselves' needs to be unpacked and undone to acknowledge ongoing questions towards a dismantling of colonialism, racism, patriarchy, and ableism in outer space affairs. NewSpace is a narrative framing for a common system for, and vision of, how "we all" should make use and make meaning of outer space, through a very narrow set of codified morals of technoutopianism and astrocapitalism (Salazar 2023). As Audra Mitchell observes, the visions outlined by NewSpace entrepreneurs to colonise outer space have important implications for human security and will likely have profound impacts in terms of gender, race, the vulnerability of migrants and workers, and the rights of Indigenous peoples (Mitchell 2018). As Gál and Armstrong (2023) and Szolucha (2023) also argue, NewSpace sites, such as SpaceX's in Boca Chica, Texas, USA, or Rocket Lab's Aotearoa New Zealand Māhia Peninsula launch range, also draw significant challenges and have drawn criticism from local communities, whether it is about the dual-use of technology being used into space, or the environmental impacts of these space sites, "highlighting the tensions of communities with colonial-capitalist expansionist space science environments" (Gál and Armstrong 2023: 159). Valerie Olson in turn, has shown how dominant outer-space narratives in the US are enacted by highlighting limits and extremes, where space itself denotes "not a spatial limit but a political horizon" (2018: 28). For Natalie Treviño the future that mostly US-centric space advocates envision simply reproduces the norms, systems, and myths of oppression and violence of the European colonial order. This cosmic order separates nature from humanity, enforces a hierarchy of humans, and renders nature, and those denied personhood, fully exploitable (Treviño 2023; Salazar and Gorman 2023). Michael Oman-Reagan (2017) has pointed out that "as venture capitalist space entrepreneurs and aerospace contractors compete to profit from space exploration, we're running up against increasingly conflicting visions for human futures in outer space".

The enclosure of outer space futures

The notion of enclosure is a term that comes from English landownership and is often understood in relation to the appropriation of common land for private purposes in Europe during the Middle Ages. By enclosing the land, commoners are deprived of their rights of access and privilege, leading to dispossession. The erosion of the commons has also been applied to outer space now that the Outer Space Treaty of 1967 has come under pressure from a new wave of legal instruments, such as the United States

As an established body of work on the geopolitics of outer space has shown, outer space has been subject to a futural mode of neoliberal and globalising capitalism (Ortner 2016). Oliver Dunnett et al. (2019) calls it astrocapitalism, a dominant political and economic narrative—determined by forces of capital, extractivism, and profit and the enclosure of outer space (Jones 2021).

As has been extensively documented, the notion of extractivism emerges in the mid 2000's in the work of several Latin American scholars and activists, in part, as the other side of the coin of the notion of Buen Vivir. It appears in the wake of the commodities boom of the late 1990's and early 2000's; in the context of neoliberal globalization leading to extensive deregulation, liberalization, privatisation on the back of broad support and embrace of the Washington Consensus, and on the wake of reforms in the 1980s and 1990s by the World Bank and the International Monetary Fund which promoted a redefinition of the state as a meta-regulatory

actor, leaving extractivist activities, its regulation, and the appropriation of profits to private capital.

In parallel to the neoliberal reorganization of the late 1990's and the commodities boom of the time, and certainly not coincidentally, we see the emergence of NewSpace and the inexorable rendering of outer space as new resource frontier. The proposed extraction of minerals from near-Earth asteroids and the Moon in anticipation of a future space economy and even settlements beyond the upper atmosphere, became in this same period, an area of research investment, technological development, and capital speculation. Cait Storr (2021) has observed how much extant literature on space resource extraction is industry-captured and presumes the astrofuturist premise: that expansion of the geophysical domain of natural resource commodification is not only inevitable, but a desirable, capital-driven solution to both resource conflict and planetary limits. For Storr (2021), the advent of a commercially dominated regime for regulating space resource extraction signals neither an escape from terrestrial jurisdiction nor a failure of international law, but a predictable evolution of its expansionist logic. From this perspective, the contemporary jostling over the legal regime that should govern space mining is less a sideshow to the main event of compounding environmental and economic crisis, than a symptom of a systemic counter-response to that crisis which perpetuates the extractivist imaginary that produced it.

Dunnett (2023) has described how studies "attuned to broader geographies of empire and colonial enclosure have highlighted modes of local resistance to outer-space projects, their harmful impacts in specific communities, and their extended global networks of power" (p. 85). In this context technoutopian visions of human expansion into space have been torqued toward explicitly privatised, capitalist, and extractivist narratives which are in varying degrees utopian and dystopian. The proposed extraction of minerals from near-Earth asteroids and the Moon (off-Earth mining), in anticipation of a future space economy and even settlements beyond the upper atmosphere, is widely being regarded as an emerging area of research investment, technological development, and capital speculation (Kearnes and van Dooren 2017). For Julie Klinger this invokes the concept of the frontier as being key to understanding why it is that we are eager to conduct mining on celestial bodies including the Moon. For space archaeologist Alice Gorman "the colonial aspects of space exploration are a mirror of those same aspirations played out on Earth", enacted through processes of imaginative framing, experimentation, and enclosure (Gorman 2005: 99). Narrative evidence paints a picture in which, as Matthew Weinzierl starkly puts it, "even an established, efficient space marketplace offers no guarantee that the pursuit of private priorities in space will serve the public or respect the public's ethical judgments. Some questions lie outside the natural scope of economists (for example, with regard to our moral responsibility to preserve outer space as we find it). But if we fail to exert oversight over the space economy, its legitimacy—and thus its success—will be undermined" (Weinzierl 2018: 173).

In a similar vein, Craig Jones (2021) observes how the 'NewSpace economy' seeks to legitimise extractivist efforts "not only through the physical and legislative enclosure of Outer Space but [also] through the enclosure of imaginative spaces … through process(es) of disimagination" (n.p.). This is what Jaramillo and Carmona (2022) call 'temporal enclosures' to "describe corporate strategies that give rise to what we call *temporal enclosures*, the process by which mining companies aim to restrict imaginable outcomes to those that favour them, producing the sense of a manageable and inescapable future in which forthcoming activities are presented as both inevitable and desirable" (p. 11). In other words, NewSpace narratives provide not only topos but also as chronos of production of capitalist value. Anthropologists David Valentine and Amelia Hassoun (2019) have discussed the perils that neoliberal capitalism pervades contemporary attempts at theorising futurity. By developing an

anthropological theorisation of futures, they call for temporal multiplicities and collective future imagining—temporal pluralisation, or an opening up of futures.

Space environmentalisms

Writing in 1969 and reflecting on the initial Apollo images and the first humans to walk on the Moon, Allen Ginsberg observed that "No Science Fiction expected this Globe-Eye Consciousness". Soon after, Earth Day took place for the first time –on April 22nd, 1970. It came to materialize an emerging planetary consciousness, fuelled by the vitality of anti-war and civil rights movements, where environmental concerns took centre stage for the first time. Some of the first images to illustrate this new awareness of a 'global environment' -which later became an icon exhausted by the environmentalist movement in the global north during the 1970's and 1980's - were the famous images taken by the Apollo missions. First, the 1968 image of the Earth rising on the Moon's horizon - taken by the Apollo 8- but most notoriously, the most famous image of the 'blue marble' taken by the Apollo 17 crew in 1972. In fact, these images opened up for the first time a path for a new kind of planetary imagination, a new form of planetary consciousness which took on a new dimension once the planet was able to be 'seen' from afar; from outer space; a planetary disposition that computer imaging - also since the 1970's – has been able to powerfully convey through modelling and visualization of a global ecology (Salazar 2015). As environmental cultural studies scholar Ursula K. Heise points out, these images provide "an apt metaphor for a cultural moment in which an entire planet becomes graspable as one's local backyard" (Heise, 2008: 4).
As we have argued elsewhere (Granjou, Walker and Salazar 2017) around the same time of the Apollo Missions, the rise of futures studies, roughly around the formation of the World Futures Studies Federation (WFSF) in 1967 and coinciding with the launch of the journal *Futures* in 1968, was intricately connected to the emergence and development of a dialectical and inter-twined relationship: that is, between technologies of environmental forecasting, and techniques of anti-environmentalist anticipation and political intervention. Some of the most substantial early investments in futures methodology, and indeed in anticipatory environmental science, were made by transnational fossil-fuel corporations. Classic is the work by Royal Dutch Shell at the time, when quantitative, computer-driven planning was very much in vogue, and they started experimenting in 1967 with a different way of looking into the future: scenario planning.

In recent years, as the environmental impacts of the new space age are becoming visible, important narratives of space environmentalism have emerged (Marino 2023; Lawrence et al. 2022; Olson 2018; Dovey 2021). Some of these are interested in engagements with "radical new ways of world-making and a reimagination of the planet as embedded in a wider space ecology" (Battaglia et al. 2015). As Dovey asserts, "the growing sophistication of environmental ethics frameworks means that many of us now understand that nature—whether on Earth or off-Earth—has intrinsic worth and the right to exist outside of any use-benefit it may bring to humans" (2021). Other narratives are presenting evidence that calls for more adequate governance and protection of outer space environments as fundamental to the building of more sustainable futures (Marino and Cheney 2023). Lawrence et al. put forward the case for the orbital space around the Earth to be considered as "an additional ecosystem, subject to the same care and concerns, and the same broad regulations as the oceans and the atmosphere" (2022: 428). Recent work has also posited question to astrobiology to widen their remit beyond the call to preserve pristine extraterrestrial environments from earthly contamination to "engage with anti-imperialism and sustainability in space research and activities (Marino 2023). For Marino (2023) a dialogue between astrobiology and points of view from postcolonial, decolonial, and critical Indigenous studies are critical to "rethink mainstream images and maps of outer space environments, as well as

the relationships and practices that bring them into being" (279) as well as for addressing the "shortcomings of existing legal instruments, and the possibility to reform them to place environmental concerns at their core" (Marino and Cheney 2023). In this line Lisa Messeri has shown how exoplanet astronomy's search for habitable planets is a reflection of nostalgic, colonial desires to recover Earth's original Eden but elsewhere in the solar system, at a moment in time when "the prospect of repairing our own planet is daunting" (2017: 333). And as Elizabeth Kessler (2012) illustrates, how space sciences construct a notion of a cosmic environment is shaped by already existing aesthetic norms and narratives fashioned by the representation of the US's 'American West' trope (Gál and Armstrong 2023).

Evidence is mounting about the harmful environmental impacts of rocket launches. Eloise Marais estimates that harmful environmental impacts would need to exceed 100 launches per year. The number of launches since 2020 already exceeds this figure. In fact, in May 2023 a coalition of environmental groups filed a sue against the U.S. Federal Aviation Administration (FAA), for failing to fully anticipate the environmental damage that SpaceX's Starship vehicle arguably caused to fragile ecosystems and lands (Wall 2023).

The contemporary space age presents an important political ecological predicament where the climate emergency and collapse of major ecosystems appears to be fuelling a 'space rush' where some space entrepreneurs promote space colonisation as capitalism's ultimate "spatial fix" (Dickens and Ormrod 2007: 49) and as a response to planetary environmental catastrophe (Valentine 2012; Marino 2023). Marino argues that "discourses on environmentalism in outer space are endorsing these images of nature, possibly with little awareness of the long-standing and mounting critiques of environmentalist models that are steeped in narrowly western histories and understandings of nature" (2023: 285).

Indigenous and Black Futurisms

De Witt Douglas Kilgore (2003) has shown how "the exclusion of women and racial minorities from the pioneering astronauts corps of the 1950s and 1960s was a deliberate gesture". For Kilgore, creating a more inclusive futures in space relies on storytelling other kinds of "different stories about what going to space means for the development of human civilization and who might benefit…it need not be an endless extension of either nineteenth century imperialism or white supremacy" (Kilgore 2003).

In an article published in Nature which examines data on ethnic or racial diversity in science in different countries, Elizabeth Gibney presents evidence from the UK Higher Education Statistics Agency (HESA) two show how 0.6% of Britain's science professors are Black (160 of the 22,855 professors across all academic fields, and among those, just one-quarter are women) (Gibney 2023: 390). The international space community in recent years has recognised that the human future in space is not served well by the entrenchment of a white, heteronormative monoculture. In 2016 Social Studies of Outer Space the International Astronautical Federation developed the 3G platform (Geography, Generation, Gender) to address equality and diversity. Nonetheless, the pace of change is slow: the number of women in the space sector, for example, has not risen above 20% globally (and the number of Black and Indigenous women is considerably less). Planetary scientists and astronomers have also entered the debate with notable interventions in the field of the ethics of space observation and space exploration. Emily Martin et al. for instance, in the current context of expansion in private industry-led space exploration, argue that "as the population of Earth's orbital environment and human exploration of space intensifies, it is critical to have a strong ethical framework in place so that mistakes of the past are learned from and not repeated" (Martin et al. 2022: 641). For Frank Tavares et al. the planetary sciences must engage in a "robust

reevaluation" of how discussions about crewed and uncrewed missions to the Moon, Mars, and elsewhere in the solar system ought to "resist colonial structures" and their rootedness in the violence of colonialism that has served exploration off-Earth (Tavares et al. 2020). In their incisive work *The Disordered Cosmos*, astronomer Chanda Prescod-Weinstein (2021) shows how their cosmological work is in part a product of a form of settler colonialism that asserts control over territory by replacing its Indigenous population and manufacturing a disconnection of Indigenous knowledge from its larger cosmology. A growing number of scientists, artists, scholars, and activists alike are vigorously calling for a substantial and emancipatory shift in the way space exploration is spoken and written about (Walkowicz in Drake 2018). As Prescod-Weinstein puts it, "perhaps the way we think about the universe can still provide a way to step outside of our usual language and think abstractly about our society. We must have care in making this kind of move; there is always the potential for misrepresentation" (2021: 99).

The seminal work of Alondra Nelson (2000) was most influential to tackle mainstream hegemonic conceptions of a raceless future, with Afrofuturism exploiting culturally distinct approaches to technology and digital worlds. Sheree Renee Thomas has traced the origins of Afrofuturism in narratives that are more than a century old. In effect, "Afrofuturism is always alternate history", writes Sofia Samatar, not as in "singular History but … histories that are cultural, unstable, and contingent [and where] to propose an alternate history is to propose that history can be altered, to change directions, to inaugurate an alternate future" (Samatar 2017: 187). For Rasheedah Phillips, co-founder of Black Quantum Futurism collective, "Afrofuturist methodologies provide weapons for disrupting the messages that Black people won't survive into and thrive in the future(s)" (2020: 48). Phillips has produced notable work on how the concept of time has been weaponized, and specifically, how while the "settler colonial project is often referred to as one that successfully colonized space, it also necessarily involved a conquering of the temporal domain of the future" (Phillips 2021). In part, this colonisation of the future is not only spatial. Phillips notes how thinking or talking about the future "involves a spatialization of time", a process of "space-time mapping" where the future is preconceived spatially—near or far, but always in front" (2021).

Audra Mitchell and Aadita Chaudhury use the term BIPOC futurisms where they acknowledge the term BIPOC (Black, Indigenous, People of Colour) refers "to people and communities who self-identify as such or are assigned this label within the racial taxonomies imposed by ongoing (settler) colonialism, capitalism, and other Euro-centric projects of domination" (2020: 309). Craig Henry Jones uses Ethnofuturism an umbrella term to refer to a "process by and through which histories that deviate from the hegemonic 'norm' are reinvigorated and mobilised to (re)produce alternative discourses of futurity". Examples of such futurisms for Jones, include among others Afrofuturism, Aotearoa futurism, Cambrofuturism, and Sinofuturism. Josh Rios uses the term Chicanafuturism to discuss technologies of resistance as a "possible future return to the past. (2017: 59). Blaire Topash-Caldwell writes about Neshnabé Futurisms which "guide Native American ecologists, theorists, and activists in the Great Lakes region in mitigating and surviving ecological destruction of their homelands" (2020:3).

An increasing number of Native American scholars are engaging with some of the burning questions of the so-called Space Age in distinctive ways. Lou Cornum (2021) has written on Black and indigenous science fiction, showing how authors of colour use sci-fi to subvert a genre that has always been prone to reproducing colonial imaginaries. As Lou Cornum observes, it is crucial to recognise how science fiction by Black and Indigenous authors act as models of world building, and as a "theoretical elaboration of a concrete spacetime transformed from the here and now" (Cornum 2021). Black and Indigenous speculative fiction provides a mode of "decolonial speculation" (Cornum and Moynagh 2020) where paraliterary

genres outline a critique of temporality that "furthers the challenge to Eurochronology posed by the Black and Indigenous intellectual and creative traditions" (p. 12). Writing from the standpoint of the "colonizee", Cornum invokes a reversal of "the telescope's gaze of who is exploring who" (2015: n.p). This is not a mere literary trick, Cornum emphasises, "but a profound deconstruction of how we imagine time, progress, and who is worthy of the future" (2015: n.p). Or, as Cornum puts it otherwise: "In the colonial imaginary, indigenous life is not only separate from the present time but also out of place in the future, a time defined by the progress of distinctively western technology". "Why", Cornum wonders, "can't indigenous peoples also project themselves among the stars? Might our visions of the cosmos forge less harmful relationships than colonial visions of a final frontier, both here on Earth and beyond?" (Cornum 2015: n.p).

The state and its politics of recognition reproduce the colonisation of Indigenous imaginaries of time, temporality, and futures. As Kyle Powys Whyte eloquently demonstrates, "important emerging scholarship discusses how concepts and narratives of crises, dystopia, and apocalypse obscure and erase ongoing oppression against Indigenous peoples and other groups" (2018: 234). In the edited collection *Walking the Clouds*, Grace Dillon (2012) uses the term Indigenous futurisms to refer to science fiction works from a growing movement of First Nations authors and artists, mostly from North America, spanning literature, cinema, visual arts, and video games. For Dillon, Indigenous futurisms arise from an impulse to subvert what she terms "reservation realisms" as a category imposed on First Nations literatures. Relatedly, Michelle Raheja in *Reservation Reelism* (2011) has traced and outlined the notion of 'visual sovereignty' in a radical rethinking of Native cultural production in cinema and video in the United States. Raheja argues that cultural artists are providing nuanced and complex forms of self-representation against the powers of the state, while "imagining a futurity that militates against the figure of the vanishing Indian and engaging in visual sovereignty on virtual reservations of their own creation" (2011: 240). In the book *Spiral to the Stars: Mvskoke Tools of Futurity* Laura Harjo (2019) uses Mvskoke and Indigenous feminist epistemologies, conceptions of Indigenous space, place, and mapping in a community praxis of futurity, to outline the notion of "kin-space-time" constellations. This operates as a "pluriversal chronopolitics" (Salazar 2023) to overcome trauma and re-story memory and futures in spiral ways, connecting a past, present, and future.

Similarly, Bawaka Country has consistently shown how the colonial cosmologies of NewSpace "assume that there are no people or other beings Indigenous to 'outer space', and that there is no life there to harm" (2020: 2). They dispute that there is an 'outer' space separate from Earth where the harmful effects of extraction can be externalised and point out that the annexation of Indigenous lands and displacement of Indigenous peoples is enabled for the development of infrastructures and logistical projects that promote space exploration (Bawaka Country 2020).

Conclusions

The contemporary new space age is characterised by a re-emergence of space ambitions in the context of a proliferation and commercialization of space activities, that frames outer space as an essential part of every country's economic, social, and scientific progress. But, as space security becomes an increasingly salient policy issue, there is also an alarming build-up of counter-space capabilities worldwide (Secure World Foundation 2023). The tricky predicament for both governments and commercial operators in space is that outer space *is* a shared global commons, where the activities of any one country or company would end up having consequences and repercussions for all.

Outer space narratives continue to be the subject of techniques and practices that concretise an “uneven distribution of futurity” that signals “how the modern experience of futurity … has been conditioned by historically specific de-futuring practices that violently deny these same possibilities to the racialised Others of the modern Self” (Grove et al. 2022: 7).

Imagining space futures implies also thinking-with Earth, as a broad body of work and scholarship in feminist theory, critical Indigenous studies, and science and technology studies have shown, where scientific practices affect and are affected by questions of race, ethics, politics, and justice in the production and reproduction of social, political, and ecological imaginaries (Salazar and Gorman 2023).

This paper has aimed to synthesise an array of alternative narratives of outer space that diverge from mainstream and popular accounts of outer space exploration and settlement, and which ultimately stand in opposition to more influential narratives and imaginaries. It presents evidence of how mainstream narratives and modes of storytelling close down space futures and argue that a move to open the storymaking, storytelling and storylistening spectrum is required to canvass different futures in space.

References

After Oil Collective. 2022. *Solarities: Seeking Energy Justice*, edited by Ayesha Vemuri and Darin Barney. Minneapolis: University of Minnesota Press.

Aït-Touati, Frédérique. 2011. *Fictions of the Cosmos*. Chicago: Chicago University Press.
Aït-Touati, Frédérique. 2019. “Récits de la Terre.” *Critique, Vivre Dans un Monde Abîmé*, 1 (860–61): 5–16.

Battaglia, Debbora, David Valentine, and Valerie Olson. 2015. “Relational space: An earthly installation. *Cultural Anthropology*, 30(2): 245-256.

Bawaka Country (including A. Mitchell et al.). 2020. “Dukarr Lakarama: Listening to Guwak, Talking Back to Space Colonization.” *Political Geography* 81: 102218.

Behrendt, Larissa. 2019. “Indigenous Storytelling: Decolonizing Institutions and Assertive Self-Determination: Implications for Legal Practice.” In *Decolonizing Research: Indigenous Storywork as Methodology*, edited by Jo-Ann Archibald, Q’um Q’um Xiiem Archibald, Jenny Bol Jun Lee-Morgan and Jason De Santolo, 175–86. London: ZED Books.

Benjamin, Ruha. 2016. Catching our breath: critical race STS and the carceral imagination. *Engaging Science, Technology, and Society*, 2: 145-156.

Benjamin, Ruha. 2020. “Race to the Future? Reimagining the Default Settings of Technology and Society,” Mossman Lecture, McGill University, Montreal, October 28.
Berinstein, Paula. 2002. *Making Space Happen: Private Space Ventures and the Visionaries Behind Them*. Medford, NJ: Plexus Publishing.

Bodkin-Andrews, Gawaian, Shannon Foster, Aunty Frances Bodkin, Uncle John Foster, Uncle Gavin Andrews, Aunty Karen Adams, Uncle Ross Evans, and Bronwynn Carlson. 2022. “The colonial storytelling of good intent: Or the inspired erasure of our ancestors?”, *Griffith Review* 75: 110-122.

Cornum, Lou. 2015. “The Space NDN’s Star Map.” *New Inquiry*, January 26.

Cornum, Lou. 2021. “Skin Worlds: Black and Indigenous Science Fiction Theorizing Since the 1970s.” PhD Dissertation, City University of New York. https://academicworks.cuny.edu/gc_etds/4422.

Cornum, Lou, and Maureen Moynagh. 2020. “Introduction: Decolonial (Re) Visions of Science Fiction, Fantasy, and Horror.” *Canadian Literature* 240: 8–18. https://doi.org/10.14288/cl.vi240.

Craig, Claire and Sarah Dillon. 2023. “‘Storylistening’ in the science policy ecosystem”. *Science*, 379 (6628): 134-136.

Dickens, Peter, and James Ormrod. 2007. *Cosmic Society: Towards a Sociology of the Universe*. London: Routledge.

Dillon, Grace. 2012. *Walking the Clouds: An Anthology of Indigenous Science Fiction*. Phoenix, AZ: University of Arizona Press.

Dillon, Sarah. and Claire Craig. 2022. “Storylistening: A case study in how to include the humanities in evidence provided for public reasoning”. *Journal of the British Academy*, 10: 21-28.

Drake, Nadia. 2018. “We Need To Change the Way We Talk about Space Exploration.” *National Geographic*, 10 November. https://www.nationalgeographic.com/science/article/we-need-to-change-way-we-talkabout-space-exploration-mars.

Dovey, Ceridwen. 2021. “Making Kin with the Cosmos”. https://humansandnature.org/making-kin-with-the-cosmos/

Dunnett, Oliver, Andrew S. Maclaren, Julie Klinger, K. Maria D. Lane, and Daniel Sage. 2019. “Geographies of Outer Space: Progress and New Opportunities.” *Progress in Human Geography* 43 (2): 314–36. https://doi.org/10.1177/0309132517747727.

Dunnett, Oliver. 2023. “The Spaces of Outer Space”. in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 84-92. London and New York: Routledge.

Frigg, Roman. 2010. “Fiction and Scientific Representation.” In *Beyond Mimesis and Convention: Representation in Art and Scienc*e, edited by Roman Frigg and Matthew Hunter, 97–138. Dordrecht, The Netherlands: Springer.

Gál, Réka Patricia and Eleanor Armstrong. 2023. “Feminist Approaches to Outer Space: Engagements with Technology, Labour, and Environment”, in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 158-172. London and New York: Routledge.

Gibney, Elizabeth. 2022. How UK science is failing on diversity. *Nature*, 612: 390-395.

Ginsberg, Allen. 1972. “In a Moonlit Hermit’s Cabin”. In *The Fall of America: poems of these states 1965-1971*. San Francisco: City Lights Books.

Gorman, Alice. 2005. “The Cultural Landscape of Interplanetary Space.” *Journal of Social Archaeology* 5 (1): 85–107. https://doi.org/10.1177/1469605305050148

Granjou, Céline, Jeremy Walker and Juan Francisco Salazar. 2017. The politics of anticipation: On knowing and governing environmental futures. *Futures*, 92, pp.5-11.

Grove, Kevin, Lauren Rickards, Ben Anderson, and Matthew Kearnes. 2022. “The Uneven Distribution of Futurity: Slow Emergencies and the Event of COVID-19.” *Geographical Research* 60 (1): 6–17.

Harjo, Laura. 2019. *Spiral to the Stars: Mvskoke Tools of Futurity*. Tucson, AZ: University of Arizona Press.

Heise, Ursula K. 2008. *Sense of Place and Sense of Planet*. New York: Oxford University Press.

Jaramillo, Pablo, and Susana Carmona. 2022. "Temporal enclosures and the social production of inescapable futures for coal mining in Colombia." *Geoforum* 130: 11-22.

Jasanoff, Sheila and Kim, S. H. 2015. (Eds). *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power.* Chicago: University of Chicago Press.

Jones, Craig Henry. 2021. “Enclosing the Cosmos: Privatising Outer Space and Voices of Resistance.” Society + Space Magazine, 24 May 2021. https://www.societyandspace.org/articles/enclosing-thecosmos-privatising-outer-space-and-voices-of-resistance.

Kilgore, De Witt Douglas. 2003. *Astrofuturism: Science, Race, and Visions of Utopia in Space*. Philadelphia, PA: University of Pennsylvania Press.

Klinger, Julie Michelle. 2021. “Environmental Geopolitics and Outer Space.” *Geopolitics* 22 (3): 666–703. https://doi.org/10.1080/14650045.2019.1590340.

Lawrence, Andy, Meredith L. Rawls, Moriba Jah, Aaron Boley, Federico Di Vruno, Simon Garrington, Michael Kramer, Samantha Lawler, James Lowenthal, Jonathan McDowell & Mark McCaughrean. 2022. The case for space environmentalism. *Nature Astronomy* 6: 428–435. https://doi.org/10.1038/s41550-022-01655-6

Leddy, Siobhan. 2019. “We should all be reading more Ursula Le Guin”. The Outline. https://theoutline.com/post/7886/ursula-le-guin-carrier-bag-theory

Le Guin, Ursula K. 1989. *Dancing at the Edge of the World: Thoughts on Words, Women, Places*. 1st ed. New York, NY: Grove Press.

Lempert, William. 2014. “Decolonizing Encounters of the Third Kind: Alternative Futuring in Native Science Fiction Film.” *Visual Anthropology Review* 30 (2): 164–76. https://doi.org/10.1111/var.12046.

Kearnes, Matthew, and Thom van Dooren. 2017. “Rethinking the Final Frontier: Cosmo-Logics and an Ethic of Interstellar Flourishing.” *GeoHumanities* 3 (1): 178–97. https://doi.org/10.1080/2373566X.2017.1300448

Martin, Emily C., Lucianne Walkowicz, Erika Nesvold, and Monica Vidaurri. 2022. “Ethics in Solar System Exploration.” *Nature Astronomy* (6): 641–42. https://doi.org/10.1038/s41550-022-01712-0.

McKinson, Kimberley D. 2020. “Do Black Lives Matter in Outer Space?” *Sapiens.* https://www.sapiens.org/culture/space-colonization-racism/

Marino, Alessandra. 2023. “Reconstellating Astroenvironmentalism: Borders, Parks and other Cosmic Imaginaries”, in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 280-292. London and New York: Routledge.

Marino, Alessandra, and Thomas Cheney. 2023." Centring Environmentalism in Space Governance: Interrogating Dominance and Authority Through a Critical Legal Geography of Outer Space. *Space Policy*, 63, p.101521.

Mazzucato, Mariana. 2021. *Mission economy: A moonshot guide to changing capitalism*. London: Penguin.

Messeri, Lisa. 2016. *Placing Outer Space: An Earthly Ethnography of Other Worlds*. Durham, NC: Duke University Press.

Messeri, Lisa. 2017. "Gestures of Cosmic Relation and the Search for Another Earth." *Environmental Humanities* 9 (2): 325–40. https://doi.org/10.1215/22011919-4215325.

Mita, Merata. 2000. "Storytelling: A Process of Decolonisation." In *The Journal of Puawaitanga, Special Issue: Indigenous Women and Representation*, edited by Leonie Pihama, 7–9. Auckland: The University of Auckland.

Mitchell, Audra. 2018. "Outer Space." In *Security Studies: An Introduction*, 3rd edition, edited by Paul D. Williams and Matt McDonald, 569–82. London and New York: Routledge. https://doi.org/10.4324/9781315228358-39.

Mitchell, Audra. 2019. "Can International Relations Confront the Cosmos?" In *Routledge Handbook of Critical International Relations*, edited by Jenny Edkins, 51–64. London and New York: Routledge.

Mitchell, Audra, and Aadita Chaudhury. 2020. "Worlding Beyond 'the' 'End' of 'the World': White Apocalyptic Visions and BIPOC Futurisms". *International Relations* 34 (3): 309–32. https://doi.org/10.1177/00471178209489.

Nelson, Alondra. 2000. "Braving the New World—AfroFuturism: Beyond the Digital Divide." In *Race and Public Policy*, edited by Makani Themba, 37–40. Oakland, CA: Applied Research Center.

Nelson, Alondra. 2002. "Introduction: Future Texts." *Social Text* 20 (2 (71)): 1–15. https://doi.org/10.1215/01642472-20-2_71-1.

Olson, Valerie. 2018. *Into the Extreme: US Environmental Systems and Politics Beyond Earth.* Minneapolis: University of Minnesota Press.

Olson, Valerie. 2023. "Refielding in More-Than-Terran Spaces", in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 33-44. London and New York: Routledge.

Olufemi, Lola. 2021. *Experiments in Imagining Otherwise*. London: Hajar Press.

Oman-Reagan, Michael P. 2017. "Queering Outer Space." SocArXiv, Open Science Framework. Manuscript, submitted 22 January 2017. https://osf.io/preprints/socarxiv/mpyk6/.

Ortner, Sherry B. 2016. "Dark Anthropology and Its Others: Theory Since the Eighties." HAU: *Journal of Ethnographic Theory* 6 (1): 47–73. https://doi.org/10.14318/hau6.1.004.

Phillips, Rasheedah. 2019. "The Nowness of Black Chronopolitical Imaginaries in the Afro/Retrofuture." *The Funambulist* (24), 19 June. https://thefunambulist.net/magazine/24-futurisms/nowness-black-chronopolitical-imaginaries-afro-retrofuture-rasheedah-phillips.

Phillips, Rasheedah. 2020. “Communal, Quantum & Afrofutures: Time & Memory in North Philly.” In *Space-Time Collapse II: Community Futurisms*, edited by Black Quantum Futurism, 10–51. Philadelphia, PA: The Afrofuturist Affair/House of Future Sciences Books.

Phillips, Rasheedah. 2021. “Counter Clockwise: Unmapping Black Temporalities from Greenwich Mean Timelines.” *The Funambulist* (36), 21 June. https://thefunambulist.net/magazine/they-have-clocks-wehave-time/counter-clockwise-unmapping-black-temporalities-from-greenwich-mean-timelines.

Raheja, Michelle H. 2011. *Reservation Reelism: Redfacing, Visual Sovereignty, and Representations of Native Americans in Film*. Lincoln, NE: University of Nebraska Press.

Sage, Daniel. 2008. “Framing Space: A Popular Geopolitics of American Manifest Destiny in Outer Space.” *Geopolitics* 13 (1): 27–53.

Salazar, Juan Francisco. 2015. “Science/Fiction: Documentary Film and Anticipatory Modes of Futuring Planetary Change”, in *Companion to Contemporary Documentary Studies* edited by A. Lebow and A. Juhasz (eds), 43–60. Malden, MA and Oxford: Wiley-Blackwell.

Salazar, Juan Francisco. 2017. “Speculative Fabulation: Researching Worlds to Come in Antarctica.” In *Anthropologies and Futures*, edited by Juan Francisco Salazar, Sarah Pink, Andrew Irving and Johannes Sjöberg, 151–70. London and New York: Bloomsbury.

Salazar, Juan Francisco. 2023. “A Chronopolitics of Outer Space: A Poetics of Tomorrowing”, in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 142-154. London and New York: Routledge.

Salazar, Juan Francisco, Paola Castaño. 2022. *Framing the Futures of Australia in Space: Insights from Key Stakeholders*. Parramatta: Western Sydney University.

Salazar, Juan Francisco, and Alice Gorman. 2023. *Routledge Handbook of Social Studies of Outer Space*. London and New York: Routledge.

Samatar, Sofia. 2017. “Toward a Planetary History of Afrofuturism.” *Research in African Literature*s 48 (4): 175–91. https://doi.org/10.2979/reseafrilite.48.4.12.

Secure World Foundation. 2023. *Global Counterspace Capabilities Report*. https://swfound.org/media/207567/swf_global_counterspace_capabilities_2023_v2.pdf

Smiles, Deondre. 2020. “The Settler Logics of (Outer) Space.” Society+Space, 26 October 2020. https:// www.societyandspace.org/articles/the-settler-logics-of-outer-space.

Smiles, Deondre. 2023. “Anishinaabeg in Space”, in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 251-262. London and New York: Routledge.

Squire, Rachael, Oli Mould, and Peter Adey. 2021. “The Final Frontier? The Enclosure of a Commons of Outer Space.” Society and Space Magazine. Accessed 31 May 2022 at https://www.societyandspace.org/forums/the-final-frontier-the-enclosure-of-a-commons-of-outer-space.

Storr, Cait. 2021. ‘Space is the Only Way to Go’: The Evolution of the Extractivist Imaginary of International Law. *Routledge Handbook of International Law and the Humanities*, 295, p.300.

Szolucha, Anne. 2023. “Planetary Ethnography in a “SpaceX Village”: History, Borders, and the

Work of “Beyond”, in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 71-83. London and New York: Routledge.

Tavares, Frank, Denise Buckner, Dana Burton, Jordan McKaig, Parvathy Prem, Eleni Ravanis, and Natalie Treviño, et al. 2020. “Ethical Exploration and the Role of Planetary Protection in Disrupting Colonial Practices.” Arxiv preprint, arXiv:2010.08344. https://doi.org/10.48550/arXiv.2010.08344.

Topash-Caldwell, Blaire K. 2020. *Neshnabé Futurisms: Indigenous Science and Eco-politics in the Great Lakes.* PhD Dissertation, University of New Mexico.

https://digitalrepository.unm.edu/anth_etds/200.

Treviño, Natalie. 2023. “Coloniality and the Cosmos”, in *Routledge Handbook of Social Studies of Outer Space*, edited by Juan Francisco Salazar and Alice Gorman, pp 225-237. London and New York: Routledge.

Tumlinson, Rick. 2023. “Missing the moment history happens: The media and 'NewSpace'”. Space.com. https://www.space.com/newspace-media-missing-the-moment

Tutton, Richard. 2018. “Multiplanetary Imaginaries and Utopia: The Case of Mars One.” *Science, Technology, & Human Values* 43 (3): 518–39. https://doi.org/10.1177/0162243917737366.

Tutton, Richard. 2021. “Sociotechnical Imaginaries and Techno-Optimism: Examining Outer Space Utopias of Silicon Valley.” *Science as Culture* 30 (3): 416–39. https://doi.org/10.1080/09505431.2020.1841151.

Valentine, David. 2012. “Exit Strategy: Profit, Cosmology, and the Future of Humans in Space.” *Anthropological Quarterly* 85 (4): 1045–67. http://doi.org/10.1353/anq.2012.0073.

Valentine, David, and Amelia Hassoun. 2019. “Uncommon Futures.” *Annual Review of Anthropology* 48 (1): 243–60. https://doi.org/10.1146/annurev-anthro-102218-011435.

Van Dooren, Thom. and Deborah Bird Rose. 2012. Storied-places in a multispecies city. *Humanimalia*, 3(2), pp.1-27.

Vertesi, J., 2019. “All these worlds are yours except…”: Science Fiction and Folk Fictions at NASA”. *Engaging Science, Technology, and Society*, 5: 135-159.

Vizenor, Gerald, ed. 2008. Survivance: Narratives of Native Presence. Lincoln: University of Nebraska Press.

Wall, Mike. 2023. “Environmental groups sue FAA over SpaceX Starship rocket”. Space.com. https://www.space.com/spacex-starship-rocket-environmental-groups-sue-faa

Weinzierl Matthew. 2018. “Space, the Final Economic Frontier”, *Journal of Economic Perspectives* 32(2): 173–192.

Werner, Debra and Caleb Henry. 2020. “How the space sector is responding to the killing of George Floyd”. SpaceNews. https://spacenews.com/how-the-space-sector-is-responding-to-the-killing-of-george-floyd/

Whyte, Kyle Powys. 2018. “Indigenous science (fiction) for the Anthropocene: Ancestral dystopias and fantasies of climate change crises”. *Environment and Planning E: Nature and Space*, 1(1-2): 224-242.

Synthesis Paper 5

Regarding Citizenship and Affordances, on Earth and in Space. *Listening to some Stories about Idealism, Identity, and Interoperability in Built Environments Everywhere*

Fred Scharmen (Architecture)

Executive Summary:
This article synthesizes three primary threads: 1) some stories from American history, 2) a broad look at policies regarding the legal regulation of the built environment, and 3) a set of interpretations of the Outer Space Treaty. The 2013 film *Gravity* is used as an example to illustrate certain implications of future policy regarding the legal status of astronauts and the built environment in outer space.

In legal documents, these stories show how three figural categories are created and used: "man," "architect," and "astronaut." In the first case, the question of the rhetorical intentions of the use of "man," "men," and "mankind" is instructive to trace. Whether or not the original meaning was meant to be narrow or abstract, advocates for disenfranchised have successfully used this rhetorical construction to hold power to account and effectively create the broadest possible expansion of the category. Today, while this language is deprecated in institutions and politics as being unnecessarily gendered, it is still broadly understood to be inclusive of all of humanity, and by extension certain rights are guaranteed to all of us in this category. The term "architect" has a specific legal definition in most jurisdictions. The professional role comes with certain rights and responsibilities, most notably to the public health, safety, and welfare. These obligations are recognized as being in potential conflict with a client's private interests, but the professional regulations say that the public good should take precedence. In the case of "astronaut," the Outer Space Treaty, a foundational document for law in outer space, has certain things to say about the rights and responsibilities that come along with this category and designation. Interpretations vary about who can claim that role and title. When placed alongside stories about the other two roles and terms here, certain implications about future scenarios regarding interpretation of "astronaut" narrowly or broadly come to light.

The roles of these three figures - man, architect, astronaut – resonate with one another. These abstractions all come together and intersect at the material level. The design and construction of the built environment fill out these stories with concrete reality. The built environment, on or off of Earth, supports the rights and responsibilities of those who use it safely. The obligation to the health, safety, and welfare of those users starts with the designers of the built environment, but it extends into basic standards of care and requirements for mutual aid that ultimately define the daily life of that public itself. The tendency for these roles to collapse into one another is implied in both the foundations of space law, and in the existence and utility of regulations and standards for the production of space in space, where, after all, the hostility and dangers of the environment outside put all the more onus on the architecture itself.

This paper will specifically answer the prompt's call for work on questions of access, ownership, rights and responsibilities in space, and especially the need for “future design of effective negotiation and governance structures.”

Paper:

Specification

What does a door handle have to do with the Declaration of Independence? The Declaration’s authors and signatories asserted, in 1776 in what later become the United States of America, that certain truths were self-evident, and certain rights were inalienable. They also note that these rights should be secured by the government, which would in turn derive its powers from the consent of the governed. This was, at the time, astonishing bluster. The whole construction, from foundational base axioms, to the framing of consent, was a new design, with new untested materials assembled in novel ways. The founders might have had a rough blueprint of the structure they wanted to build here, but they had no demonstrated support or capabilities yet for filling in the detail or making anything real. Worse, some of the terms and specifications remained poorly defined. After all, who were in fact these “men” that were created equal in the first place? This was either a glaring omission relying on some vague and uninvoked notion of “common sense” as an assumed shared ground, or a deliberate attempt to go as lofty and abstract as 18th century ontology could, and capture all of humanity with the broadest category available. But more on that later. For now, back to the door handle.

In Europe, the United Kingdom, North America, and much of the rest of the world, the height, dimensions, and other properties of door handles are specified by building codes. In addition to their location, certain other mechanical properties are defined and constrained as well. Door handles are disciplined by regulations about how readily graspable they should be, how much pressure ought to be required to turn or push them, and how much force might be exerted to finally open the door. Handles in the European Union are required to be mounted somewhere in a range between 80cm and 110cm, in the UK, they should be between 80cm and a less generous 105cm, in the US, the span is shifted upwards, from 86.4cm to 121.9cm.

The Declaration of Independence includes a list of inalienable rights. Significantly, the document acknowledges that this list is incomplete. The authors use the term “among these” to distinguish the small but punchy subset that they designate, Capital Letters and all, as: “Life, Liberty and the pursuit of Happiness.” The specifications that apply to door handles and other aspects of the built environment in building codes exist downstream from this font. These are literally the laws of the lands. The ways in which the built environment presents itself to us as users and occupants have a very specific term in the design world that names them: affordances. In the 1970s, perceptual psychologist James J. Gibson coined this term to capture all of the aspects of the environment that offer complementarity to an organism. In this case we are concerned with the human organism, and the affordances of the built environment are not accidental, they are designed by other humans and they offer ways for users and their world to interact. This can be a dangerous business. Steps made too high or too low can precipitate a stumble or fall, obstructions overhead can injure when they are unnoticed, and door handles that aren’t in the right place can cause tragedies. In emergencies, and in everyday life, the design, specification, and implementation of affordances can support or impede our ability to pursue Happiness, as well as our Liberty, and even our Life.

The technical specifications in building code flow downhill from the less concrete idealism in governments' founding documents. In transferring the requirements of building code from law to built space, the figure of the architect has a special role in all of these jurisdictions. In the United States, the architect is legally responsible for the health, safety, and welfare of the public. In the European Union, architects have explicit obligations to the public interest that come before their obligations to their clients. In the United Kingdom, the Architects Registration Board requires that those with the professional title consider the "wider impact" of their work at all times. In this way, built architecture is what guarantees abstract rights and constructs them into material reality. Working outwards from the roughly designed framework sketched by the authors of the Declaration of Independence, we might hold more truths to be self-evident, that all affordances should be created more or less equal, whether we are in the United States, the European Union, or the United Kingdom. As a human, the Declaration implies, you have the inalienable right to encounter a door handle's existence about where you'd expect it to be.

Treaty

When considering the future design of effective negotiation and governance structures in outer space, it is necessary to start with similar foundational documents. Submitted by the United Nations in 1967, at the height of the Space Race for the Moon landing between the United States and the Soviet Union, the Outer Space Treaty now has 113 nations as parties to it. These include the United States, Russia, the United Kingdom, and most of the states that compose the European Union. This document presents the closest analogue to texts like the American Constitution, and the Declaration of Independence, for outer space.

The Outer Space Treaty (OST) has 17 Articles that do things like specify that the exploration of space should benefit all countries, and all "mankind" (there's that term again, which we'll return to below). The OST enshrines international cooperation and free access, forbids sovereign territorial claims, upholds existing international law, and proscribes the establishment of military bases, much military conduct, and the installation of weapons of mass destruction in space. Other articles go on to establish national responsibilities in space, for activities undertaken by their citizens and by private companies with national origin. They establish liabilities for damages caused by this activity, and define ownership over objects and installations in space. In an idealistic portion of Article IX, the treaty specifies prioritization of the principles of mutual assistance, due regard, and harm reduction. Articles X, XI, XII, and XIII lay out a framework for mutual inspection and openness between nations and their activities in space. The treaty further requires nations to notify the UN and the scientific community about their spacefaring activities.

Article V is especially salient here, and is worth quoting in full:

> States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party or on the high seas. When astronauts make such a landing, they shall be safely and promptly returned to the State of registry of their space vehicle.

> In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties.
>
> States Parties to the Treaty shall immediately inform the other States Parties to the Treaty or the Secretary-General of the United Nations of any phenomena they discover in outer space, including the moon and other celestial bodies, which could constitute a danger to the life or health of astronauts.

Opinions among experts and practitioners of international law and space law vary, but some scholars maintain that at least some articles of the Outer Space Treaty have passed into the realm of *customary law*. That is, through the establishment of recognized regular practice, some portions of the document apply broadly to the activities of all nations on Earth, whether they have signed and adopted the treaty or not, even if they later decide to withdraw from its provisions. As in the case of the Declaration of Independence, this document is a statement of basic principles and ideals. It leaves details to be fleshed out later, by other means, downstream of the abstractions and intentions outlined here. One fuzzy bit is the definition of outer space in the first place. Where, above the surface of the Earth, does it start? Different institutions and nations have different answers. And who, exactly, gets to have the title "astronaut"? In order to address this, we might look at a few related categories first.

Man

When the Declaration of Independence references "all men" as a category of beings that are "created equal," and when the Outer Space Treaty specifies that the exploration and use of outer space "shall be the province of all mankind," who are they indicating? Obviously this is gendered language, but as we discussed above, was the universality of this category assumed to be self-evident? Or did the authors of these documents mean to exclude some people directly? These two texts were produced in very different contexts. The authors of the Declaration, in 1776, may have meant only to include free, male, property owners above the age of majority in their definition of "all men." Some scholars, like Stanford University historian Jack Rakove, don't believe that this term was meant to establish individual liberty at all. The Declaration authors were intending to secede from the authority of the British crown, after all, and create a new system of self-governance. "All men are created equal" might serve the rhetorical purpose of designating equality between *groups of people*, in this case the Americans and the British, in order to argue for independence. "But after the Revolution succeeded," Rakove says in a 2020 interview, "Americans began reading that famous phrase another way. It now became a statement of individual equality that everyone and every member of a deprived group could claim for himself or herself. With each passing generation, our notion of who that statement covers has expanded. It is that promise of equality that has always defined our constitutional creed." And it is under the theoretical establishment of this promise of equality that the authors of the Outer Space Treaty, writing in 1967, reference "all mankind." This expanded definition, though, of "all men" who are "created equal" was not easily won.

It was perhaps most persuasively fought for, in the United States, by the formerly enslaved. In 1851 the abolitionist and women's rights advocate Sojourner Truth gave a speech at a convention in Ohio. This talk was later popularized as "Ain't I a Woman?" a phrase that does not show up in the most reliable transcription of the speech. Truth used the occasion to speak

extemporaneously about how men and women were equal, and about how the extension of rights to women would take nothing from the rights of men. Her final sentence can be read as apt summary of the future of any narrow categories captured or implied by the term “man” as used in the Declaration: “… man is in a tight place,” Truth says, “the poor slave is on him, woman is coming on him, and he is surely between a hawk and a buzzard.”

The next year, another famous abolitionist also gave a rousing speech about who gets to be included in the category of “men.” “What to the Slave is the Fourth of July?” has become the popular name for a talk that was transcribed and published at the time as “Oration, Delivered in Corinthian Hall, Rochester, by Frederick Douglass, July 5th, 1852,” the day after the anniversary of the Declaration’s delivery. In one among many virtuosic moments in this speech, Douglass deploys a masterful rhetorical device - he raises the question of the inclusivity implied in the Declaration’s “all men” only to dismiss it as already settled business. Addressing the text directly, he turns the document’s own language right back around on itself: “Would you have me argue that man is entitled to liberty? That he is the rightful owner of his own body? You have already declared it.” “What, then,” he asks, “remains to be argued?” Obviously, Douglass deigns to point out, the enslaved are men, sophistry supporting the point is hardly necessary, “I have better employment,” he says, “for my time and strength.”

Nevertheless, Douglass, and Truth before him, have done the work. They have held the nation’s feet to the fire of its own ideals. They are literally fleshing out the details of the abstracted utopian idealism that drives the plans sketched in the foundational documents of the country. By helping to establish this expanded interpretation of “men,” the work of these activists and others who were members of the “deprived groups” that Rakove identifies, has ended up benefitting all. And when the Outer Space Treaty, almost 200 years after the Declaration of Independence, references “all mankind” as the beneficiaries of the use and exploration of outer space, the language may still be outdated to contemporary ears, but the meaning is clear. To eliminate once and for all any ambiguity about terms in discussions of space science, NASA updated its official style guide in 2006 to deprecate gendered language like “manned spaceflight,” in favor of more inclusive language like “crewed spaceflight.” If the Outer Space were written today (an unlikely happenstance!) it would probably more directly reference “the province of all humankind.”

Architect

In the United States, the European Union, and the United Kingdom, the professional use of the term “architect” is protected by law. In all of these jurisdictions, no one working in the built environment may call themselves an architect without having met certain requirements having to do with education, testing, and experience. And in many places, those who have earned the use of the professional title “architect” may have that privilege legally revoked if they fail to uphold their responsibilities to the public that are specified in the various nation’s codes of conduct.

In the United States, the National Council of Architectural Registration Boards (NCARB) produces and regularly updates its *Model Rules of Conduct* for architects. When states adopt these rules into laws pertaining to architectural professional licensure and behavior, they are affirming the structure and content of the document. In that text, the first principle upheld is that all of the following rules are hard requirements, not lofty aspirational goals that practitioners try their best to meet. the second principle sets the big picture clearly, and says

that the main objective of all of these rules is “the protection of the public health, safety, and welfare.” The document goes on to acknowledge that sometimes this obligation may be in conflict with the architect’s other commitment to the private interests of their clients, but nevertheless, the public good comes first.

That obligation to the public good is a direct consequence of the rights invoked in the American Declaration of Independence and further elaborated in the American Constitution. A major mechanism that architects use to ensure the public good is the implementation of building codes and specifications. The architect makes sure that building codes and other applicable laws are followed in the design of the project, just as the building inspector establishes that the codes are defining the parameters of the structure as built. The door handle and the Declaration can’t act on their own to ensure rights, they need advocates and stewards to speak and act for them. So the architect is a figure that translates the abstract ideals from foundational documents into the concrete material and dimensional realities.

But architects, at least in the United States, have an additional set of duties. According to a strict reading of NCARB’s *Model Rules of Conduct*, an architect has an obligation even to report their own client, if the client is making decisions and actions that violate the rules and might “adversely affect the health and safety of the public.” Further, American architects are required to report any knowledge of any other decisions by *other architects*, which might violate building codes and jurisdictional laws. The strictest reading of this stipulation, though hard to enforce in practice, would impart a grave and permanent responsibility to anyone with the architect’s professional title. They would be the guardians of the built environment’s safety at all times, even while going about their daily life outside the scope of their own workday practice. While going to the store, visiting friends, at a concert, or walking down the street, in theory they can never neglect their professional role. If they observe unsafe conditions of any kind, created by anyone, this reading implies, they are professionally obligated to act and help.

The NCARB *Model Rules* reference a concept from common law - architects should be judged by a “standard of care,” that also governs the behavior of other professional groups like physicians and attorneys. Architects are advocates for the health, safety, and welfare of everyone, they speak for the users and occupants of the built environment, but they also speak on behalf of structures themselves, translating their language of matter and dimension back and forth into legible and usable space that supports Life, Liberty, and the pursuit of Happiness. They walk through the world with an eye towards care. In this obligation to care, and this mandate to speak for aspects of the environment, architects also have a role that’s cognate with the American environmental activist and advocate position of “riverkeeper” or “waterkeeper,” persons able to bring suit against polluters and exploiters on behalf of watersheds, waterways, and other natural or human systems that engage with them. Along with “health, safety, and welfare,” “Life, Liberty, and the pursuit of Happiness,” the invocation of “care” fills out a particularly poignant list of ways to prioritize reciprocal relationships between humans and their environments, built and otherwise.

<u>Astronaut</u>

“In space,” fiction author Elvia Wilk wrote, in a 2022 short story, “everything is architecture.” “… you can only live if you build something,” she says, “and there’s nothing around you except what you build. Just building. The building itself, and the act of constantly building it.” The Outer Space Treaty implies that the figure of the astronaut has similar concerns to the

architect. And along with those matters of concern, the astronaut has certain rights. The expectations for a standard of care here, in outer space, flow in multiple directions. There is not just the reciprocal obligation between user and environment, but also between users themselves, that obtains. Building is everything, and even more so than on Earth, it happens together here.

Because of the nature of the external hostile environment in space, you can only live if you build something, and the authors of the Outer Space Treaty recognized, in the late 1960s, that building and codifying relationships between people was just as, if not more, important as building physical structures themselves. This is implied by the key phrase in Article V of the OST: “In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties.” The phrase “all possible assistance” has the same kind of stealthy resonance that “health, safety, and welfare” does elsewhere. What seems simple implies a lot. It might be easy to imagine some basic scenarios in the hostile environment of space in which assistance might be required. Running out of air? Other astronauts are obligated to share theirs with you, if they are able. Need to dock an ailing spacecraft at a foreign facility, the same generosity should apply. What about food? Personal safety from abuse? The principle of mutual aid applies everywhere. By becoming signatories and ratifiers of the OST in 1967, nations that were otherwise rivals in a Space Race recognized that the outcome of that contest was by no means certain at that point, and no matter who won, sharing the benefits, and the danger, would be the best-case scenario for all. It’s a moment of sheer bluster and practical idealism worthy of respect from the authors of a document like the Declaration of Independence. We hold these truths to be self-evident, that we’re all on our own out there, but we’re also all in it together.

Like that seemingly clear and ambiguous term “men” in the Declaration, the authors of the Outer Space Treaty left a key term frustratingly undefined. Like architects, astronauts have a duty to give - and receive - a standard of care, but who gets to be an astronaut in the first place? In popular 20th century culture throughout most of the world, this question never seemed to raise many eyebrows. Astronauts were those who, as the Tom Wolfe book and movie of the same would say, have “The Right Stuff.” The training was traditionally rigorous, the status was elite, and the figures were iconic. But the process excluded, intentionally or not, women and minorities. In much of the 20th century, the popular image of the astronaut was of a white guy with a buzz cut and a military background. The United States armed forces have a set of official astronaut badges that they award to anyone in the service who has flown above 80 km altitude, the point at which ballistics start to matter more than aeronautics in flight. By this metric, billionaires Jeff Bezos and Richard Branson (among others) and former Star Trek captain William Shatner are all astronauts. Not everyone thinks that this is fair.

The currently emerging era of private spaceflight has complicated popular and technical distinctions about who gets to claim to be an astronaut. Space tourism presents only one wrinkle here, another is the soon to be expanding category of the space worker, which we know from popular 21st century media like The Expanse books and television series. It’s easy to look down on the day-tripper and the joy rider, and to valorize the laborer or asteroid miner, but to exclude both from the elite status of astronaut-hood. Many of the stories in popular accounts of the new field of private spaceflight implicitly set up some skepticism about whether or not those who buy a ticket to space, instead of following the elite process of selection and training that public agencies like NASA require, actually *deserve* to be called astronauts.

Further complicating these cosmic waters, the American Federal Aviation Administration (FAA) issued guidelines in 2021 that codified their "Commercial Astronaut Wings" program. To qualify, you must have 1) completed some minor flight training, 2) traveled above the edge of outer space defined as 50 miles altitude, and 3) "Demonstrated activities during flight that were essential to public safety, or contributed to human space flight safety." The FAA criteria read like a fusion of language from the Outer Space Treaty and the architect's *Model Rules of Conduct*. Public safety and spaceflight safety are paramount, the FAA says, and astronauts should work to contribute to those conditions. This definition also excludes anyone who is in it just to float around a bit and enjoy the view. If you're not helping, you don't necessarily count. Similarly, but somewhat contradictorily, NASA uses the term "Spaceflight Participant" (and sometimes "Citizen Astronaut") to describe anyone who isn't performing science onboard, like Tokyo Broadcasting System journalist Toyohiro Akiyama, who flew to Mir in 1990, or American billionaire space tourist Dennis Tito, who went to ISS in 2001. NASA has also used "Payload Specialist" to describe people who might be doing science, but who aren't employed directly by the agency. "Astronaut" is, besides all of the other things, also a job.

Inspiration

All of the people who work in space science, whether for private companies or public agencies, rivals or allies, recognize that "space is hard." It's an often-repeated consolation in the industry, sent in public and private messages between actors and institutions, especially when efforts inevitably and occasionally fail. When things go well, a corresponding celebratory message is often sent, variations on "congratulations on helping to make outer space more accessible to all." There's a sense among practitioners that their goals and the things that inspire them are shared equally, even if public good and private gain are mixed and sometimes confused.

The 2021 Inspiration4 Mission, launched by SpaceX in their Dragon capsule and Falcon rocket, seemed to be custom designed to address the FAA's requirements directly. The major funder of the mission was American billionaire defense contractor Jared Isaacman. Isaacman owns, among other companies, a private air force provider named Draken International. Isaacman organized a crew that included an Air Force veteran, a physician's assistant, and a former NASA astronaut candidate named Dr. Sian Proctor. This group completed some flight training with Isaacman's company, and with SpaceX, before spending almost 3 days in space. While there, they conducted experiments and gathered data to contribute to the field of space medicine. The mission was also fundraiser for St. Jude Children's Research Hospital. All of the FAA's boxes are checked, and the mission definitely made major contributions to the public good and public safety, earning St. Jude hundreds of millions of dollars in donations, most directly from Isaacman. As part of the trip, Dr. Proctor became the first Black woman to pilot a spacecraft. Isaacman plans to continue his work with SpaceX, starting in fall of 2023, with a new series of missions named Polaris, with ultimate goals to boost the Hubble Space Telescope.

All of these activities in space: passenger, researcher, pilot, crew, scientist, tourist, worker … all have one thing in common - they are activities in space! If we were to conduct a survey of random 5-year old children, and asked them what the name was for people who go to space and do things there, they would probably have a very clear answer: "astronaut." And indeed, under some interpretations, the Outer Space Treaty seems to agree. Article V, again, says clearly: "In carrying on activities in outer space and on celestial bodies, the astronauts of one

State Party shall render all possible assistance to astronauts of other States Parties." Some scholars and practitioners of space law argue that the only definition offered by the OST for the term "astronaut" is that it describes anyone carrying on activities in outer space. That would make everyone in space an astronaut by default, and on the way clarify a whole host of disagreements, ambiguity, and contradictory language.

Outer space, in the cultural imagination, is bound up with inspiration and idealism. The opening of OST's Article V echoes the language of the 1966 Star Trek original series: "States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space …" When the authors and signatories of the OST specify that the exploration and use of outer space should be "the province of mankind," they are drawing directly on the previous establishment of an expanded definition for the category "mankind" that fought for so effectively by the likes of Sojourner Truth and Frederick Douglass. Space is for everyone, even a "commons" - at least in the language of another less popular United Nations Treaty on Outer Space, The Moon Agreement of 1979, which neither the United States nor the United Kingdom recognize.

Because "space is hard," the need for mutual aid and shared benefit is paramount, and this everywhere colors the language in the Outer Space Treaty. It is a foundational document that draws from earlier examples like the Declaration of Independence. Equity and equality are the basic assumptions that underlie the principle of mutual aid in the first place. Language questions about "man," "men," and "mankind" had already been settled (in theory if not totally in practice) a century previous to the release of the OST. But space is still a harder place for some than for others. In the 9-year period in which NASA didn't have access to an American spacecraft that could launch crew, between the end of the Space Shuttle program in 2011 and the beginning of the SpaceX Crew Dragon program in 2021, American astronauts had to catch rides to the International Space Station in Russian Soyuz craft, launched from Kazakhstan. NASA had previously been launching at least one or two Black American astronauts per year, but during this interregnum, they declined to send any to space for almost a decade, quietly resuming the launch of Black astronauts with the second Dragon mission. Space is not yet equally accessible for all, but that potential for universal access is one of the inspirational things about it. Why would the authors of the Outer Space Treaty intentionally raise new questions about equality around the term "astronaut"? That would be especially unhelpful, given the weighty rights and responsibilities that go along with the status that term grants.

The stories above—about the semantic expansion and clarification of the category indicated by "men" in the Declaration of Independence, and about the duty of those in the category of "architect" to a standard of care and obligations to the built environment and the public—suggest possible futures for the term "astronaut" regardless of the intentions of the OST's authors. If the term "astronaut" is understood now to indicate anyone carrying on activities in outer space, as may likely have been the original purpose, then that would help prevent the creation of another set of "deprived groups" that Rakove identifies as fighting for individual liberty under the Declaration of Independence. If that term is given a more explicitly narrow definition now, then these histories suggest a series of problems lie in the future of space science and space exploration.

First there may be more arguments about semantics. Terms like "citizen astronaut," "commercial astronaut," "spaceflight participant," and "payload specialist" suggest a future that has to confront a complicated proliferation of qualifiers, each slicing more narrowly into big

categories, ideas and ideals. In the history of civil rights law in the United States, we find dead ends and disasters here, like the Dred Scott decision of 1857, based on a bad faith reading of semantic categories, in which the Supreme Court ruled that Dred Scott, as an enslaved person, was not a citizen, and was never intended to be one under the Constitution. Therefore, they found, he had no standing to sue for his freedom. There may be breakdowns in mutual aid in dangerous situations. In practice in an emergency, when "all possible assistance" is obligated, there is no time to parse whether the person next to you in space has undergone a certain number of hours of flight training, or to check if they have a pin with wings on it issued by a state authority, before offering aid. Help is most efficiently given, and offered, without such barriers, and the Outer Space Treaty requires that help to flow both ways. Astronauts deserve all possible assistance but they are also required to offer it. In a pinch, more astronauts around means more safety for all. And finally, if the category of "astronaut" is not specified in broad terms now, there may be an eventual inevitable struggle for equity in space later, possibly inspired by the Outer Space Treaty's own idealistic language about "all mankind," built on previously established and less contested broad categories.

So the figure of the astronaut has a certain resonance with the figure of the citizen, captured in one way by the indication of "men" who are created equal in one document, and another more expanded and definitive way by "all mankind" in another document. But in their obligation to humanity generally, and to the public they find themselves in within their artificial environments, the figure of the astronaut has duties that rhyme with those required of the figure of the architect. As a set of fragile, small, interior worlds within a vastly large and dangerous set of exterior territories, the environments that humans encounter and make in outer space need someone who can mediate between abstract ideals and material reality, with that same sense of public obligation that architects and astronauts require. The design, construction, and maintenance of an emergency egress path, after all, is also an act of mutual aid, it works for me as well as it works for you. Astronauts collapse both "man" and "architect" together, a new kind of citizenship that explicitly participates in the making of the world's built environment. This is, again, where we arrive at the material and dimensional reality of the hardware - the door handle that allows us to leave one space and enter into another that is safer. Space needs the equivalent of the figure of the architect, someone who is obligated to work for the public good in the built environment. Everything here is architecture, and, in a sense, everyone has the responsibilities of the architect.

Emergency

In the 2013 film *Gravity*, Sandra Bullock plays Dr. Ryan Stone, in space to help assist the Hubble Space Telescope (like Isaacman hopes to do with Polaris). Technically, under NASA's terminology, a "payload specialist," Dr. Stone is suited up on a spacewalk away from her shuttle to replace some imaging apparatus in the telescope when a disaster strikes. A Russian ground based military exercise has destroyed one of their spy satellites, and the debris field is expanding to create a chain reaction, with more collisions creating even more debris which create more collisions. In space science this scenario is known as "Kessler Syndrome." Stone is rescued and seeks refuge in a number or temporarily safe spaces, first in the doomed shuttle orbiter, then in the International Space Station, she uses a Soyuz spacecraft to fly from there to the Chinese Tiangong space station, then a Shenzou spacecraft to finally return to Earth.

The shuttle is almost completely destroyed, there is no possibility for refuge there. Dr. Stone's companion, Matt Kowalski, has a "Manned Maneuvering Unit" (NASA would deprecate this

language today) that acts like a jetpack for his spacesuit, they are able to use that to get to the International Space Station. Only Stone makes it inside, after negotiating the airlock. She has to orient herself within the station and locate a fire, and, when that fails, flee to a Soyuz ship. After figuring out another hatch, she has to flip through the manual in order to determine how to use the Soyuz controls, and get out again to free the ship from cables caught on the station. Once heading to the Chinese Tiangong station, she has no way to stop the vehicle, so she gets out and uses a fire extinguisher for thrust to jump across the void. She has to operate another airlock and navigate another station to get into the Shenzhou ship and escape before this station is also destroyed, then there is a final sequence with the control panel in which she's able to release everything but the heat shielded landing module and get back to Earth, followed by one more problem with the spacecraft door.

This is a gripping story, and it can be read many ways. Dr. Stone's character is also coming to terms with grief about her late daughter's passing, and she's struggling with her own will to live just as much as she is fighting for physical survival. Along the way, she loses Kowalski, played by George Clooney, but not before he can aid her one last time after his own death, via her subconscious, oxygen starved, mind. One way to read the narrative is as a series of interactions with affordances along an emergency egress path, and in this light, door handles become crucial. She struggles with every hatch. Every airlock door, every spacecraft entry portal, every transition is different and painful. These are, after all, pieces of hardware that were manufactured by at least three different countries - Russia, the United States, and China, and on a total of two space stations and two spaceships. Her difficulty with the hatch recalls the real life disaster that happened during a capsule test with the crew of Apollo 1, a spark ignited the super-oxygenated atmosphere inside the ship, and the crew died, possibly in part after trouble getting the hatch open, this early model had been designed to swing inwards, not outward, towards safety.

Another set of difficulties she has is with wayfinding. The stations are confusing places, with lots of visual noise even on a calm day, and finding a path to exit during an emergency with smoke and fire is even harder, especially for a stranger. Unlike in ground-based architecture, space stations use a lifeboat model from naval architecture for emergency egress. On Earth a building's exit paths are well marked, and they are shaped by working backwards from a theoretical maximum amount of occupants the structure might have. This total number is rarely reached in practice, and the paths have an extra margin added in, so there is always excess capacity. On space stations, the reverse is true. The total maximum size of the crew is limited by the capacity of the return vehicles that are currently docked. If there aren't enough seats to carry everyone safely back to the ground, then no new crew can go up.

The difficulties encountered by Dr. Stone in the film point to another set of future problems that could arise with regard to two of the major themes we've encountered so far. What sort of category is the user or occupant of an environment in space - what should everyone there have in common? And what are the responsibilities that the designers of the built environment have when it comes to anticipating and making interactions between those users and their spaces? In a future in which the category of "astronaut" encompasses everyone who is carrying on activities in space, regardless of their origin or the purpose of their actions, then there could be a reciprocal relationship designed and standardized from the start between their knowledge and expectations and their physical environment. On Earth, the door handles are in roughly the same place, but we don't start out our lives knowing that. We have to train

ourselves to relate to the built world. The door relates to us, and we relate to it. If everyone is an astronaut, and they all know their rights and responsibilities in space, then standardized training can help mediate and condition the user's expectations.

Similarly, a future in which certain dimensions, usability features, wayfinding cues, and layouts, become regulated and standardized, as in Earthly building code, will be one in which a well-trained astronaut user will always find familiarity. Alternatively, a future in which the identities of people in outer space become fragmented, without any over-arching category that they can all claim and share, and one in which the standard affordances and expectations in the built environment become similarly disordered, is a much more dangerous place to be. Dr. Stone, in the film, encounters condition after condition in the built environment that threatens her Life, her Liberty and her ability to pursue Happiness.

In the lifeboat model for ships at sea, there are always extra. Because a ship might capsize in either direction, there are enough escape craft on the starboard side to allow everyone to get away, and that capacity is duplicated on the port side. In space, there are always just enough, and no more. This is one of the film's points in which it sacrifices strict accuracy in favor of plot development, which pedantic fans love to pick apart. Dr. Stone, though, encounters extra lifeboats wherever she goes, and it's instructive to think of this not as an oversight on the part of the filmmakers, but a small utopian gesture. Why should there be only just enough? In this hostile place, shouldn't we console each other with abundance, this move suggests, especially in times of need? The environment offers aid. Another bit in the film is also telling. Stone doesn't have a chance to try to dock the Russian Soyuz craft with the Chinese Tiangong station, they have not matched velocities, but if she slowed down enough, the hardware from the two nations would have safely connected. The docking mechanism is standardized, the descendant of an invention developed jointly during the Soviet and American Apollo - Soyuz Test Project exercise. This was a historical moment of meeting in space that many consider a prefiguration of the end of the Cold War. Hardware standardization assures that mutual aid is possible, there is no sharing of air where the suit's nozzles can't connect. Similarly, she struggles with the controls of the Soyuz and the Shenzhou, but ultimately figures out how to make them work. This is because the later craft is based on the earlier one, and the markings may be in a different language, but many of the same buttons are right where they might be expected.

As my colleague, the space archaeologist Justin Walsh, points out, when we get into a car on Earth, things are where we think they should be. The gas pedal, steering wheel, and brakes, are easy enough to find, on just about every continent. Despite the almost accidental resonance between Shenzhou and Soyuz, this kind of standardization is not mandated or universal in spacecraft. Dr. Stone would have to learn the controls all over again if she found her escape lifeboat was an Orion, a Starliner, or a SpaceX Dragon capsule. Again, a future in which an overarching category of well-trained users, empowered with rights and responsibilities, encounters an environment that is similarly well regulated and standardized, is one that is safe and liberating.

The astronauts owe a standard of care to one another, and to their environment. But these stories illustrate how the environment also needs a standard of care built in to it, in order to offer in turn necessary care to the users. Astronauts could be enabled and expected to report and improve unsafe conditions in the same way that architects are. Astronauts have an

obligation to the public written into their foundational charter documents in the same way the professional obligations of the architect are made clear in their own *Model Rules.* There is a natural resonance between these types of actors. A safe space future that speaks to the ideals outlined in foundational documents needs coordination between those abstractions and concrete built reality, handled by people who are held to a specific standard of care. These categories of people (citizen, architect, astronaut) mediate between utopian aspirations and material conditions. In a space future these roles may all collapse into one. A future in outer space, and on Earth, without overarching categories and standards, on the other hand, will be characterized by chaos and danger, and may dredge up old conflicts under new names. The *Declaration of Independence* is to the door handle as the *Outer Space Treaty* is to the airlock, the rights and responsibilities specified in one are made concrete at the site of the hardware specifications of the other, by people who are empowered to care.

Synthesis Paper 6

Exploring Space Science Community Engagement with Storylistening Principles

Elizabeth Stanway (Astrophysics)

Executive Summary:
The Dillon & Craig (2022) storylistening concept has been developed with a focus on proving a robust framework for interpretation of narrative evidence from the humanities and related disciplines. However, while scientists often prefer to frame discussion amongst themselves in quantitative and technical terms, the space science community must also engage with narrative construction and analysis when communicating to a non-specialist audience, including policy makers and the general public. This is particularly true in the related areas of space domain awareness (i.e. the generation and tracking of space debris) and dark sky protection (specifically the impact of satellite mega-constellations), both of which pose questions of sovereignty, defence, governance and technological anticipation. In each case, narratives must balance the benefits of space utilisation with their potential negative impacts, particularly on the space science community, and clearly communicate these with potential stakeholders.

In this synthesis paper, I consider the ways in which the science community has engaged with this narrative construction, and the public response to that engagement, in the context of the storylistening framework. Having first summarised the topics under consideration, I consider formative readings of narrative-representations of space debris and dark skies issues.

The first case study considers fictionalised representation of these issues in the form of science fiction narratives and the dialogue formed by the public response of science communicators to these narratives. Having briefly discussed James White's short story *Deadly Litter* (1964) and Yukimura's manga *Planetes* (1999), I focus on the space debris narrative in Alfonso Cuarón's *Gravity* (2013), exploring how its framing and narrative modelling have been critiqued by space scientists in the public domain. Finally I consider the use of Isaac Asimov's short story *Nightfall* (1941) as an inverted model for stories of dark sky protection.

Moving from fiction to more conventional science communication, the second case study focuses on public-facing journal articles by scientists regarding their concerns over light pollution and the proliferation of satellite megaconstellations, identifying the narrative elements employed through a storylistening analysis of a Nature Astronomy Focus issue on Dark Skies (2023). I show that even within a single collection of evidence, the framings, identities and models used by science narrators can vary significantly. As in the first study, I consider reactions to the publication, this time from media and non-specialist audiences.

Finally, the third case study discusses *Our Fragile Space* (Alexander, 2023), an artistic narrative designed as science communication co-creation between the artist and expert space scientists. A storylistening analysis is used to demonstrate an expert reading of the narrative and its intent, demonstrating how such installations can be used to generate narrative

evidence. In particular, the framing of space debris as a problem for all imbibers is effectively invoked by choice and positioning of pictures, while the setting of the installation provides additional framings which will influence the perception of the art.

In each case, by examination of the case studies and their siting within a wider field of similar communications, I evaluate to what extent the key principles of collective identities, new framings, narrative models and anticipations are represented in the dialogue as presented by the space science communities and interpreted by the media and public. I identify how representations of the same topic can vary in their framing, and the strengths and limitations of narrative models in this field. I determine that of the four key pillars of the storylistening framework, science communication engages least with anticipatory modelling, preferring to offer alternatives rather than resolve narratives with a firm conclusion. Despite this, the synthesis of evidence from the different forms of science narratives considered here demonstrates that expert storylistening can provide a valuable framework for analysis of scientific and science-adjacent narratives.

Introduction

In this synthesis paper, I consider the ways in which the science community has engaged with narrative construction in the context of the storylistening framework and two key areas of active development in space policy: dark skies protection and space domain awareness. Having first summarised the topics under consideration, I consider three case studies of narrative representations in science. The first case study considers fictionalised representation of space debris and dark skies in the form of science fiction narratives and their dialogue with science communicators. The second case study focuses on public communication by scientists regarding light pollution in the form of journal articles, also considering reaction to their publication. Finally, the third case study discusses *Our Fragile Space*, an artistic space debris narrative designed as science communication cocreation between the artist and scientists. In each case, I evaluate to what extent the key principles of collective identities, new framings, narrative models and anticipations are represented in the dialogue as presented by the space science communities, and as interpreted by the media and public.

Dark Skies Protection and Space Domain Awareness

The issue of **dark skies protection** is not a new one. The growing ambient light around cities and towns calls into question the relative value of industrial (e.g. businesses working through the night), public safety (e.g. provision of street lighting), environmental (e.g. impact of light pollution on wildlife) and cultural concerns (e.g. difficulty of discerning the Milky Way and constellations in urban environments, impact of artificial light on astronomical observatories). *Light pollution* rose to prominence as a term in the 1970s, driven in part by the work of Riegel (1973), Walker (1973) and others advocating for astronomical dark skies, and in 1979 the UN Convention on Long-Range Transboundary Air Pollution defined artificial light at night as a pollutant within its remit. Extensive work in the decades since has demonstrated the wide range of negative impacts of artificial light at night, including risks to mental and physical health (e.g. Chepesiuk, 2009; Sánchez de Miguel et al., 2022)

While no international framework exists for regulating light pollution, increasing recognition of its impacts, together with technological advances, has led to adoption of low energy,

downward-focussed technologies for street lighting, and consideration of light pollution impacts in planning and regulation decisions.

In the last few years, however, the issue of dark skies protection has faced a new challenge - and one which calls for attention from policymakers on an international level. Technological innovations have led to the creation of *satellite mega-constellations*, primarily for telecommunications (and particularly high-speed internet) applications. The previous generation of satellite communication mostly relied on signals relayed by single space vehicles in the distant geosynchronous Earth orbit (GEO). Starting in the 1990s, the geosynchronous telecom satellites were complemented by small groups of cooperative satellites, known as constellations, in a much closer medium Earth orbit (MEO). These are used primarily for navigation purposes, with the best known being the Global Positioning Satellite (GPS) system.

The first telecommunications constellations in low Earth orbit (LEO) were also launched in the 1990s, largely to provide mobile phone services. The low power available to compact hand-held devices precluded their broadcasting reliable signals to GEO, requiring a closer satellite. To ensure that least one such rapidly-orbiting satellite was always above the horizon required that many identical satellites were launched, with the early Iridium constellation boasting almost a hundred spacecraft. However, the rise of demand for high-speed internet, together with increasing commercialising of space access, has led to a step change in the rate of satellite construction and launching. Commercial company SpaceX launched the first satellites in its Starlink mega-constellation in 2019 and will exceed 12,000 individual spacecraft, in an orbit about half the height of the early Iridium network. Their launches each release a train of bright satellites that are later boosted into higher and more dispersed orbits. These have attracted intense attention and media interest (e.g. Pettit, 2020). Several similar mega-constellations either proposed or under construction, with projected numbers of satellites in LEO reaching several tens of thousands within the next decade (Barentine et al., 2023).

The existence of these mega-constellations enters dark sky protection debates in several ways: the impact of bright artificial sources on naked-eye-visible stellar constellations, particularly at twilight; the impact of fainter satellites on optical astronomy; and the impact of communications to and between satellites on radio astronomy. As a result, learned societies and associations in the space science area have intensified campaigns of information and lobbying regarding dark skies protection in recent years, with the International Astrophysical Union (IAU) creating its Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS[1]) and associated Dark and Quiet Skies Global Outreach Project in early 2022. Amongst other advocates for such dark sky protection are individual astronomers and cultural champions, both in the academic and amateur domains (see e.g. Dunnett, 2015, for an analysis of the cultural geography of light pollution in the UK).

A related concern, also rising in prominence in recent years, is the difficulty of tracking and controlling the interactions between orbiting material, particularly between active and inactive satellites or other debris generated by human activities. This field is increasingly described as **space domain awareness** (SDA), a general term which incorporates aspects of satellite tracking, space sustainability, technology development, space policy and socio-economic

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

studies. It involves challenges of identifying, tracking, monitoring, regulating or even manipulating the build-up of human-generated space debris.

The pioneering work of Donald Kessler and collaborators in the 1970s, hypothesised a chain reaction in orbit - each collision between space craft generating debris which damaged other craft, until the entire orbit became inimical both to human life and other satellites (Kessler & Cour-Palais 1978). Several prominent incidents involving damage to active satellites or crewed spacecraft being struck by debris at orbital speeds (kilometres per second) occurred in the 2000s-2010s, raising fears of a Kessler effect event with devastating impact on an increasingly satellite dependent society (see Witze, 2018, for a historical overview). The rapid growth in satellite mega-constellations since 2019, together with issues of governance and regulation has caused further concern amongst the scientific community. The rate of collision incidents is increasing. Both the Chinese space station and Aeolus, an Earth-monitoring scientific observatory operated by the European Space Agency, for example, have been forced to execute orbital avoidance manoeuvres when Starlink satellites pass within their collision exclusion zones - the disparate safety margins required by the small, mass-produced communication satellite, and the large, one-off scientific facilities, as well as the lack of a clear order of precedence or agreed process can cause confusion and miscommunication over the need for such manoeuvres.

The need for both data acquisition and space policy development in the areas of SDA and Dark Skies has been highlighted by several governmental and government-sponsored agencies, including NASA, ESA, the UK Science and Technology Facilities Council, the UK Office for Science and Technology and the UK Space Agency. The space sciences community has responded with initiatives such as the University of Warwick's Centre for Space Domain Awareness and the Global Network on Sustainability in Space (GNOSIS[2]), which brings together science and humanities academics, industry and policymakers. Crucially, while astronomers and space scientists are both stakeholders and data gatherers in these issues, their views and results must be clearly communicated in non-technical terms. These will inevitably be set against the potential societal and economic benefits of space commercialisation, and both public and governmental stakeholders are also involved. As such, technical and data-driven reports must be supplemented by narrative evidence - a form of storytelling and anticipatory modelling that is both constructed by the scientists themselves and generated in response to scientific reporting.

While narrative evidence has been considered in specific astronomy-related contexts, for example in areas such as dark skies tourism (Derrien & Stokowski, 2020) or preservation of traditional culture (Hamacher et al., 2020, Blair 2018), to date there has been little engagement of western scientists with the evaluation of narrative evidence in this field, or of how such communication has been interpreted. The storylistening technique (Dillon & Craig, 2022) provides a helpful framework for the synthesis of such narrative evidence.

Fictional, Scientific and Science-Adjacent Narratives

The storylistening framework provides a context for the interpretation and incorporation of narrative evidence in public policy and decision making. In this context narrative evidence can

[2] gnosisnetwork.org

be interpreted broadly. From a literary and film studies perspectives, narratives are fictional or fictionalised accounts which tell stories. These may be based to a varying degree on factual information but prioritise a narrative structure, as codified, for example, by the narrative theory of equilibrium which asserts that most stories establish an equilibrium, disrupt it, recognise and resolve the disruption and finally reach a new equilibrium (Todorov 1971).

However, in media studies and related fields, the study of narratives includes the way in which information is presented, for example in the construction of news reports. More generally, elements of narrative in the form of personal stories or contextualisations of information are ubiquitous in the interactions of humans with the world around them, contributing to reporting of medical, legal, cultural and even scientific issues. In each case, the current status quo must be established, a change to it considered, and the results of that change communicated to an audience.

Science communication studies ask fundamental questions about how those engaging in scientific research interact with those outside their specialisms, in areas ranging from the practical applications of medical science to the less applied areas such as quantum physics or astrophysics. One area of recent scholarship has focussed on the nature of the information transfer - whether it is unidirectional, bidirectional or involves co-creation, or alternatively whether it lies within a deficit model, a dialogue model or a participation model (see e.g. Trench 2008). Science communication, it has been argued, is often distinct from science engagement, with the former positioning scientists as separate from, or even superior to, others, while the latter recognises the importance of two-way information transfer and discussion.

Another important framing for science communication is the intent of the interaction - whether scientists present facts without imposing their own opinions (an *honest broker*, Pilke, 2007) or actively curate the evidence in order to advance their own view (acting as either as an acknowledged *subject advocate* or a more insidious *stealth advocate*, Pilke, 2015). While this view of science knowledge brokerage may be overly simplistic (e.g. Gluckman et al., 2021; Turnhout et al., 2013), an acknowledgement of the broker's intent and positioning is of crucial import in interactions between scientists, the public and policymakers. Such discussions have been further stimulated by the Covid-19 pandemic, which highlighted the need for clarity and trust in science communication.

Traditional science communication from active research scientists has been largely unidirectional, in the form of press-releases and similar publications. Indeed, a recent analysis of science communication strategy by the European Space Agency (ESA) identified 95% of its activity in 2018-2020 as corresponding to a sender-receiver deficit model, in which the audience is seen as passive or even potentially hostile (Pfleger et al 2022). This is slowly changing. There is an increased recognition of community input, with interdisciplinary workshops (e.g. Royal Astronomical Society, 2020; Walker et al., 2020; Hall et al., 2021; GNOSIS, 2022) that promote mutual exchange between scientists, industry stakeholders and policymakers.

However the majority of scientific issues are still communicated to the general public through the press-release paradigm. Here, scientists, sometimes acting in partnership with local or institutional media specialists, attempt to frame their findings in a non-quantitative manner, to engage the widest possible audience. Press releases often develop stories contextualising

the work reported in the lived experience of the reader, or serve a modelling or anticipatory role connecting the reader to technical topics by analogy or extrapolation. However, such press releases are frequently not reported verbatim. As a result, the public imbibes scientific output mediated by news agencies or individual journalists. These may tailor the content or its presentation to the interests of narrower target audiences and introduce elements of framing or storytelling in *science-adjacent* narratives. Yanovitzky & Weber (2019) have positioned such news media as knowledge brokers, emphasizing their role in linking knowledge between fields and to the public, but did not consider their narrative role. Nor has the role of members of the public imbibing such narratives in building their own stories in which to contextualise the information received sufficient attention. The importance of such alternative forms of information dissemination has been recognised in the adoption by scientific journal publishers of the commercial altmetric system[3], which traces the online impact of reported research, allowing authors to monitor the narratives springing from it. As Craig & Dillon (2023) have argued, such narratives are relevant to evidence collection in the science policy field and must be analysed critically and robustly.

Formative Readings

The use of storylistening to evaluate such science and science-adjacent narratives can be explored with reference to formative readings, in the areas of fictional narratives with scientific input, purpose designed science advocacy communication and its interpretation in the media, and artistic co-creation in science communication.

Case Study 1: Fictional Narratives

Fictional narratives have featured concerns over space domain awareness since long before the field gained popular attention. James White's short story *Deadly Litter* (1964) explores a future in which the release of anthropogenic debris into space is seen as an abhorrent crime. In this narrative, a number of vessels have been lost due to debris strikes, resulting from litter ejected into space decades or even centuries before. A retired ship's captain is investigated for this crime, committed in an effort to save his own spacecraft eleven years previously. By presenting the narrative from the point of view of the investigator, White invites the reader to share his disgust at the crime and identify with those potentially threatened by space debris. The framing does not dwell on the mechanisms of space travel or its wonder, but instead roots the narrative on Earth in a more familiar police-procedural context, easing the cognitive dissonance of readers for whom space was a distant and unfamiliar setting. In building its model of a future in which space travel is routine, yet remains dangerous, *Deadly Litter* is notable for predicting the sheer mundanity of much space debris:

> *"There had been a time when people thought it funny that a ship could be wrecked by a few tea leaves, or a frigid, iron-hard potato peeling. But among spacemen, Gregory thought sourly, it was the sort of thing at which you died laughing."* (White, 1964).

White himself had no formal scientific training, although he became a technical clerk at an aircraft company soon after publishing *Deadly Litter*. Given its early date, written just a few years after the first human space activity, the story is limited in its anticipatory value for space debris policy today, positioning the issue as a threat only to those in space, rather than to the

[3] https://www.altmetric.com/

whole of society on the ground. It is nonetheless a striking early example of narrative model creation in this field.

More recent examples of SDA narratives can be found in the animated television series *Thunderbirds Are Go* (2015-2018), which presented an anticipatory vision of space utilisation complete with space junk clear-up efforts and considered debris production from an orbital collision (Stanway, 2022). Space clean-up was also the major theme of the manga (Japanese comic) *Planetes* (Yukimora, 1994-2004), and the anime (television animation) adaptation (Taniguchi, 2003) developed with scientific input from the Japanese space agency, JAXA. *Planetes* is a complex series which explores the framing of space from the point of view of commercialisation, globalisation, equitable distribution of resources and exploration. Its narrative modelling of a near-future commercialised space allows the writers to anticipate concerns over space debris threats to spacecraft, and radiation damage to space travellers, amongst political and psychological issues. The narrative model of young protagonists coming of age in a congested space encourages the target audience to identify with their struggles. The series has been cited by Gärdebo and coauthors (2017) in their analysis of the role of satellites and space debris in the epistemological basis of the modern technosphere and would reward further study. However *Planetes* is unfortunately little known in the UK and has not had a significant popular culture impact.

A fictional narrative repeatedly referenced in media coverage of space domain awareness topics, is the feature film *Gravity* (Cuarón, 2013). This story follows two astronauts, stranded in space when a debris-generation chain reaction destroys the Hubble space telescope, the space shuttle, International Space Station and Chinese Tiangong space station. Cut off due to the destruction of communication satellites, the protagonists must move between space vehicles and find a way to descend safely to Earth. The film has been extensively studied in the context of its sound (Canduso, 2016) and visual design (Atkinson, 2016), its philosophical (Read, 2023) and psychological (Blothner, 2015) positioning and portrayal of technology and gender (Palmer, 2019) in space.

The framing of Cuarón's film can be read in two principal ways: with strong elements of nationalistic positioning that echo the 1960s Space Race, or as a human-against-nature survival narrative. The astronaut protagonists are Americans, working for NASA rather than representing commercial interests, while the debris-generation chain reaction is initiated by a Russian anti-satellite missile test. Space debris itself represents the film's main antagonist and human space utilisation in this film is presented as both heroic and at threat from human actors. By focussing on individuals, rather than the politics or reactions of those on Earth, Cuarón frames the story as a battle for survival against the harsh space environment. However this reading is not entirely straightforward. Caroll (2019), for example, has positioned *Gravity*, alongside *The Martian* (Scott, 2015), as a reaction against the atopia (or "non-space") and subsequent isolation that has resulted from globalisation. While national identity is certainly invoked, both through the protagonists' exchange of their respective back stories and through comments such as one astronaut noting that *"Half of North America just lost their Facebook"*, collective identity is not as strong a theme in the film as individualism. Indeed, the lead protagonist spends a substantial fraction of the film alone and incommunicado.

In a science-adjacent narrative context, *Gravity* has also been subject to scrutiny regarding its technical accuracy (or lack thereof) by prominent science communicators. The extent to which

Gravity constructs an accurate narrative model in which to contextualise the threat of space debris has been questioned by astronomers Neil deGrasse Tyson (Watercutter, 2013) and Phil Plait (Plait, 2013) and former astronauts Scott E. Parazynski (Watkins, 2013) and Garrett Reisman (Reisman, 2013) each of whom noted factual errors in the film's modelling. Perhaps most prominent of these is the plot-driven premise that everything in space occupies a very similar orbit, allowing the astronauts to travel straightforwardly between space stations, and the debris to equally damage both LEO human space activities and GEO commercial communication satellites. In fact, the relative altitudes and orbital velocities would render this scenario impossible as modelled. Nonetheless, all the commentators enjoyed the film and noted that the errors would not be apparent to non-experts, while commending the attention to detail in other aspects of the film's portrayal of space technologies. It is interesting to note that this technical commentary also provided a platform for collection of additional relevant narrative evidence in the form of anecdote. Reisman, for instance, commented on the real threat of space debris, recalling that:

> *"During my first spacewalk, my partner, Rick, had to bring in a handle that was stowed on the outside of the station. When he got it inside he noticed a hole, about a millimeter in diameter, that was shot through the half-inch solid aluminum material by a piece of orbital debris. It looked like someone had taken a cocktail straw and shoved it right through the metal. He looked at me and said, "If that hit one of us..."*" (Reisman, 2013).

Thus while the narrative model in *Gravity* introduced factual inaccuracies in the interests of drama, it nonetheless highlights a real and extant threat to the safety of astronauts and telecommunications-dependent systems. It also provided a model within which science communicators could clearly communicate subject-specific knowledge to the public. Unlike much science fiction (but as will be seen in later scientific narratives), the anticipatory role of *Gravity* is limited. The setting is contemporary, with no significant technological or societal extrapolations beyond the current day. The chain reaction described could happen (with certain caveats) today, rather than relying on significant extrapolation. Despite its scientific inaccuracies, the film nonetheless acts as a thought experiment, highlighting the possible consequences of a space debris generation cascade.

By comparison, popular fictional narratives addressing light pollution are relatively rare. While bright lights are often synonymous with big cities, and thus symbolise modernity, the cultural impact of losing contact with the night sky has not formed the focus of many narratives. However science fiction does provide an inverted model. Published in 1941, *Nightfall* by Isaac Asimov explores the interaction between scientific and religious communities on a hypothesised world with multiple suns. An unusual syzygy occurs every two millennia leading to eclipse of all the suns simultaneously, bringing true darkness and a revelation of the stars in its wake. The changed relationship to a sky which had hitherto been opaque leads to madness and societal collapse.

While *Nightfall* lacks physically plausibility as written (Deshmukh & Murthy (2014), the story has been cited in the context of light pollution narratives. In his introduction to an article on the health impacts of light pollution, Gilad (2016) for example juxtaposes the premise of Nightfall with the widely-repeated anecdote that during a power cut in 1994, alarmed residents of Los Angeles called the police to report a glowing liquid in the sky, unable to recognise the Milky Way (e.g. New York Times, 2008). Indeed Falchi et al. (2016), the authors of the research

Gilad discusses, also make reference to Asimov's *Nightfall*, albeit in passing. Here *Nightfall* is being used as an inverted narrative model for Earth, comparable to the early 1940s in technology. While Asimov's original framing for his narrative in a tension between science and religion is not invoked by Gilad or Falchi et al., the underlying themes of distrust of science and the importance of a night-sky-informed cultural worldview can be seen connecting the fictional narrative with the problem it is used to illustrate. Importantly, darkness in *Nightfall's* narrative, like light pollution in modern dark skies narratives, is a problem affecting all, with either physical or mental health impacts. The collective identity invoked here encompasses all imbibers of the story.

The manner in which *Nightfall* has been used, despite its apparent disconnect from the topic in question and from the world in which policy decisions must be made, shows the flexibility of stories in the presentation of scientific issues. This power has not been overlooked by journalists: media reports that space junk might prevent us from finding alien life (e.g. Michalitsianos, 2023) are deeply embedded in the science fiction imaginary. Recent film *Don't Look Up* (McKay, 2021) was used to frame reports of the potential impact of mega-constellations on asteroid searches (e.g. Hawkins, 2022), while Prof Alan Fitzsimmons (Queen's University, Belfast) used the narrative framings presented by the films *Don't Look Up* and *Gravity* to contextualise his commentary on space debris (Fitzsimmons, 2022).

While recognising the power of this science fictional imaginary, however, it is also important to consider the narrative structure in science and science-adjacent reporting in the absence of fictionalised content, as we will see in the next case study.

Case Study 2: Nature Astronomy Dark Skies Focus (March 2023)

An extensive body of literature exists written in the last few years by, or on behalf of, space scientists with the goal of communicating SDA and dark skies narratives. These include press releases and discursive articles from the learned societies, major observatories or individual scientists. Scientific press releases themselves are largely factual but are inevitably framed by elements of narrative describing the proliferation of satellites as a disruption to the equilibrium of our relationship with the sky, anticipating the results of inaction, and invoking collective identities amongst the audiences. The media response to each of these press releases is itself a form of narrative construction.

Here, I will consider an example of a focussed science communication effort which invoked narrative principles: the March 2023 issue of *Nature Astronomy,* a peer-reviewed science journal launched in 2017. While aimed at a more specialist audience than its public-facing parent journal *Nature*, it publishes commentary and reviews on the culture and social context of astronomy in addition to scientific research articles. The March 2023 issue of *Nature Astronomy* was presented as a Dark Skies Focus edition with an editorial (Nature Astronomy, 2023), two opinion articles (Venkatesan, 2023; Falchi et al., 2023), a 'perspective' review article (Barentine et al., 2023) and two research articles (Kruk et al., 2023; Kocifaj et al., 2023) on topics related to dark skies protection and the impact of satellite mega-constellations. While the research articles (and to a lesser extent the review) were written primarily for a technical audience, the remaining articles target a more general audience, and represent examples of narrative construction and application in science communication.

The unsigned editorial is explicit in its advocacy and call to action. Entitled “Let there be (natural) light, it invokes a collective identity that encompasses all its readers in its opening paragraph: “the extent of the problem, laid out in our Focus on dark skies, is startling and should turn us all into activists.” The journal does not specify that this is uniquely the role of space scientists, although these likely dominate the readership. Instead, it positions all readers as equally affected by the matter, whatever their background, and promotes an active subject advocate stance more traditionally associated with the humanities rather than science communication. After summarising the relevant papers in the issue, the editorial ends with a reference to the recently finalised United Nations High Seas Treaty (2023) as a plausible model and template for a future orbital regulation.

The first opinion piece, by astronomer Aparna Venkatesan, is entitled “Stewardship of space as shared environment and heritage” and presents a narrative of threats to the cultural role of astronomy. In the context of a storylistening analysis, it contains a telling passage:

> *Space is our shared heritage and ancestor — connecting us through science, storytelling, art, origin stories and cultural traditions — and it is now at risk. Many of today’s leading space exploration corporations themselves harness the power of storytelling, depicting the colonization of space as a frontier and an escape: a modern ‘manifest destiny’. These narratives amplify conquest rather than communities, and feature only a few apex saviours with no roles for most of humanity. In contrast, the origin stories of the Big Bang theory or millennia-old sky traditions have our common heritage and belonging as the resonant centrepiece.” (*Venkatesan, 2023)

There is no ambiguity in the framing of Venkatesan’s narrative here. It explicitly positions problems of SDA and dark skies protection as an attack on the shared heritage invoked by the UN Outer Space Treaty (1967) - the responsibility of, and affecting the rights of, all humanity. Venkatesan both stresses the importance of stories in shaping our understanding of our relationship with space and critiques the way they can be used to communicate ideals and assumptions that may not be recognized by casual story-imbibers.

The article is also overt in its critique of past resource utilisation on Earth. Discussing the need for legislation of space, Venkatesan questions whether the export of corporate culture to the unregulated near-Earth environment might lead to unrestrained sexism, racism or other inequalities. Here the history of western industrial society on Earth, its unmoderated exploitation of resources in unregulated contexts, and its historical record of inequality is being held up as a narratively-constructed model for the future of space, in order to argue the need for accountability and oversight.

Space scientist Fabio Falchi and collaborators contributed the second opinion article in the Focus issue: “A call for scientists to halt the spoiling of the night sky with artificial light and satellites”. The framing of this piece is passionate subject advocacy - urging scientists to take an active stance rather than act as passive information brokers. As was the case for Venkatesan, Falchi et al invoke the loss of cultural heritage as a framing for their argument:

> *The loss of the natural aspect of a pristine night sky for all the world, even on the summit of K2 or on the shore of Lake Titicaca or on Easter Island is an unprecedented global threat to nature and cultural heritage.* (Falchi et al, 2023)

This cultural heritage framing is accompanied by a more aggressive positioning of the paper as a critique of corporate greed. The article extensively uses narrative in the form of anecdote and cultural references to build its model of the current system and anticipate the future. A key passage reads:

> *Let's recall what has happened in other fields in the last decades, such as the findings related to tobacco smoke (active and passive), acid rain, climate warming, diesel emissions, asbestos, the ozone hole, silicosis, PFAS (forever chemicals), opioids, and sugar, to name only some. Every time some health or environmental issue arises and starts to be addressed in the scientific literature, the 'machine of doubt' is put into action by the polluters to stop, or at least delay by years or decades, the adoption of countermeasures and rules to protect human health and the environment. The strategy is always the same.* (Falchi et al., 2023)

The model under construction here is one Falchi and coauthors term "big light" in analogy to the 'big oil', 'big tobacco' and 'big pharma' labels used by subject advocates to argue against profit-driven corporate decision making. A story of the deliberate decision by past manufacturers to limit the lifetimes of lightbulbs is used to question how current producers of LED lighting will create new markets for their products and consider possible consequences for light pollution. The authors also identify "big space" as a model for satellite mega-constellation proliferation, characterising the issues facing dark sky protection as socio-political rather than scientific in nature. As in the quoted passage, they anticipate that attempts to regulate mega-constellations will face active resistance from those whose profits are threatened. The authors' firm advocacy framing urges scientists to campaign for regulation rather than mitigation of the problem but falls short of detailed anticipation of the process by which this can be achieved.

The remaining articles in the Focus issue communicate more technical and quantitative insights into the impact of light pollution and satellite mega-constellations on astronomy, together with the difficulty of modelling that impact. However - as is the case for most scientific research publications - each begins and concludes with passages describing the context of the work and interpreting the quantitative results for readers. In the 'perspective' review article (Barentine et al 2023), this is framed as a narrative: it identifies mega-constellations as a technology disruptive of the current equilibrium, recognises and explores the impact of their unlimited expansion, and projects a possible set of consequences. Their critique of the current expansion in the final analysis is stark and - as was the case for Venkatesan - explicitly comments on the construction of narrative by mega-constellation operators:

> *Despite a narrative of democratizing space and delivering affordable global broadband, it is a model that prioritizes urgency, privatized benefits and short-term goals over real sustainability and the public interest. This also ignores our shared ancestry and heritage in space.* (Barentine et al., 2023)

However, the narrative conflict is left unresolved, expressing hope for a more regulated future rather than anticipating of concrete solutions. Indeed, the idea of on-orbit debris removal (prominent in many SDA narratives, e.g. Alexander, 2022) is effectively dismissed as unproven and unlikely to make a big impact.

Figure 1 summarises the structural elements of narrative in this Focus issue. We find all four aspects of the storylistening framework addressed, making plain the common themes and differences between authors.

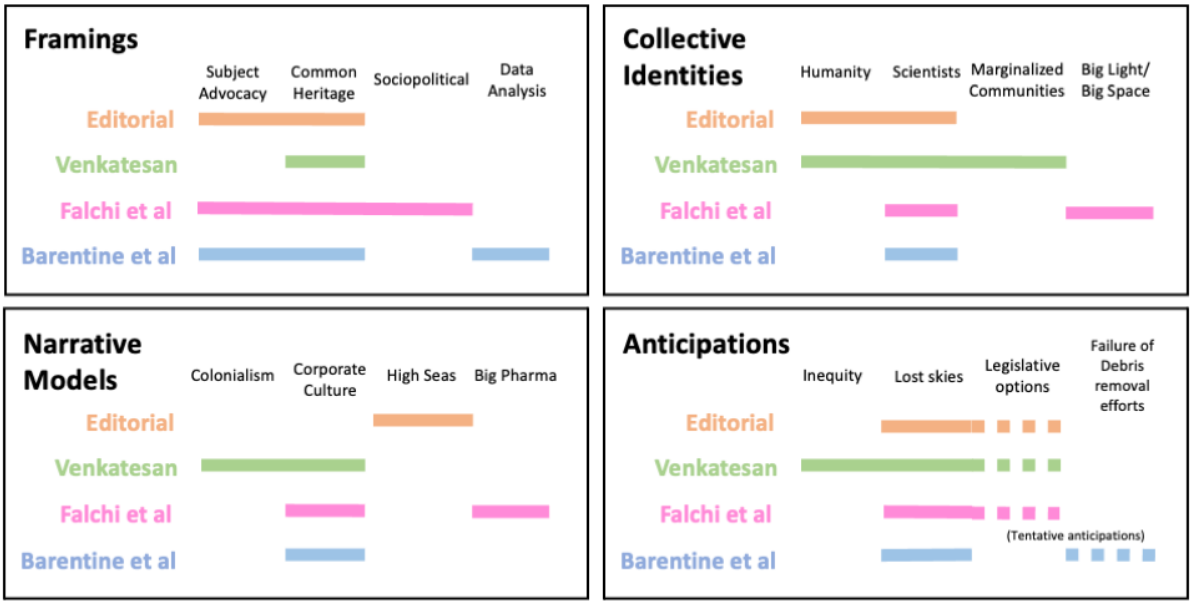

Figure 1: The different narrative elements of four articles in the March 2023 Dark Skies Focus issue of Nature Astronomy *journal.*

The Dark Skies Focus issue attracted media attention to SDA. A report distributed by the Agence France Presse (Collen 2023) appeared in publications as diverse as India Engineering News, Japan Today, ABS (Australia), Daily Sabah (Turkey), ScienceAlert (US) and Today Online (Singapore) amongst others, and in modified form in eNCA (South Africa, Suarez 2023). This report follows the narrative of the articles closely, drawing excerpts of text from each to highlight the collective identity of scientists as those sounding the alarm, the framing in terms of cultural and natural losses and the anticipation that the situation will worsen without regulation. Similar reports appeared in French language newspapers (including Le Figaro and France24), in the UK (e.g. Davis, 2023; Blakely et al 2023) and elsewhere (e.g. Singh, 2023). The Altmetric (2023, May 30) aggregator for online reports lists 96 news articles, 5 blogs, 2 public Facebook pages and 137 tweets discussing the strident Falchi et al. article on astronomical advocacy, which formed the focus of much of the reporting. While many of these represent re-tweets or repetitions, several twitter users have chosen to direct their comments to Elon Musk and Jeff Bezos, the CEOs of two of the leading space technology firms. Here we see individuals associating themselves with the collective identities invoked in the narrative, but sometimes reframing the problem as one for isolated individuals to resolve rather, than as a common problem which requires collective action.

Several news reports conflated the *Nature Astronomy* articles with a letter published in Science on less than two weeks earlier (Napper et al., 2023) calling for a global treaty to limit space debris. This invoked the tragedy of the commons as a framing, with reference to the High Seas Treaty as a narrative model. It had itself attracted considerable media coverage (altmetric identified 68 news outlets, 4 blogs and 85 tweets by the time of writing in May 2023,

e.g. Marshall, 2023). The conflation of dark skies and SDA reports in the context of mega-constellation news narratives is inevitable, and media responses to the *Nature Astronomy* articles cannot be considered without the context of other media attention both before and after their March 2023 release. A near miss between satellites in January 2023, for example, created a flurry of public attention regarding space debris, while press releases promising high speed satellite broadband, and near-continuous launches of naked-eye-visible and highly distinctive Starlink satellite trains have kept the mega-constellation issue literally in the public eye over much of the last two years.

As this case study demonstrates, scientific and science-adjacent reporting makes a constant use of narrative to frame and enhance its messaging. Understanding the cognitive and functional role of these narratives is essential to understanding how the public, and policymakers, perceive the information scientists provide. This is certainly true of science publications, but may also be appropriate in the context of non-text-based science communication, as we will explore next.

Case Study 3: *Our Fragile Space*

Our Fragile Space is an art installation and exhibition, created by photographer Max Alexander. Debuting in private showings at insurance brokers Lloyds of London in October 2022, to highlight the potential financial impact of space debris, and at Spaceport Cornwall for the January 2022 Virgin Space launch attempt, it was installed for public viewing in Coventry Cathedral Ruins for three weeks in May 2023, and will be taken to the next session of the UN Committee on the Peaceful Uses of Outer Space (COPUOS, May-June 2023) and to the Blue Dot Festival (July 2023), amongst other venues over the next two years. The exhibition comprises 75 photographs and illustrations together with accompanying text, exploring different aspects of space debris and near-space activity and collectively building a narrative of human space utilisation. Originally funded and developed with support from the University of Warwick's Habitability Global Research Priority fund and Centre for Space Domain Awareness, Alexander further developed the project working with a range of space scientists, industrial stakeholders and others, who are featured amongst the images. As such, this is an example of narrative co-creation which crosses interdisciplinary boundaries.

Alexander describes himself as an "editorial and commercial photographer" who "specialises in science communication through photography"[4]. Perhaps unsurprisingly then, a prominent **collective identity** invoked by the exhibition is that of the scientific community. A large number of the images in the exhibition are portrait photographs, featuring scientists including Dr Robert Massey of the Royal Astronomical Society, Prof Donald Kessler and Dr Jonathan McDowell (a prominent space debris scientist on social media). Other images feature crystal-sharp images of space-science equipment, the results of controlled experiments, such as those simulating space debris impacts, or clean-rooms for satellite construction, complete with staff in protective clothing. Importantly, however, Alexander is careful not to present the scientific community solely in the context of traditional western scientism or as entirely distinct from the self-identity of potential audiences. Scientists including Moriba Jah (University of Texas at Austin) and Mini Chakravarthini Rai (University of Lincoln) are shown in the traditional dress of their non-western background cultures, visualizing the connection between their identities

[4] http://www.maxalexander.com/profile/ (accessed 29th May 2023).

as scientists and aspects of non-scientific identity. Others are shown dressed casually in jumpers, T-shirts and jeans. In the juxtaposition between the space debris context and the informal or traditional dress, Alexander constructs a collective identity for the space science community that extends beyond the traditional boundaries of their discipline and reconnects with the commonality of humankind.

Alexander also contextualises the image of scientists, engineers and experiments with other imagery including anonymous portraits of a car user, a bicycle courier, a farm worker and pilots landing an aeroplane in Tenerife, all dependent on satellite navigations, as well as images of busy roads, landfill sites and financial centres. Collectively, these encompass an extensive range of aspects of modern western life and so present a construction of collective identity that extends to embrace that of the viewing public.

Based on picture selection and presentation, Alexander is clearly **framing** space debris as a problem and a danger to our modern way of life. Examples of impact damage, including a photograph taken while on the International Space Station by astronaut Tim Peake, emphasise the danger to life for those few in space. However the inclusion of images of ambulances, aeroplane flightdecks and finance hubs emphasises the more immediate risks that affect the audience directly. In images of Robert Massey (a vocal advocate for dark sky protection, Massey, 2020) positioned against the light-pollution and skyglow of London's skyscrapers at night, satellite trails above a neolithic burial chamber, and the radio interference seen by Jodrell Bank Observatory, Alexander expands his space debris framing to encompass the dark and quiet sky protection motif.

The framing of an art exhibition is unusual in that it can vary depending on the location of the installation. *Our Fragile Space* debuted at Lloyds of London, with the modernist architecture of the building providing a strong framing of space debris as an economic issue for satellite operators and, by extension, their insurers. Shown at Spaceport Cornwall it was framed by aspirations for UK space utilisation, emphasising the prominence of UK scientists and start-up companies amongst the imagery. Displayed in Coventry Cathedral Ruins (the legacy of World War II incendiary bombs, Figure 2), it is framed by evidence of humanity's inhumanity to others, wasteful destruction and conflict, and so emphasises the destructive power of space debris and the importance of cooperation to resolve the issue. Taken to the COPUOS meeting in Vienna, it is framed by the need for improved regulation and discussion of international space policy. And displayed at the Blue Dot festival, in the shadow of the Jodrell Bank Observatory's Lovell Telescope, it emphasises both the dark and quiet sky framing and the connection to the lives of the viewing public. These framings are clearly intentional on the part of the artist and demonstrate the need to consider not just the narrative evidence as presented but also its contextual setting.

Figure 2: Use of Second World War ruins at Coventry Cathedral to frame a space debris narrative in Our Fragile Space *(May 2023).*

Our Fragile Space is a self-guided exhibition with images viewable in any order, based on the circulation of a visitor around the photograph frames. However it is also clearly constructed as a narrative, and the intended viewing sequence of the frames is more explicit by the exhibition guide produced for the Lloyds of London premier (Alexander, 2022). This divides the images under nine subheadings of varying length, beginning with “Our Links to Space” and moving through “A Cluttered and Noisy Sky”, “The Cost of Living”, “Recognising the Threat of Space Debris”, “Eye on the Sky”, “Technology and Techniques for Removing Debris from Orbit”, “What we Leave Behind”, “Racing to the Top” and “Our Orbital Future”.

Of these, the first five sections use imagery and associated text (including guest essays) to construct a **narrative model** of our current interaction with the near-Earth environment, and its emerging impacts on the world in which we live. They present both the successful integration of satellite technology with our current society and way of life, and the threat to it as demonstrated by growing evidence of debris accumulation and impact damage, as well as cultural damage associated with dark and quiet sky losses. This is an effective use of visual images and their brief descriptions to construct a narrative model of our world and its current status that is more evocative and more easily visualised by audience than the quantitative model of facts and statistics that would form a more traditional science communication. Alexander confirmed this in his written introduction to the exhibition:

> Our Fragile Space *takes a human perspective, from the ground looking up, connecting the Earth to the near-space environment. I chose this everyday approach to make the issues more tangible because space debris is just up there, part of Earth’s environment.* (Alexander, 2022)

Thus his model building is explicitly intended to provide a framework in which visitors, and expert storylisteners, can contextualise the current SDA landscape and its possible evolution.

The final four sections of the exhibition present a more **anticipatory narrative**, which is rooted in contemporary technology development but extends towards a speculative future. Given the

photographic medium, most of the imagery here is of individuals working in this field or of current experimental technology. It captures the large and active market in start-up companies exploring space debris removal, and as such is positioned as optimistic regarding the chance of controlling space debris in the future. The short section “Racing to the Top” combines text from a satellite-specialist legal expert, Prof Joanne Wheeler, with imagery of text of the UN Outer Space Treaty and a portrait of Wheeler behind an armillary-sphere sundial, anticipating the need for regulatory and space policymaker involvement in shaping the future geometry of this field. The anticipation value in the *Our Fragile Space* narrative is relatively limited, nonetheless, since it is unable to extend more than a few years beyond our current time. Instead the anticipation is mostly implied by the absence of a clear picture of the future: by implication an absence of action will lead to continuation and worsening of the problems already presented in the modelling sections.

Perhaps unsurprisingly, the media and public response to *Our Fragile Space* has been limited by the need for informed commentators to attend the exhibition in person. The majority of reporting has been based on press releases from sponsors and involved organisations, rather than personal responses to the exhibition. Popular science magazine New Scientist published a short comment (Li, 2023) based on press release text, accompanied by images from the exhibition. An article appeared on the BBC News Website, quoting Alexander and the University of Warwick’s Professor Don Pollacco, also based on a press release from the university and lacking original narrative commentary (Dawkins, 2023). By contrast, local newspaper, *The Coventry Observer*, also reported from the same release but emphasised the framing invoked by the local setting, repeating the press release statement that it *“aims to enable viewers to reflect on their understanding of the skies above from the threat of the November 1940 Blitz to a fragile and threatened environment”* (Smith, 2023).

There was equally muted response on social media, with Twitter reaction limited to involved parties and a handful of tweets from New Scientist magazine publicising their article on the exhibition. These received a few responses from the public, mostly commenting on the tendency of humans to pollute their environment, although two readers tagged the post for the attention of Starlink CEO Elon Musk (who did not respond). These responses, while few, construct their own narrative models on the issue at hand. For example, the tweet

> *This will be the 'what were we thinking?' issue equivalent of the plastic lined rivers and oceans today in twenty years. What is it with humanity and waste?* (Howson, 2023)

invokes a ground-based environmentalist model for space debris, and, through the use of “we” explicitly recognises the commenter’s own participation in the collective identity of those at fault. By contrast,

> *@elonmusk any plans to address this issue in future? You seem to be our only hope with most things that involve technology!* (H, 2023)

instead positions the report within an anticipatory paradigm that requires actions from others, in this case a technology celebrity. Finally,

> *'Prison Earth.' It could stifle space travel in the future. Are you @neiltyson and @elonmusk.* (FSM, 2023)

also takes an anticipatory approach, this time focussing on the possible consequences of inaction. As in the previous tweet, it invokes celebrity rather than recognising the commenter's own identity as amongst those affected, although the grammatical construction does not make it clear whether the individuals identified are mentioned as part of the problem, part of the solution, or simply as needing to be made aware of the issue.

This public response to *Our Fragile Space* is likely indicative of the physical restrictions of the exhibition format and the demographic of those likely to visit the exhibition to date. It demonstrates the limitations of this form of narrative construction as a tool for public communication. However, as the storylistening analysis above demonstrates, *Our Fragile Space* illustrates the potential of artist/science community co-creation to provide constructive narrative evidence that informs the space policy debate, communicating concepts and concerns without the need for quantitative and statistical evidence.

Storylistening in a Space Science Context

Here we have presented a synthesis of narrative evidence in the areas of space domain awareness and dark sky protection policy input in the context of the storylistening framework. In each case, the consideration of narrative evidence - *"the product of the expert act of both direct critical engagement with stories, and critical engagement with others' reading, viewing, or listening to stories"* (Dillon & Craig, 2022) - through storylistening techniques highlights aspects of the use of narrative in communication by space scientists. The need for attention to such narratives has also been highlighted by others.

Madden & Koprowski (2020) asserted that *"space has a narrative problem"*. They urged that the construction of narrative, and in particular the narrative of loss and disaster, was essential in communicating the risks of space debris to currently-disengaged audiences. Their analysis of *"an engaging, humanizing narrative"* for space in the context of their "Without Space" science outreach project closely mirrors the storylistening framework in its emphasis on framing (to address a wide variety of publics), communicating collective identities (i.e. that all humans are affected through a range of relatable examples), modelling (as noted, *"narratives allow audiences to make sense of data in their social context"*) and the effectiveness of anticipations (i.e. in the results for individuals, rather than nations, of a loss of satellite communications).

But while the storylistening framework can provide insight into scientific narratives, it may be worth considering whether it also has limitations. To take an example, in a newspaper article on space debris for The Guardian in 2022, Ian Sample presented a clear overview of the UK's SDA activities. He uses framing in the context of UK innovation, the film *Gravity* to provide a narrative model, and an anecdotal narrative of his visit to RAF Fylingdales to contextualise the nature and extent of the UK's space tracking efforts. His discussion of orbital collisions between satellites (with specific reference to the interaction between the communications mega-constellations and larger vehicles) invokes a narrative based on familiar, ground-based traffic to model less familiar orbital dynamics: *"There is no highway code in space, no accepted right of way. So it's often those with most to lose who ensure disaster is averted."* (Sample, 2022).

Such science-adjacent reporting is clearly amenable to analysis of the framings, collective identities and models emphasised in the storylistening paradigm. However, in the area of anticipation, science and science-adjacent narratives appear to fit less straightforwardly into such analysis. As was the case in *Our Fragile Space* (Alexander, 2022), Barentine et al (2023), Falchi et al (2023) and as in *Gravity's* omission of any discussion of longer-term consequences of the debris event, Sample stops short of resolving his narrative. Instead of a clear anticipatory narrative model, he presents a discussion of the current efforts to mitigate the future space debris problem. This reports current advisory guidance on practice, and novel technologies to deorbit extant debris, without expressing a firm opinion on their likely success or failure. Such substitution of plausible or aspirational next steps in place of the firm anticipation expected of most narratives appears to be common in the case studies considered here and suggests that in scientific and science-adjacent narratives, the role of anticipation in the storylistening framework may need to be adjusted. The emphasis in scientific training on evaluating probabilities favours a more tempered discussion of possible outcomes, rather than firm predictions. Indeed Gluckman et al (2021) identified communication of "*the uncertainties, caveats, and reliability of evidence"* as one of the key roles of effective brokerage at the science-policy interface – one that overtly anticipatory narrative in space science is ill-suited to address.

This possible wariness of speculative anticipation amongst scientific communicators was articulated by Peter Calow (2023) in a letter published in response to Craig & Dillon's 2023 article '"Storylistening" in the science policy ecosystem'. As he notes: *"Science delivers options, not solutions"*. Calow also highlighted concerns regarding the ability of narrative to deviate from or modify the truth - a concern that echoes the debate over accurate orbital physics in *Gravity* referenced in the case study above. As has been discussed before (e.g. Schlaufer 2018), it is certainly possible for narrative constructions to present different politically-motivated interpretations even when based on the same scientific data. However, in their responding letter, Craig and Dillon noted a distinction between *storytelling* (the role of science communication) and *storylistening* (the expert act of critical engagement with the story). The latter can recognise and acknowledge the flaws and narratively-required manipulation of the former.

As this synthesis has demonstrated, despite the challenges of reconciling humanities and scientific approaches, storylistening provides a framework for the informed analysis of science narratives, allowing these, as well as the data on which they are based, to form part of a pluralistic evidence base in space policy decision making.

Bibliography:

Alexander, M., (2022). *Our Fragile Space* [Exhibition catalogue]. Exhibited at Lloyds of London October 6 – 21 2022.

Altmetric, (2023). A call for scientists to halt the spoiling of the night sky with artificial light and satellites. Overview of attention for article published in *Nature Astronomy*, March 2023. *Altmetric*. https://nature.altmetric.com/details/144115576/twitter

Atkinson, S., (2016). *Gravity*—Towards a Stereoscopic Poetics of Deep Space. In: Spöhrer, M. (eds) Die ästhetisch-narrativen Dimensionen des 3D-Films. *Neue Perspektiven der Medienästhetik*. Springer VS, Wiesbaden. doi: 10.1007/978-3-658-09422-5_5

Barentine, J. C., Venkatesan, A., Heim, J., Lowenthal, J., Kocifaj, M., & Bará, S. (2023). "Aggregate effects of proliferating low-Earth-orbit objects and implications for astronomical data lost in the noise", *Nature Astronomy*, 7, 252. Doi: 10.1038/s41550-023-01904-2

Blakely, R., (2023, Mar 21). Satellites and light pollution blocking astronomers' view. *The Times* (London). https://www.thetimes.co.uk/article/satellites-and-light-pollution-blocking-astronomers-view-5pkqz9xd6

Blair, A., (2018). An Exploration of the Role that the Night Sky Plays in the Lives of the Dark Sky Island Community of Sark. *Journal of Skyscape Archaeology*, 3(2), 236–252. doi: 10.1558/jsa.34689

Blothner, D., (2015). The 'poor ego's' adventures in outer space – Gravity by Alfonso Cuarón, *The International Journal of Psychoanalysis*, 96:1, 211-223, doi: 10.1111/1745-8315.12294

Calow, P., (2023). Storylistening's role in policy advice. *Science*, 379, 1198-1198. doi: 10.1126/science.adg8025

Candusso, D., (2016). 'Designing a sonic landscape: A practice-led approach to creating 3-D sound space for screen', *Fusion Journal*. BATHURST, NSW, Australia: Charles Sturt University - Faculty of Arts and Education, (10), pp. 144–161. https://search.informit.org/doi/10.3316/informit.247911701216803.

Carroll, S., (2019). Lost in Space: Surviving Globalization in *Gravity* and *The Martian*. *Science Fiction Studies*, 46(1), 127–142. doi: 10.5621/sciefictstud.46.1.0127

Chepesiuk, R., (2009). Missing the Dark - Health Effects of Light Pollution. Environmental *Health Perspectives*, 117(1), A20-27. doi: 10.1289/ehp.117-a20

Clormann, M. & Klimburg-Witjes, N., (2020). "Space Debris Sustainability: Understanding and Engaging Outer Space Environments", in Madi, M., & Sokolova, O. (Eds.). (2020). *Space Debris Peril: Pathways to Opportunities* (1st ed.). CRC Press. doi: 10.1201/9781003033899

Collen, J., (2023, Mar 20). Astronomers sound alarm about light pollution from satellites. *Agence France Presse*. https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:67TP-1T11-DY93-M22J-00000-00&context=1516831.

– (2023, Mar 20). Astronomers sound alarm about light pollution from satellites. *Japan Today*. https://japantoday.com/category/features/environment/astronomers-sound-alarm-about-light-pollution-from-satellites

– (2023, Mar 20). Astronomers sound alarm about light pollution from satellites. *ABS-CBN*. https://news.abs-cbn.com/spotlight/03/21/23/astronomers-sound-alarm-about-light-pollution-from-satellites

– (2023, Mar 21). Satellites Pose 'Unprecedented Global Threat', Scientists Warn. Here's Why. *Science Alert* (USA). https://www.sciencealert.com/satellites-pose-unprecedented-global-threat-scientists-warn-heres-why

– (Uncredited) (2023, Mar 21). Astronomers sound alarm about light pollution from satellites. *Today online*. https://www.todayonline.com/world/astronomers-sound-alarm-about-light-pollution-satellites-2133931

– (Uncredited), (2023, Mar 21). Astronomers sound alarm about light pollution from satellites. *India Engineering news*. https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:67TX-20R1-JBYT-H2YB-00000-00&context=1516831.

– (Uncredited), (2023, Mar 21). Alarm around Earth: Astronomers worry of satellite light pollution. *Daily Sabah*. https://www.dailysabah.com/life/science/alarm-around-earth-astronomers-worry-of-satellite-light-pollution

– (2023, Mar 22). Astronomers sound alarm about light pollution from satellites. *Space Daily*. NewsR.in https://www.newsr.in/n/Science/1zpks0pnv3/Astronomers-sound-alarm-about-light-pollution-from-satellites.htm

Craig, C. & Dillon, S., (2023). “Storylistening” in the science policy ecosystem. *Science*, 379, 134-136. doi: 10.1126/science.abo1355

Cuarón, A., (2013). *Gravity*. Warner Bros. Pictures.

Davis, N., (2023, Mar 20). Calls for ban on light-polluting mass satellite groups like Elon Musk’s Starlink. *The Guardian* (London). https://www.theguardian.com/science/2023/mar/20/light-polluting-mass-satellite-groups-must-be-regulated-say-scientists

Dawkins, A., (2023, May 9). Coventry exhibition highlights dangers of space debris. *BBC News*. https://www.bbc.co.uk/news/uk-england-coventry-warwickshire-65497564

Degenring, F., (2015). On behalf of the dark: functionalisations of light pollution in fiction in *Dark nights, bright lights: night, darkness and illumination in literature*, 201-225.

Derrien, M. M. & Stokowski, P. A., (2020). Discursive constructions of night sky experiences: Imagination and imaginaries in national park visitor narratives, *Annals of Tourism Research*, 85,
2020, 103038, doi: 10.1016/j.annals.2020.103038.
Dillon, S. & Craig, C. (2022). *Storylistening: Narrative Evidence and Public Reasoning*. Routledge. ISBN: 1000467260

Deshmukh, S., & Murthy, J., (2014). "Nightfall: Can Kalgash Exist", *arXiv e-prints*, arXiv:1407.4895. 10.48550/arXiv.1407.4895

Dunnett, O., (2015). Contested landscapes: the moral geographies of light pollution in Britain. *Cultural Geographies*, 22(4), 619–636. doi: 10.1177/1474474014542746

Falchi, F et al., (2016). The new world atlas of artificial night sky brightness. *Sci. Adv*, 2, e1600377. doi: 10.1126/sciadv.1600377

Falchi, F., Bará, S., Cinzano, P., Lima, R. C., & Pawley, M., (2023). "A call for scientists to halt the spoiling of the night sky with artificial light and satellites", *Nature Astronomy*, 7, 237. doi: 10.1038/s41550-022-01864-z

Fitzsimmons, A., (2022, Sep 15). 'Fireball' sighting: Our night skies are becoming more polluted with satellites, meteors and space debris. *Belfast Telegraph* Online. https://www.belfasttelegraph.co.uk/news/northern-ireland/fireball-sighting-our-night-skies-are-becoming-more-polluted-with-satellites-meteors-and-space-debris/41992935.html

FSM [Flying Spaghetti Monster, @FSM_Official1] (2023, May 8). 'Prison Earth.' It could stifle space travel in the future. Are you @neiltyson and @elonmusk [Tweet]. *Twitter*. https://twitter.com/FSM_Official1/status/1655427832745476097

Gärdebo, J., Marzecova, A., & Knowles, S. G., (2017). The orbital technosphere: The provision of meaning and matter by satellites. *The Anthropocene Review*, 4:1, 44-52. doi: 10.1177/2053019617696106

Gilad, M., (2016). How City Lights have made the stars disappear. *Haaretz*. Israel. https://www.haaretz.com/science-and-health/2016-09-23/ty-article-magazine/.premium/how-city-lights-have-made-the-stars-disappear/0000017f-e628-d97e-a37f-f76df3e70000

Gluckman, P.D., Bardsley, A. & Kaiser, M., (2021). Brokerage at the science–policy interface: from conceptual framework to practical guidance. *Humanit Soc Sci Commun,* 8, 84. doi: 10.1057/s41599-021-00756-3

GNOSIS, (2022). Space Sustainability for the Next Decade (and Beyond). GNOSIS Annual Conference 2022. https://gnosisnetwork.org/gnosis-annual-conference-2022/ [accessed: 30 May 2023]

H [@heyhokunty] (2023, May 11). @elonmusk any plans to address this issue in future? You seem to be our only hope with most things that involve technology! [Tweet]. *Twitter*. https://twitter.com/heyhokunty/status/1656542572473458688

Hall, J., Walker, C., Rawls, M., McDowell, J., Seaman, R., Venkatesan, A., Hall, J., (2021). SATCON2: Executive Summary. In Report of the SATCON2 Workshop, 12–16 July 2021. doi: 10.3847/25c2cfeb.4554c01f

Hamacher, D. W., de Napoli, K., & Mott, B., (2020). "Whitening the Sky: light pollution as a form of cultural genocide", *arXiv e-prints*, arXiv:2001.11527. 10.48550/arXiv.2001.11527

Hawkins, J., (2022, Dec 8). SpaceX mega constellations may hinder planetary defenses, new survey says. BGR.com. https://bgr.com/science/spacex-mega-constellations-may-hinder-planetary-defenses-new-survey-says/ [Accessed: 30 May 2023]

Howson, S. [@samhowson] (2023, May 13). This will be the 'what were we thinking?' issue equivalent of the plastic lined rivers and oceans today in twenty years. What is it with humanity and waste? [Tweet]. *Twitter*. https://twitter.com/samhowson/status/1657287682655911936

Kessler, D. J., & Cour-Palais, B. G., (1978). "Collision frequency of artificial satellites: The creation of a debris belt", *Journal of Geophysical Research*, 83, 2637. doi: 10.1029/JA083iA06p02637

Kocifaj, M., Kómar, L., Lamphar, H., Barentine, J., & Wallner, S., (2023). "A systematic light pollution modelling bias in present night sky brightness predictions", *Nature Astronomy*, 7, 269. doi: 10.1038/s41550-023-01916-y

Kruk, S., García-Martín, P., Popescu, M., Aussel, B., Dillmann, S., Perks, M. E., Lund, T., Merín, B., Thomson, R., Karadag, S., & McCaughrean, M. J., (2023). "The impact of satellite trails on Hubble Space Telescope observations", *Nature Astronomy*, 7, 262. doi: 10.1038/s41550-023-01903-3

Li, G., (2023, May 3). Space debris problem highlighted in new series of photographs. *New Scientist*. https://www.newscientist.com/article/mg25834371-400-space-debris-problem-highlighted-in-new-series-of-photographs

Madden, E. & Koprowski, E., (2020). Solving Space's Narrative Problem. 71st International Astronautical Congress (IAC), 12-14 October 2020. https://www.researchgate.net/publication/344954950_Solving_Space's_Narrative_Problem_-_71st_International_Astronautical_Congress_IAC_-_The_CyberSpace_Edition_12-14_October_2020 [accessed: 30 May 2023]

Marshall, N., (2023, Mar 10). Scientists call for global action to tackle space junk. *The Independent*. https://www.independent.co.uk/space/space-junk-global-action-satellites-b2297877.html

Massey, R., Lucatello, S. & Benvenuti, P., (2020). The challenge of satellite megaconstellations. *Nature Astronomy*, 4, 1022–1023 . doi: 10.1038/s41550-020-01224-9

McKay, A., (2021). *Don't Look Up*. Netflix.

Michalitsianos, J., (2023, Jan 31). CLUTTERED SPACE Humans are destroying our chances of finding alien life with disturbing rise in 'space junk' around Earth, experts warn. *The Sun* (London). https://www.thesun.co.uk/tech/21219446/humans-are-destroying-alien-life-disturbing-rise-space-junk/

Mróz, P., Otarola, A., Prince, T. A., Dekany, R., Duev, D. A., Graham, M. J., Groom, S. L., Masci, F. J., & Medford, M. S., (2022). "Impact of the SpaceX Starlink Satellites on the Zwicky Transient Facility Survey Observations", *The Astrophysical Journal*, 924, L30. doi: 10.3847/2041-8213/ac470a

Napper, I. E. et al., (2023). Protect Earth's orbit: Avoid high seas mistakes. *Science* 379, 990-991. doi: 10.1126/science.adg8989

Nature Astronomy, (2023). "Let there be (natural) light" [Editorial], *Nature Astronomy*, 7, 235. doi: 10.1038/s41550-023-01935-9

New York Times, (2008, Oct 07). A Little Less Light [Editorial]. *New York Times*, A30. http://0-search.proquest.com/historical-newspapers/little-less-light/docview/897162506/se-2

Palmer, L., (2019). Untethered technology in Gravity: Gender and spaceflight from science fact to fiction. *Science Fiction Film and Television,* 12(1), 29-51. https://www.muse.jhu.edu/article/720347.

Pettit, H., (2020, Apr 20). NIGHT LIGHTS How to see Starlink satellites – Elon Musk's bright space tech to pass over UK TONIGHT. *The Sun* (London). https://www.thesun.co.uk/tech/11438821/how-to-see-starlink-elon-musk-spacex-satelite-uk/

Pfleger, A., Gerber, A. and Struck, A., (2022). Strategic communication at the European Space Agency: juxtaposing strategy and public attitudes *JCOM*, 21(06), A02. doi: 10.22323/2.21060202

Pielke R., (2007). *The honest broker*. Cambridge University Press, Cambridge

Pielke R., (2015). Five modes of science engagement. Roger Pielke Jr.'s Blog: *Science, Innovation*, Politics. http://rogerpielkejr.blogspot.com/2015/01/five-modes-of-science-engagement.html. [Accessed 30 Mar2023]

Plait, P., (2013, Oct 4). "Bad Astronomy Movie Review: Gravity". *Slate*. https://slate.com/technology/2013/10/bad-astronomy-movie-review-gravity.html [Accessed: 29th May 2023]

Riegel, K. W., (1973). "Light Pollution", *Science*, 179, 1285. doi: 10.1126/science.179.4080.1285

Reisman, G., (2013, Oct 17). "What Does A Real Astronaut Think Of 'Gravity'?". *Forbes*. https://www.forbes.com/sites/quora/2013/10/17/what-does-a-real-astronaut-think-of-gravity/ [Accessed: 29th May 2023]

Read, R., (2023). Wittgensteinian Film-as-Philosophy Exemplified: Exploring the Exploration of Point-of-view in Cuaron's Space-Exploration Film Gravity. In: Fox, C., Harrison, B. (eds) *Philosophy of Film Without Theory*. Palgrave Film Studies and Philosophy. Palgrave Macmillan, Cham. doi: 10.1007/978-3-031-13654-2_8

Royal Astronomical Society, (2020). Satellite Mega-Constellation Meeting. Presentations and notes. https://ras.ac.uk/ras-policy/science-policy-consultative-forums/satellite-megaconstellations [Accessed: 30 May 2023]

Sample, I., (2022, Apr 21). Mind that satellite! The mission to clean up dangerous space junk. The Guardian. https://www.theguardian.com/science/2022/apr/21/mind-satellite-mission-clean-up-dangerous-space-junk-astronauts-debris

Sánchez de Miguel, A et al., (2022). Environmental risks from artificial nighttime lighting widespread and increasing across Europe. *Sci. Adv.*, 8, eabl6891. doi: 10.1126/sciadv.abl6891

Schlaufer, C., (2018). The Narrative Uses of Evidence. *Policy Stud J*, 46: 90-118. doi: 10.1111/psj.12174

Scott, R., (2015). *The Martian*. 20th Century Studios.

Singh, A., (2023, Mar 21). 'Light pollution from satellites worse than previously thought, warn scientists', *WIO News* (Canada). https://www.wionews.com/trending/light-pollution-from-satellites-worse-than-previously-thought-warn-scientists-574195

Smith, R., (2023, May 10). Cathedral hosts space exhibition. *Coventry Observer*

Stanway, E., (2022, May 15). "A FAB new vision for space?". *Cosmic Stories* blog. https://warwick.ac.uk/cosmicstories/a_fab_new/ [Accessed: 29 May 2023]

Suarez, M., (2023, Mar 20). Astronomers sound alarm about light pollution from satellites. eNCA.com https://www.enca.com/analysis/astronomers-sound-alarm-about-light-pollution-satellites

Todorov, T., (1971). The 2 Principles of Narrative. *Diacritics*, 1(1), 37–44. doi: 10.2307/464558

Trench, B., (2008). Towards an Analytical Framework of Science Communication Models. In: Cheng, D., Claessens, M., Gascoigne, T., Metcalfe, J., Schiele, B., Shi, S. (eds) *Communicating Science in Social Contexts*. Springer, Dordrecht. doi: 10.1007/978-1-4020-8598-7_7

Turnhout, E. et al., (2013). New roles of science in society: Different repertoires of knowledge brokering, *Science and Public Policy*, 40(3), 354–365. doi: 10.1093/scipol/scs114

United Nations, (1967). Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. https://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf [accessed: 30 May 2023]

United Nations, (1996). The 1979 Convention on Long-Range Transboundary Air Pollution. https://unece.org/sites/default/files/2021-05/1979%20CLRTAP.e.pdf [accessed: 30 May 2023]

United Nations, (2023, Apr 14). Draft agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. https://www.un.org/bbnj/sites/www.un.org.bbnj/files/a_conf232_2023_crp2_rev1_en.pdf [accessed: 30 May 2023]

Venkatesan, A., (2023). "Stewardship of space as shared environment and heritage", *Nature Astronomy*, 7, 236. doi: 10.1038/s41550-023-01915-z

Walker, C., Hall, J., Allen, L., Green, R., Seitzer, P., Tyson, T., Yoachim, P., (2020). Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigations. *Bulletin of the AAS*, 52(2). doi: 10.3847/25c2cfeb.346793b8

Walker, M. F., (1973). "Light Pollution in California and Arizona", *Publications of the Astronomical Society of the Pacific*, 85, 508. doi: 10.1086/129496

Watkins, G,. (2013, Oct 8). "An Astronaut Fact-checks Gravity". *Vulture*. https://www.vulture.com/2013/10/astronaut-fact-checks-gravity.html [Accessed: 29 May 2023]

Watercutter, A., (2013, Oct 7) “Astrophysicist Neil deGrasse Tyson Fact-Checks Gravity on Twitter”, *Wired*. https://www.wired.com/2013/10/neil-degrasse-tyson-gravity/ [Accessed: 29 May 2023]

White, J. (1964). *Deadly Litter*. Ballentine Books.

Witze, A., (2018). News Feature: The quest to conquer Earth’s space junk problem. *Nature*, 561, 24-26. doi: 10.1038/d41586-018-06170-1

Yanovitzky, I. & Weber, M. S., (2019). News Media as Knowledge Brokers in Public Policymaking Processes, *Communication Theory*, 29(2), 191–212, doi: 10.1093/ct/qty023

Yukimura M., (1999–2004). Planetes [プラネテス, Puranetesu], Kodansha Publishing (Tokyo)

Synthesis Paper 7

Classic and Contemporary Narratives of Space Exploration

Natalie Trevino (Space Ethics)

Executive Summary
From Ancient Greece to the Age of Discovery, outer space has been a source of inspiration, knowledge, and myths. Astrology and astronomy were fundamental to early civilizations. Over the last 65 years, the exploration of space has been a major aspect of the political and societal lives of those in the United States, the USSR (then Russia), Europe, the United Kingdom and much of Africa, Asia, and the Latin America. The justifications for space exploration are often linked to historical conditions-such is the case of the US-space as the new frontier speaks to American sensibilities and manifest destiny, while other historical analogies and narratives, like those of the United Kingdom, focus more on exploration as rationality and routine, mirroring the exploration of the seas and the Artic. Other narratives of space focus less on justifying the why and focus more of that possibilities of what space exploration could mean: we find these narratives in the countless works of Afro-futurism, Indigenous Futurism and works of fiction that inspire marginalized peoples and give hope for a better, brighter future. The narratives of space exploration both political justifications and possibilities come from history, experience and often, science fiction. Science fiction cannot be ignored when it comes to a feedback loop of inspiration from and for space exploration. From US President Ronald Reagan's use of Star Wars as a narrative to justify Cold War space technology research to Star Trek fans campaigning for the first Space Shuttle to be named Enterprise, science fiction and science fact often have just as much power and influence. Many classic space narratives often use historical myths to create meaning on a national level, the US with its frontier metaphor is not just popular, it is almost the dominate construction of space with both the UK and the Europe Space Agency using the language even while neither have Frontier history. The United Kingdom's use of Maritime narratives connects its own history as a strong Seafaring society to the exploration of space. Classic space narratives often tie exploration to the nation because during the Space Age space exploration was a national project, while know in the Newspace Age private companies have been major players. There has been an increase in speculative futurisms focused on Afro-centric and Indigenous futures. These contemporary narratives are beginning to have an impact on the way in which space discourse focuses on the who and why of space exploration. Rather than focusing on the nation, ethno-futurisms are focusing on the cultural, artistic, and technological possibilities of space.

Introduction:
While humans did not reach space until the mid-twentieth century due to the advancements of techno-science developed during World War 2, humans have been interested in space since, perhaps, the dawn of time. From Ancient Greece to the Age of Discovery, outer space has been a source of inspiration, knowledge, and myths. Astrology and astronomy were fundamental to early civilizations. Over the last 65 years, the exploration of space has been a major aspect of the political and societal lives of those in the United States, the USSR (then Russia), Europe, the United Kingdom and much of Africa, Asia and the Latin America. The justifications for space exploration are often linked to historical conditions-such is the case of

the US-space as the new frontier speaks to American sensibilities and manifest destiny, while other historical analogies and narratives, like those of the United Kingdom, focus more on exploration as rationality and routine, mirroring the exploration of the seas and the Artic. Other narratives of space focus less on justifying the why and focus more of that possibilities of what space exploration could mean: we find these narratives in the countless works of Afro-futurism, Indigenous Futurism and works of fiction that inspire marginalized peoples and give hope for a better, brighter future. The narratives of space exploration both political justifications and possibilities come from history, experience and often, science fiction. It is almost impossible to dive deep into the major aspects of space exploration without mentioning the impact of science fiction on the various space endeavours. From US President Ronald Reagan's use of Star Wars as a narrative to justify Cold War space technology research to Star Trek fans campaigning for the first Space Shuttle to be named Enterprise, science fiction and science fact often have just as much power and influence. Many classic space narratives often use historical myths to create meaning on a national level, the US with its frontier metaphor is not just popular, it is almost the dominate construction of space with both the UK and the Europe Space Agency using the language even while neither have Frontier history. The United Kingdom's use of Maritime narratives connects its own history as a strong Seafaring society to the exploration of space. Classic space narratives often tie exploration to the nation because during the Space Age space exploration was a national project, while know in the Newspace Age private companies have been major players. This is not to say that classic space narratives and stories have ceased to be important, no, rather that the narratives are expanding to include ethnic, cultural and inclusive stories. There has been an increase in speculative futurisms focused on Afro-centric and Indigenous futures. Culturally relevant speculative fiction has had a presence in Space discourse since the Space Age, famously Sun Ra's Space is the Place from 1972, situated space utopianism within the realm of Black Liberation.

Major Space Narratives:

Space exploration was one of the major projects of the twentieth century. With the Space Race between the USSR and the USA dominating the common knowledge of space, there is more too space than just the moon landing or later, the International Space Station. In my work as a space theorist, I have seen the variety of stories and values that have impacted space policy, practitioners and the general public. Space, the final frontier, is a phrase that many people know, but few know that space fact and science fiction are intimately linked, space as a frontier is just as much a US space policy point as it is a Star Trek reference (Trevino, 2020). In this synthesis paper, I will detail the various classic stories that are used to explain and justify space exploration as well as newer and more recent stories that have just begun to impact the realm of space. Both story types, what I am calling classic and contemporary, are important when considering the future of space governance. Broadly understood, these stories often link historical events to the present (or what is now the past) as a way to understand some relation between national identity, technology, and governance and the whole of the universe. Beginning with the United States and its use of the frontier as a story to inspire the development and continuation of a national program of space exploration, or what we now know as NASA, frontierism is probably the most well known and often used metaphor for space exploration. However, this is just one of the many nations that have historical narratives attached to their space projects. For the UK, it is the use of maritime metaphors and science fiction have been central to its cultural space experience (Dunnett, 2021). While the USSR centred communist values to its own program-notably secularism- countering the US use of

Christianity during the early days of NASA (Rubenstein, 2022). As more nations join the number of those with space programs or space ambitions, more national narratives will be introduced with the values that accompany them. Knowing and understanding these stories will help policy makers as they navigate the increase in diversity in space actors in space governance over the course of the next decade. This synthesis paper will be structured by detailing the major narratives of the United States, the United Kingdom and the Europe before moving on to examine the influential narratives of major science fiction and futurisms that have begun to impact space discourse. I structure it this way as to focus on the major Western space powers and those stories that have greatly influenced them. Then I move on to summarize the up-and-coming narratives involving inclusion and diversity in the realm of futurisms. There is a great wealth of US space narratives thus it may appear more detailed and important, however, this could be understood as an aspect of US space superiority during and after the Cold War, it is not that US narratives are universal or superiority, rather mirror the prominence of the US during the twentieth century.

Space, the final frontier. This is, arguably, the most famous phrase relating to space and space exploration. It is opening line of the 1960's television show Star Trek. Premiering in 1966, just shy of a decade after the creation of NASA and the start of the space race, Star Trek ran for three seasons, although it would go on to have movies and numerous other TV shows since. The full monologue:

> Space: the final frontier. These are the voyages of the starship *Enterprise*. Its five-year mission: to explore strange new worlds; to seek out new life and new civilizations; to boldly go where no man has gone before!

Later updated to be gender neutral, this statement has a cultural influence like nothing before it. But Star Trek did not invent that frontier and space relation, no, in fact, the use of the frontier metaphor in US space discourse came about before the venture into space (Johnston, 1958). Such phrasing appeared in a presidential memo on space exploration in the 1950s (Johnston, 1958). Even before that memo, Werner von Braun, a famous space advocate and NASA engineer, used that narrative when discussing space on "Man in Space" a television production produced with Walt Disney. "Man in Space" focused on the possibilities of space exploration, von Braun used the frontier metaphor as a way to connect the cultural pride American audiences to the exploration of space. This production itself was based on a series of Collier articles titled "Man will Conquer Space Soon," these articles were written by a variety of space enthusiasts and scientist, von Braun included. Much of the content of these articles influenced mid-century conceptions of space exploration: voyages to the Moon and Mars, space stations and extended living in space (Logsdon, 2010, 2019).

Let us return to Star Trek for a moment before explaining the full Frontier narrative of American space exploration. Star Trek had and continues to have a massive cultural impact on both science fiction and the world of science, many people working in the space industry cite the show as the inspiration for their career, technological development, including the mobile phone, were inspired by the technology of Star Trek (Dunbar, 2016) Star Trek fans themselves, are the reason why the original prototype space shuttle was named Enterprise (Woods, 2009). These facts are not merely cute anecdotes of space culture, but rather reveal the power that stories have on people and how they engage with the world around them. The influence of Star Trek on the realities of space exploration cannot be overstated. Famed

physicist Stephen Hawking was a fan of the series, once noting that he was working on how to create the “warp drive,” the in-universe source of propulsion (Ulster, 2018). The stories, ideas, technologies, and characters of Star Trek had and continue to have direct and indirect influences on policy, direction, and peoples. The relationship between NASA and Star Trek can be described as one of mutual appreciation and inspiration.

Notably, Star Trek is often cited as inspiration for Future Scientists. The television series and movies have played a significant role in inspiring many individuals to pursue careers in science, technology, engineering, and mathematics (STEM), including aerospace (Dunbar, 2016)). Over the years, NASA and the creators of Star Trek have collaborated on various projects. As mentioned earlier, NASA named its first space shuttle "Enterprise" following a successful write-in campaign by Star Trek fans. This collaboration helped promote both NASA's space shuttle program and the Star Trek franchise (Dunbar, 2016).

Star Trek's futuristic technology has often served as inspiration for real-life technological advancements. Many inventions and concepts depicted in Star Trek, such as handheld communicators (similar to modern smartphones) and tablet computers, have influenced the design and development of actual technologies. (Mars, 2019)

Star Trek has become an integral part of popular culture, and NASA recognizes its cultural significance. NASA often engages with popular culture to communicate its mission and inspire the public. Star Trek, with its emphasis on exploration, discovery, and scientific advancement, aligns well with NASA's objectives. The agency occasionally collaborates with Star Trek actors, incorporates Star Trek references in its outreach materials, and participates in events related to the franchise. Famously, Star Trek actress Nichelle Nichols who played Lieutenant Uhura, campaigned for NASA to help bring marginalized peoples into space exploration ((Reuters, 2022). I will return to Star Trek later in the section on Afro-futurism.

The story of the space frontier begins in the American west. While the actual history of the colonization of the Americas is one of genocide and destruction, the story of the West that is used to justify the exploration of space is one of courage and foresight (that is not to say that all of these events and qualities are mutually exclusive). The Pioneers that ventured into the wilderness of what would become the United States were men (and women) of a certain character. And this conception of the wester was first written about by a historian named Fredrick Jackson Turner.

Frederick Jackson Turner was responsible for constructing and canonizing the myth of the Frontier in his 1893 essay “The Significance of the Frontier in American History” and subsequent 1920 book The Frontier in American History. Space advocates cite Turner’s “Frontier thesis” as an inspiration and justification for space exploration (Bainbridge, 2009a, 2009b; Clarke, 1951, 1966, 1973; Cruz, 2018; Elias, 1990; Jenks, 1958; Johnson, 1970; Kauffman, 1994; Kearnes & van Dooren, 69 2017; Launius, 2000, 2002, 2004; Logsdon, 2010; O'Neill, 1977, 1981; Sadeh, 2002; Von Braun, 1952, 1991; Ward, 1966; R. Zubrin, 1999; Zubrin; & Wagner, 1996). For Turner, the frontier was not just a part of American history, but, rather, the central motivating component that powered the production of America as a nation-state. The qualities that defined the characteristics of American democracy were forged on the Frontier. According to Turner, the Frontier created the American character, and

demonstrated that European culture lacked the necessary elements to survive and conquer it. As Turner puts it:

For a moment, at the frontier, bonds of custom are broken, and unrestraint is triumphant. There is no tabula rasa. The stubborn American environment is there with its imperious summons to accept its conditions, the inherited ways of doing things are also there; and yet, in spite of the environment, and in spite of custom, each frontier did indeed furnish a new opportunity; a gate of escape from the bondage of the past; and freshness, and confidence, and scorn of older society, impatience of its restraints and its ideas, and indifference to its lessons, have accompanied the frontier (1960, p. 29).

For Turner, the American Frontier functioned as a set of the material conditions that generated new ways of being and relating both to other people and the natural world. The pioneers encountered the environment of the West that was significantly harsher and more inhospitable than the landscapes of European country. According to Turner, it was the meeting-place of "savagery and civilization" (Turner, 1960). It staged the encounter between man and the wild of nature. For Turner, the harsh environment of the American West was initially too tough for pioneers, because European ways of life did not fit these conditions (Turner, 1921). Drawing on Turner's Frontier Thesis, Historian Walter P. Webb theorized that the American frontier was so drastically different because, unlike Europe, where borders are semi-permanent, the American frontier was malleable and mutable with no recognizable nation or peoples beyond it (Webb, 1952). And while this is not objectively true, as Indigenous peoples lived there for centuries, neither Webb or Turner recognised Indigenous ways of life or governance as such because they did not meet the defintions of the West. In these accounts, the Frontier motivated and inspired American progress. For Turner, the Frontier produced most of the defining characteristics of American exceptionalism— the democracy, the individualism, and opportunity—that crafted the very essence of America. He documents the cases of three classes of people who were attracted to the Frontier: pioneers (who live on the land), immigrants (who develop the land) and capitalists (who purchased the newly cultivated land) All three classes pushed the borders of the nation westward (Turner, 1921). Pioneering, progress, enterprise, freedom, and rugged individualism are the primary characteristics that distinguish the American spirit from the old European ways of life. And so, these dominant values produced the overarching social and political structures of the United States (Turner, 1921). While this narrative of the American west is generally discredited now, it still has a massive cultural influence on the US space community. This story of the American west, rather than the history of the American west, is what needs to be understood to understand the values inherent in US space policy and direction.

In the US context, the constellation of colonial metaphors, while some intersect with those used in Europe and the UK, are uniquely American, such as the Frontier, the Gold Rush, the voyages of Columbus, and the cowboy. Such narratives produced an American sense of what space is and how the US might engage with it. We see this in US space policy and discourse from the very beginning of the space age. Cultural narratives allow for more than political justifications for actions, often this is seen in the language of progress, an Enlightenment value, taken up in the US as a partially political but mostly social idea of America. The use of Frontier narratives for space has been used by major features in space advocacy beyond NASA. One of the most popular use of the narratives is connected to the desire to colonize the planet Mars. This is most direct example of this is the work of Robert Zubrin.

Space Advocate and Mars Society President Robert Zubrin adopts his ideas about space exploration from Turner and Webb to argue that, if the frontier is the necessary ingredient for new and “superior” social relations of the United States, for more egalitarian political systems and a changing of norms, then Mars could function as the new frontier. For Zubrin, Mars is the ideal setting for a much-needed expansion of Western civilization.

In his 1996 book *The Case for Mars*, Zubrin justifies space colonization by portraying the “Frontier” as necessary and beneficial to Europe and the United States (Zubrin; & Wagner, 1996). Both Webb’s and Turner’s theories present the history of the American Frontier as solely beneficial, in the same way many space advocates focus on the beneficial aspects of space exploration, famously, “space exploration will benefit all humankind.” Understood from that angle, the speculative works surrounding space exploration often proclaim major benefits (technology and science), while any possible or actual shortcomings are ignored. In this we can see how, American exceptionalism, the idea that the United States of America possesses unique values and characteristics, because it is nation chosen by God to be leaders of the world is uniquely positioned to lead the venture into space to then “save” civilization (Bellah, 1992; Stephanson, 1996). Thus, much of the Frontierism in space discourse rests upon American Exceptionalism. Having transformed from Manifest Destiny during the 19th century, the movement west across the American continent to space during the mid 20th century. This is the place of origin of the Frontier metaphor, the reference. “Manifest Destiny, like all ideological power, worked in practical ways and was always institutionally embedded. Historically, it could become a force only in combination with other forces and in changing ways. Not a mere rationalization, it appeared in the guise of common sense” (Stephanson, 1996, p. xiv). All of these forces, systems, norms, and material conditions produces a uniquely American relation to outer space and the exploration of it. This is significant because this story, this conception of the US and space, has influenced SpaceX founder and space advocate Elon Musk.

Elon Musk, the CEO of SpaceX and Tesla, is known for his ambitious vision of space exploration and colonization. His goal is to make humanity a multi-planetary species by establishing a self-sustaining city on Mars (Musk, 2017). Musk believes that it is crucial for humans to become a space-faring civilization in order to ensure the long-term survival of our species in the case of major catastrophe on Earth, such as an asteroid impact or climate change (Musk, 2017). Rather than reproducing Zubrin’s conception of Mars colonization, Musk expansion his vision to include reusable rockets, terraforming Mars, and constellation of satellites (Brown, 2021). In the case of reusable rockets: Musk recognized early on that the cost of space exploration is a significant barrier to progress, as historically the state had been the major funding source for the space project. To address this, and to restart the commercial space industry in the mid-2000s, SpaceX developed and successfully landed the Falcon 9 rocket, making it the world's first reusable orbital rocket (Brown, 2021).

Musk's long-term vision of establishing a self-sustaining colony on Mars directly relates to the frontierism of von Braun and Zubrin, while developing further the possibilities of Mars. He believes that having a backup plan for humanity on another planet is essential to protect against the risks of potential extinction events on Earth, such as nuclear war, asteroid impacts, or environmental catastrophes. These possibilities move beyond the narratives of saving

civilization from stagnation the way in which Zubrin understood it, to saving civilization in a material way.

SpaceX is actively developing the Starship spacecraft, a fully reusable system designed to transport humans and cargo to Mars and other destinations in the solar system. The Starship, once fully developed, is intended to be capable of carrying up to 100 passengers and supporting long-duration space travel. Recently tested for the first time, Starship blew up about 4 minutes after launch. While this has been considered a failure in online discourses, the test did produce a greater amount of engineering knowledge to move forward with (Torbet, 2023).

Mentioned briefly before, terraforming, long theorized, but not well understood, is one of Musk's ideals about the future of Mars. This too comes from the Frontier, as Turner saw the West as rough and in need of taming, or the need to transform the raw materials of that world to make it hospitable. Terraforming involves transforming the Martian environment to make it more Earth-like and hospitable for human habitation. Musk has mentioned ideas such as warming Mars by releasing greenhouse gases and eventually creating a self-sustaining atmosphere (Brown, 2021)

Elon Musk's vision of space exploration is characterized by his drive to make space travel more affordable, sustainable, and accessible to a broader range of people. For Musk, like Zubrin and Turner, is the possibilities produced on the Frontier. Moving from the American west to Mars or beyond continues to produce greater opportunities for more people Thus as Zubrin expanded upon Turner to note the need for the Martian frontier, Musk is ultimately working towards the long-term goal of ensuring the survival and expansion of humanity in the cosmos. NASA as a national program and later commercial industry have taken up Frontierism as the major narrative for space exploration. This continued by way of other speculative works such as T A Heppenheimer's *Colonies in Space* from 1977, the Whole Earth Catalog's *Space Colonies* also from 1977 and most famously Gerard O'Neill's 1976 book *The High Frontier*.

The High Frontier is mostly a work of speculative engineering, focused on mass free floating colonies at the L5 points in between the Earth and the Moon. The human and social spheres of these space colonies takes up only a few chapters, but in it, we can see how the Frontier again influenced the how and why of space colonization. O'Neill believes that social and cultural life will change very little on these colonies (O'Neill, 1977), as he was more concerned with the economic structures of the colony: trade, income, taxes, growth. (1977, 1981) According to O'Neill, "Poverty is a killer, and the wealth of space should permit most of the total human population to escape from poverty (O'Neill, 1977)." This claim mirrors Turner's conception of the types of people needed on the Fronteir to transform it, workers and capitalists. While his speculative "A Letter from Space" in The High Frontier (a missive from 8 a fictional couple who inhabit the space coloniality to their friends on Earth) evidently transports suburban American values into space, O'Neill himself did not want to speculate on governance or social organization (199). Although, in *2081*, published in 1981, only 5 years after *The High Frontier*, O'Neill speculates that future colonies in deep space will have small governments with few taxes, and laments that governments on Earth have grown in scale and power. For O'Neill, high taxes would inadvertently cause further space expansion, a people would wish to be free of them. The most significant aspect of O'Neill's space colonies is the very idea that the function of a space colony is nothing more than a reproduction of an already-existing urban space in a zero-gravity environment. For O'Neill, the prehistory of his space

colonies features very little other than the desire to expand industrial districts in the 1970s (a kind of extra-terrestrial outsourcing) and a longing for a more libertarian form of government. Again, we can see American cultural expressions in these specualatives works either understood as American or treated as universal. Like O'Neill, who produced a full vision of a future in space, Robert Zubrin's vison for a Martian future is grounded in the technical and scientific processes that will be necessary to establish a colony. Unlike O'Neill though, Zubrin's justification for Mars colonization is explicitly (rather than implicitly) rooted in his analysis of Turner's Frontier Thesis. O'Neill's colonies and engineering are still highly influential as his books are still used for space advocacy today.

Frontierism in American space discourse can be summarized best by Zubrin:

> Now why do we need to go to Mars? Why do we need, more generally speaking, a new frontier in space? I believe the fundamental historical reason is because Western humanist culture will be wiped out if the frontier remains closed. Now what do I mean by "humanist culture?" I mean a society that has a fundamental set of ethics in which human life and human rights are held precious beyond price. That set of philosophical notions existed in what was to become Western civilization since the time of the Greeks, the immortality and divine nature of the soul as popularized by Christianity, but it never became effective as the basis for ordering society until the blossoming of Christendom into Western civilization as a result of the age of discovery (2002, pp. 142-143).

Both the narratives of space that are celebrated by Zubrin and O'Neill seem out of date, after all, one was from the 1970s and the other developed in the 80s and 90s, the strength of those stories continues to impact contemporary space activities. Newspace entrepreneurs like Musk and Amazon.com founder Jeff Bezos credit these space narratives as inspiration for their own space companies. Bezos dreams of creating L5 like colonies to move industry off-Earth and Musk believes that the future of humanity lies on Mars. If, as American space policy expert Howard McCurdy says, "all great human enterprises are primarily social, and the space program is no exception [but it] could not exist without social support, without the enthusiasm of national leaders and the acceptance of the general public" (1997, p. 31) Then the Frontier metaphor has cultivated an image of space has captivated popular imagination, advocacy, and policy for decades (McCurdy & Launius, 2001).

As McCurdy writes, "imagination matters when societies contemplate new ventures. People have the ability to visualize a solution to the phenomenon with which the society grapples and possess confidence in the attainability of the goal" (McCurdy, 1997, p. 33). This is why Werner von Braun's work with Disney, as well as his Collier's articles, were essential to forming the space age, and helped to shape the belief that a future in space was attainable. This conception of attainability continues to this day with the stories first formed during the Space Age that continue to inspire and motivate space agencies and companies.

Jeff Bezos, as well as founding Amazon, created Blue Origin, a private space company that began sending humans into "space" in the year 2021 (Kaufman, 2021). Actor William Shatner, the original Captain James T. Kirk on Star Trek, was one of the people sent to space on a Blue Origins rocket (Kaufman, 2021). Bezos has expressed a strong interest in space exploration and has outlined his vision for the future of humanity in space having been inspired

by O'Neill. Bezos envisions a future where millions of people live and work in space, with the Earth becoming a residential and light industrial zone (Rogers, 2019).

Bezos has emphasized the need for human expansion into space as a means to protect and preserve the Earth. He believes that by moving heavy industry and manufacturing to space, we can mitigate the environmental impact on our home planet and ensure its long-term sustainability. This, too, was an aspect of *The High Frontier,* and while environmentalism was not an element of Frontierism, space exploration itself is one of the contributing factors to the environmental movement. In this way, we can see how initial inspirations produce material activities that then influence further narratives of space and humanity.

The Space Frontierism of the US and its continued influence through the Space Age from inspiration for von Braun to the advocacy of O'Neill and Zubrin to material developments of commercial space by Bezos and Musk, has been the primary narrative of space exploration since before the first human made satellites or human presence in space. Having been institutionalized through NASA, and exported to many other parts of the world, the frontier is not the only narrative of space, nor it is the only nationalized narrative. While it is used by both the United Kingdom and the European Space Agency, there are other narratives that have different cultural connections (Kuh, 2015; ESA, 2010).

In the case of the United Kingdom, the major cultural connection to space is with the use of maritime analogies and science fiction narratives. There are several factors that contribute to this, first there is the UK identity as a seafaring nation, and the use of maritime language on the part of major British science fiction authors and space advocates associated with the British Interplanetary Society. Famously, Arthur C. Clarke, a member of the BIS, structured his language to best match how he understood space, according to Geographer Oliver Dunnett:

"Whereas nautical language, is used by Clarke to evoke a sense of adventure at sea that would be familiar to readers, it also effectively endorses the British imperial histories associated with such language, and a sense in which human history is driven by the challenge of empire, a tendency that has been recognised in Clarke's work by various scholars. While the connection between adventure and imperialism has been well-established, the translation of maritime adventure to outer space is a unique trope of science fiction and brings with it its own set of specific geographical implications. Over and above these historical maritime associations, a more personal meaning can be read into Clarke's use of the oceanic metaphor, which relates to the condition of weightlessness. In a chapter of *Islands in the Sky* triumphantly entitled 'Goodbye to Gravity', Clarke describes moving in zero gravity as 'rather like learning to swim underwater. (Dunnet, 2021, 81).'

Much like the use of the Frontier to help the American public connect space to its national history and future, the use of maritime language in Clarke's science fiction helped connect Britain to space through a cultural important component. Because the UK has a rich maritime history and a long tradition of naval exploration along with its history of colonization, the use of maritime narratives and metaphors makes cultural sense. By using maritime language, the UK can tap into a sense of adventure, discovery, and pioneering spirit associated with its naval past, and this is seen in the mid-century science fiction and the advocacy of the British Interplanetary Society, which still plays a prominent role in British space today. While the UK did not establish a space agency until 2010, there is a long history of British involvement in

space exploration and science, after all, Sir Isaac Newton and the scientific revolution was birthed here in the British Isles. The BIS was founded in 1933 making it the oldest continuous space advocacy group in the world (Dunnett, 2021). The BIS was and is the main advocacy group in the UK, running several publications, hosting events, and supporting students (BIS, 2023). While the US had several organizations similar none have had the impact on technology, policy or science fiction that the British Interplanetary Society has had.

While the Frontier narratives has been taken up in popular culture partially due to the influence of Star Trek and early American advocacy, the maritime narratives of the UK are culturally specific and motion towards both the history of empire and the UK's role in the Enlightenment. Because of this the narratives in the UK seem to link more towards discovery, knowledge production and scientific developments while the US with the Frontier narratives describes more individualistic characteristics of the nation. In this way, we can see that the classical narratives associated with space exploration do follow a more nationalistic form even while adapting to the changes to the economy over the last 50 years.

Contemporary Narratives of Space Exploration:

While in the beginning of the Space Age only major nations had access to the resources, land, and scientists to pursue space projects this did not stop other individuals and groups from envisioning their place in the cosmos. Unlike classic science fiction that has its roots in Imperial forms, futurisms are distinct in that they are more than just fictional accounts of possible futures. Rather futurisms, notably Afro-futurism and Indigenous Futurism, are a multi-modal artistic, cultural, and intellectual movement that expresses visions of the future (sometimes in space). Afro-futurism has a long history that runs parallel to the Space Age. Most famous is the work of Sun Ra, an Afro-futurist artist who wrote "Space in the Place." As space access is democratized, cultural groups and historically marginalized people's narratives about the futures in space have begun to take a more prominent role in space discourse.

Afrofuturism, as a cultural, artistic, and literary movement, has had a significant impact on various fields, including space exploration. Unlike classical space narratives that focus on nation and technology, Afro-futurism fuses civil rights, arts and cultural aspects into narratives of the future that seek to empower marginalized groups that have historically not been part of the Frontier or Maritime narratives. In this way, Afro-futurism challenges the traditional narratives and representation in science fiction and space exploration by envisioning a future where Black people, from all over the world, and their experiences, are central to futurity. In the context of space exploration, Afrofuturism advocates for greater representation of Black astronauts, scientists, and engineers in space missions, as well as in leadership and decision-making roles within space agencies. The character of Lieutenant Uhura in Star Trek inspired not only the first white American woman in space, but also the first African-American woman in space Mae Jemison, and Charles Bolden, astronaut and the first black NASA Administrator (Reuters, 2022). Jemison herself went on to be the first astronaut to play a character in Star Trek (Creighton, 2015). Nichelle Nichols recounts that American civil rights leader Dr. Martin Luther King Jr. encouraged her to continue playing the character of Uhura as she was an inspiration for countless black folks (Starky, 2022). While Star Trek itself is not Afro-futuristic, as it does not centre black culture, it does produce characters, ideas and images that do centre blackness, which in turn inspires people.

Afrofuturism offers a unique perspective on the future, blending elements of African culture, history, and mythology with futuristic concepts. This reimagining of the future can inspire innovative ideas and visions for space exploration. Afrofuturist works often challenge existing power structures and present alternative possibilities for humanity's relationship with outer space. This can encourage new ways of thinking about space exploration and the potential benefits it can bring to marginalized communities.

Afrofuturism also explores the intersection of technology, culture, and identity. It embraces advanced technologies and speculative concepts to envision a future that incorporates and empowers marginalized communities. This can be best seen in the recent Marvel movies, Black Panther and its sequel. Both films focus on a black culture that avoided western colonization through its advanced technology. The movies showcase afro-centric art, culture, technology, values, connection to nature, and respond to the ills of the world not through pessimism but rather through cultural optimism (Loughrey, 2018). According to Afrofuturism Ingrid LaFleur, an afrofuturist approach to space exploration would place humanity in relation and harmony to all ecosystems, meaning that unlike Frontierism or Maritime narratives, Afrofuturist space exploration would seek shape a new humanity rather than reproduce historical paths (LaFleur, 2023).

Afrofuturism promotes dialogue and collaboration across cultures, fostering the exchange of ideas and knowledge. This can have a positive impact on space exploration by encouraging international cooperation and cultural exchange in scientific endeavours. One of the best examples of this and Afro-futurism in general is “Space is the Place.” "Space is the Place" is a film and concept album created by the American jazz musician and Afrofuturist visionary, Sun Ra. Released in 1974, the film combines elements of science fiction, music, and social commentary to present a cosmic narrative centred around Sun Ra and his Arkestra. The album/film focus on black people finding liberation in space away from the historical oppression on Earth (Senko-Hall, 2017).

Another form of futurism that becoming a more central and vocal narrative is that of Indigenous Futurism (Lempert, 2014; 2020). Indigenous Futurism is a concept that combines elements of Indigenous culture, history, and spirituality with futuristic visions and possibilities. While much Indigenous Futurism is North American, often responding to the Frontier narrative, Indigenous futurism includes all Indigenous peoples from around the world, even European Indigenous peoples such as the Sami and Celtics (sfrarev, 2022; Kreuger, 2017). Indigenous perspectives on space exploration have become increasingly relevant over the last decade. MIT, NASA and space advocates have focused on how Indiegnous knowledges and systems can help address the numerous issues involved with the expansion into space (Krammer, 2023; Woods, 2023)

Many Indigenous cultures have a deep connection with the environment and a holistic understanding of the interconnectedness of all living beings. Indigenous Futurism emphasizes sustainable practices and ethical considerations in space exploration, promoting the idea of respecting and preserving celestial bodies and their ecosystems (Enright, 2023). Because of this, Indigenous Futurism can help find solutions to problems of sustainability and the commons (Krammer, 2023).

Indigenous Futurism recognizes the importance of cultural preservation and the need to maintain Indigenous languages, knowledge systems, and traditions. In the context of space

exploration, it emphasizes the inclusion and representation of Indigenous cultures and their contributions to scientific and technological advancements. Because of the long history of Frontierism in space exploration, this aspect of futurism is about ensuring that all of humanity is represented in the exploration of space, not just thoughts with power and influence. Indigenous Futurism challenges the dominance of Western perspectives and seeks to decolonize space exploration by incorporating diverse cultural perspectives and knowledge systems. It emphasizes the importance of equity, inclusion, and respect for Indigenous rights and sovereignty in all aspects of space exploration, including research, policy-making, and decision-making processes.

Conclusion:

From the classical narratives of the West to the inclusive visions of the future now starting to influence space discourse, the narratives of space exploration reveal much about the cultures they arise from. The optimistic cowboy of the US and the seafaring captain of the UK reveal more about where conceptions of space arise rather that much about space itself. The interplay between science fact, space policy and science fiction does not leave much room to ignore how each aspect influences and is, in turn, influenced. Star Trek is perhaps the best example of this, it inspires and was inspired by US space exploration. The classic narratives of space exploration, seemingly out of date, still impact major space companies and agencies. This is seen in the visions of space expressed by Elon Musk and Jeff Bezos. It also shows how powerful narratives are: Bezos read *The High Frontier* in his teens, decades later he is still trying to make it a reality (Rogers, 2019). With the emerging discourse on space including more voices, cultural conceptions and artistic visions, space is becoming more open to individuals, nations, companies, and cultures. The visions of the future expressed by ethno-futurists do not exclude but rather radically reimagine the possibilities of the future.

Works Referenced:

Alalinarde, M. (2017) The popularization of space – Link between science, policy, and public perception Star Trek as an early mind-opener for space endeavors. Space policy. [Online] 4136–41.

Anderson, J. (2021) ‘Woman in Motion’ Review: Nichelle Nichols’s Real-Life Mission; In Todd Thompson’s documentary, the actress best known for her groundbreaking role as Lieutenant Uhura on ‘Star Trek’ reflects on her efforts to diversify NASA’s workforce. The Wall Street journal. Eastern edition.
Available at: https://medium.com/space-anthropology/navajos-on-mars-4c336175d945.

Bainbridge, W. S. (1976). The spaceflight revolution: a sociological study / William Sims Bainbridge. New York: Wiley.

Bainbridge, W. S. (1991a). Goals in Space. Albany, New York: State University of New York Press. Bainbridge, W. S. (1991b). Goals in space : American values and the future of technology / William Sims Bainbridge. Albany: State University of New York Press.

Bainbridge, W. S. (2009) Motivations for space exploration. Futures : the journal of policy, planning and futures studies. [Online] 41 (8), 514–522.

Bainbridge, W. S. (2009a). Motivations for space exploration. Futures, 41(8), 514-522. doi:10.1016/j.futures.2009.04.021 Bainbridge, W. S. (2009b). Space: The final frontier. Futures, 41, 511-513.

Brown, M. (2021). *After Inspiration4 triumph, Elon Musk hints at his actual longterm goal*. [online] Inverse. Available at: https://www.inverse.com/innovation/terraform-mars-elon-musk-inspiration4.

Clarke, A. C. (1951). The Exploration of Space. Greenwich, Conn: Fawcett Premier. 177

Clarke, A. C. (1966). Voices from the sky : previews of the coming space age / Arthur C. Clarke. London: Gollancz.

Clarke, A. C. (1973). Profiles of the futur : an inquiry into the limits of the possible / by Arthur C. Clarke (Rev. ed. ed.). New York: Harper & Row

Creighton, J. (2015). *Mae Jemison: The First African American Woman in Space and First Real Astronaut on Star Trek*. [online] Futurism. Available at: https://futurism.com/mae-jemison-the-first-african-american-woman-in-space-and-first-real-astronaut-on-star-trek.

Dunbar, B. (2016). *NASA and Star Trek Overview*. [online] NASA. Available at: https://www.nasa.gov/content/nasa-and-star-trek-overview.

Dunnett, O.T. (2021). *Earth, cosmos and culture : geographies of outer space in Britain, 1900-2020*. Abingdon, Oxon: Routledge.

Elias, G. H. (1990). Breakout into space: mission for a generation / George Henry Elias (1st ed. ed.). New York: Morrow.

Elon Musk Unveils Updated Mars Colonization Plan. (2017).

Enright, J. (2023). *Magical Realism & Indigenous Futures: An Interview with Cara Romero*. [online] Bockley Gallery. Available at: https://bockleygallery.com/magical-realism-indigenous-futurism-cara-romero-juleana-enright/?fbclid=IwAR1yBliePBVg83CNfH8hvGJDWXRkexf9LxDvDkcUBIySM24RRVZfarmkaGs [Accessed 2 Jun. 2023].

Howell, E. (2021). *NASA celebrates the life and career of 'Star Trek' star Nichelle Nichols*. [online] Space.com. Available at: https://www.space.com/nasa-celebrates-nichelle-nichols-uhura-outreach.

Johnston, S. P. (1958). Preliminary Observations on the Organization for the Exploitation of Outer Space Memorandum for Dr. J. R. Killian, Jr. Exploring the Unknown: NASA History office

Kaufman, M. (2021). *Captain Kirk successfully blasts into space on Jeff Bezos' rocket*. [online] Mashable. Available at: https://mashable.com/article/william-shatner-blue-origin-space-launch-captain-kirk [Accessed 7 Jun. 2023].

Krammer, W. (2023). Creating a Culture of Extra-terrestrial Concern. In: L. Billings, J. Schwartz and E. Nesvold, eds., *Reclaiming space*. New York: Oxford University Press.

Kreuger, A. (2017). Ethno-Futurism: Leaning on the Past, Working for the Future. *Afterall: A Journal of Art, Context and Enquiry*, 43, pp.116–133. doi:https://doi.org/10.1086/692561.

Kuh, A. (2015). *The cultural significance of space exploration - UK Space Agency blog*. [online] space.blog.gov.uk. Available at: https://space.blog.gov.uk/2015/01/14/the-cultural-significance-of-space-exploration/.

LaFleur, I. (2023). Scared Space. Editors: L. Billings, J. Schwartz and E. Nesvold, eds., *Reclaiming space*. New York: Oxford University Press.

Lempert, W. (2014). Decolonizing Encounters of the Third Kind: Alternative Futuring in Native Science Fiction Film. *Visual Anthropology Review*. [online] Available at: https://www.academia.edu/9342687/Decolonizing_Encounters_of_the_Third_Kind_Alternative_Futuring_in_Native_Science_Fiction_Film [Accessed 1 Jun. 2023].

Lempert, W. (2020). *NAVAJOS ON MARS: Native Sci-fi Film Futures*. [online] Medium.
Logsdon, J. M. (2010). John F. Kennedy and the Race to the Moon. Washington DC: Palgrave Macmillan.

Logsdon, J. M. (2019a). Ronald Reagan and the Space Frontier. Washington DC: Palgrave Macmillan.

Logsdon, J. M. (2019b). Ten Presidents and NASA. Retrieved from https://www.nasa.gov/50th/50th_magazine/10presidents.html

Loughrey, C. (2018). *Black Panther brings Afrofuturism into the mainstream*. [online] The Independent. Available at: https://www.independent.co.uk/arts-entertainment/films/features/black-panther-afrofuturism-ryan-coogler-definition-explainer-watch-release-date-a8209776.html.

Magazine, S. and Robinson, S. (n.d.). *What Is Afrofuturism?* [online] Smithsonian Magazine. Available at: https://www.smithsonianmag.com/smithsonian-institution/what-is-afrofuturism-180982154/ [Accessed 2 Jun. 2023].

Mars, K. (2019). *50 Years of NASA and Star Trek Connections*. [online] NASA. Available at: https://www.nasa.gov/feature/50-years-of-nasa-and-star-trek-connections.

Matiluko, Oluwaseun (2019). *Sun Ra's Space Is The Place: A Radical Black reimagining of a better future*. [online] Project Myopia. Available at: https://projectmyopia.com/sun-ras-space-is-the-place-a-radical-black-reimagining-of-a-better-future/.

McCray, P. (W. P. (2013) The Visioneers how a group of elite scientists pursued space colonies, nanotechnologies, and a limitless future. Course Book. [Online]. Princeton: Princeton University Press.

Musk, E. (2017). Making Humans a Multi-Planetary Species New Space, 5.

Rogers, T.N. (2019). *Jeff Bezos' space colonization plan was partially inspired by a 1976 book he read in high school that proposed connecting the Earth and the moon via a series of enormous, cylindrical tubes*. [online] Business Insider. Available at: https://www.businessinsider.com/jeff-bezos-space-exploration-plan-the-high-frontier-book-2019-10?r=US&IR=T [Accessed 1 Jun. 2023].

Rubenstein, M.-J. (2022). *Astrotopia : the dangerous religion of the corporate space race*. Chicago ; London: The University Of Chicago Press.

Senko-Hall, K. (2017). *Sun Ra Space is the Place (1974): Afrofuturism After 43 Years – Beautiful Bizarre Magazine*. [online] beautifulbizarre.net. Available at: https://beautifulbizarre.net/2017/02/05/sun-ra-space-is-the-place-1974-afrofuturism-after-43-years/#:~:text=The%20%E2%80%9CSpace%20is%20the%20Place.

sfrarev, A. (2022). *When was Celtic Futurism? The Irish Immrama as Proto-Science-Fiction*. [online] SFRA Review. Available at: https://sfrareview.org/2022/01/19/when-was-celtic-futurism-the-irish-immrama-as-proto-science-fiction/.t

space.blog.gov.uk. (n.d.). *The cultural significance of space exploration - UK Space Agency blog*. [online] Available at: https://space.blog.gov.uk/2015/01/14/the-cultural-significance-of-space-exploration/.

Starky, A. (2022). *Martin Luther King and his great advice for Nichelle Nichols*. [online] faroutmagazine.co.uk. Available at: https://faroutmagazine.co.uk/martin-luther-king-jr-nichelle-nichols-star-trek/ [Accessed 16 May. 2023].

Torbet, G. (2023). *SpaceX's Starship blew up after launch — it also caused 'catastrophic' damage on the ground*. [online] The Verge. Available at: https://www.theverge.com/2023/4/26/23699365/spacex-starship-damage-launch-pad-debris.

Trevino, Natalie B., "The Cosmos is Not Finished" (2020). *Electronic Thesis and Dissertation Repository*. 7567.
https://ir.lib.uwo.ca/etd/7567

Ulster, L. (2018). *Star Trek Remembers Professor Stephen Hawking*. [online] TrekMovie.com. Available at: https://trekmovie.com/2018/03/14/star-trek-remembers-professor-stephen-hawking/ [Accessed 1 Jun. 2023].

Vertesi, J. (2019) 'All these worlds are yours except …': Science Fiction and Folk Fictions at NASA. Engaging science, technology, and society. [Online] 5135–159.
Von Braun, W. (1952). Crossing the Last Frontier. In J. M. Logsdon (Ed.), Exploring the Unknown (Vol. 1, pp. 179-188). Washington DC: NASA

Wood, D. (2023). Opportunities to Pursue Liberatory, Anti-colonial and Anti-Racist Design for Human Societies Off Earth. In: L. Billings, J. Schwartz and E. Nesvold, eds., *Reclaiming space*. New York: Oxford University Press.

Woods, B. (2009) A political history of NASA's space shuttle: the development years, 1972 1982. The Sociological review (Keele). [Online] 57 (s1), 25–46.

www.esa.int. (n.d.). *ESA explores the final frontier with Star Trek fans*. [online] Available at: https://www.esa.int/Space_in_Member_States/United_Kingdom/ESA_explores_the_final_frontier_with_Star_Trek_fans [Accessed 2 Jun. 2023].
www.esa.int. (n.d.). *Europe maintains its presence on the final frontier*. [online] Available at: https://www.esa.int/Science_Exploration/Space_Science/Europe_maintains_its_presence_on_the_final_frontier [Accessed 2 Jun. 2023].

Zubrin, R. (1999). Entering Space Creating a Spacefaring Civilization. New York: Jeremy P. Tarcher/Putnam.

Zubrin. (2002). Pushing Human Frontiers. In S. J. Garber (Ed.), Looking backward, looking forward: forty years of U.S. human spaceflight symposium (pp. 137-148). Washington, DC: National Aeronautics and Space Administration, Office of External Relations, NASA History Office.

Zubrin; & Wagner. (1996). The Case for Mars 183 The Plan to Settle the Red Planet and Why We Must. New York: The Free Press