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Researching Space Science, Technology, Law and Economic Authorization Acts: A Methodological Approach to Discovering Emerging Trends

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Introduction

In our lifetime, scholars, scientists, thinkers, inventors, and visionaries are engaged in a wide variety of advances in space science and technology. For example, at the far end of the spectrum, in *Field Propulsion Physics and Intergalactic Exploration* [1] proposes a method of propulsion suitable for galactic exploration, using a combination of academic and technical approaches to lay conceptual and theoretical foundations for how humankind may travel to other star systems and galaxies. More practical activities that today are at varying stages of completion include research, development, and inventions being undertaken by the United States space agency, National Aeronautics and Space Administration (NASA), private sector companies and other national space agencies throughout the world. In this paper, we highlight the significance of a few emerging NASA technologies, the purpose of this paper being to promote the idea that anyone, indeed perhaps everyone, can develop an ongoing personal research project to build knowledge related to space science and technology. Although this brief paper only focuses on the U.S. national space program and U.S. economic initiatives, we also point out that the new space race is being run primarily through space-related economic incentives and has global implications. Using the Internet, it is possible for anyone to research the many newly emergent trends related to space science and technology, space law and economic initiatives, such as the U.S. NASA Authorization Acts. This paper thus uses information regarding the U.S. as an example, but also notes that other nations are increasingly creating space programs, constructing spaceports and getting involved in humanity's ascent into outer space development.[1] Therefore, we also provide information regarding how to conduct research using the International Astronautical Federation database. In addition, keyword searches for specific countries can be researched online in English or by translating those key terms using Google Translate.

Increasing levels of awareness are needed to enable future generations to produce positive change in the world. Anyone interested in performing this type of research and knowledge sharing or outreach can quite quickly become informed about emerging colonization and development patterns and trends. Of course, the paper relies on several assumptions, which can be challenged. First, that outer space is indeed in the process of being developed and that emergent space science and technology, economic initiatives, space law and policies are researchable. Second, that by collecting data about these phenomena, people can arrive at an understanding of what types of outer space activities are on the agenda, and thus begin to prepare themselves to participate in emerging opportunities. Third, that keyword searches such as 'NASA Authorization Act', 'space policy', 'space science and technology', 'space transportation', 'asteroid mining', 'space habitats', 'spaceports' and others can be performed so as to discover emerging trends related to outer space development. Fourth, that the future belongs to the creative forces, students, scholars, artists, and others who can harvest and use this knowledge as an intellectual experience in order to come up with new ways to address sustainability efforts here on Earth. Fifth, that involvement and contributions from a broader range of people is critical for the success of outer space development. Six, that the transformation of outer space infrastructure can be done in a way that includes everyone and allows all people to benefit. And seven, that it is only through some sort of shared and communicative vision that key actors in outer space development can be assured of rallying enough support to significantly reduce possible future plug-pulling initiatives, once outer space development begins

[1]For more information see: https://en.wikipedia.org/wiki/List_of_government_space_agencies; and https://en.wikipedia.org/wiki/Spaceport.

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expanding. After all, time and time again, key actors in development and colonization paradigms and scenarios have promised certain benefits to the majority of humankind, holding out the prospect of economic, social or psychological progress, butthese promises have remained unrealized. Nevertheless, vast opportunities exist for those bold enough to break into some aspect of outer space development, and by capturing the attention of visionary people who desire to create exciting, pioneering blueprints for their lives and make contributions towards humankind's advancement into outer space development, we hope the following information will provide insight, ideas, and inspiration.

We are not concerned that to some thinkers these assertions may seem unrealistic. The purpose of this article is to uplift, motivate, and encourage anyone who is seeking to do a new thing and to benefit humanity in the long run. Skyscrapers were once seen as unrealistic fantasy structures; but they have been constructed in most major cities throughout the world. Early trends in outer space development have already materialized and are now deemed everyday technologies. These include widespread global use of cell phones, the Internet, Facebook, Skype, and wireless financial transactions, all of which seem to have happened overnight. The telecommunications industry has provided many benefits to people all over the world; at the same time, however, inequality gaps have also widened. The second wave of outer space development began with the legalization of private spaceship travel, the plan to retire the NASA space shuttle fleet, and the preparation of companies to take on space transport from Low Earth Orbit to Earth, as well as to develop space transportation systems and launch exploration missions to Near Earth objects (i. e. asteroids), Mars, the moons of Mars, and our Moon.

Recent advances in space science and technology have made it possible for humankind to begin the process of outer space development and colonization. For example, intelligent space telescopes are now exploring the universe, sending us phenomenally detailed information about what's out there, and have confirmed the existence of thousands of Earthlike planets. New spaceships are being developed. Space mining proposals are becoming prevalent. The first phase of outer space development, which took place during the latter part of the 20th century, gave the world access to revolutionary satellite telecommunications technology. This enabled more people throughout the global public to have access to cell phones, the Internet and all of the related goods and services. Asteroid mining operations are scheduled which are expected to accrue trillions or quadrillions of dollars in natural resources, including gold, iridium, osmium and other platinum group metals, which have been discovered on Near Earth asteroids. For example, news reports estimate some asteroids to be valued in quadrillions of dollars[2]. Space mining, private spaceship development, commercial habitat and spaceports industries have moved from Sci-Fi to reality.

Yet although outer space is in the process of being developed, few are aware of this. In the absence of awareness, people cannot prepare for the opportunities that will arise; and so the vast wealth likely to arise out of these emerging activities remain a secret for most people. International space law consists of five treaties and five declarations. Few people are aware, or perhaps care, that the Outer Space Treaty of 1967 deemed outer space a res communis territory; it uses the term "province of mankind" for outer space. The peoplewho make up humankind are essentially heirs in common to outer space, yet most are not even aware of this. Nor do they usually care. This is where the key actors in outer space development can play a role in changing the current course of human development. The win-win in all of this is that more people will benefit from outer space development in meaningful ways, while this may also mean less of a perceived need to bring space activities to an end in the long term.

Through a Lens of One "Regime"

Largely outside of the media spotlight devoted to national politics, policies and laws have been enacted, hearings have been held, and decisions have been made to develop outer space. In addition to this, historical, legal, ideological, institutional, political, economic, psychological, and structural factors are all operating together in the post-Cold War era during a time of general acceptance of globalization and free market ideology. Opening space transportation, spacemining, and space habitats for private sector competition is projected to make outer space development happen fast. It appears that outer space development has been given a green light. Few people may see or understand that all these events are happening in a linear fashion that is more easily understood by those already invested in this community. This is why we want to open the discussion to the co-creative talents of architects, and why our analysis seeks to introduce these architects to terms such as "key actors" and "regime", which were borrowed from the field of international relations/political science, the field of study specializing in uncovering emerging social and behavioral patterns.

Space Agencies and Spaceports as a Global Trend

As the major development scenario unfolds for outer space, we seek to encourage more people to become key players, and to conceptualize and realize how this type of development can benefit them. Since the 1950s, NASA has been a key actor in space development; today, space agencies are increasingly springing up throughout the world[3]. Spaceport construction is also on the rise – globally[4]. In addition, growing numbers of national space agencies, companies, international organizations, and institutions, entrepreneurs and individuals have invested time, talents, and plans on outer-space-themed activities. Outer space territories that seem to be on the agenda for commercial and political development-type activities include Near Earth asteroids, Earthlike planets, Mars and our Moon. Overall, humankind seems on the way to entering a true space age, and science fiction may soon become our reality.

The New Space Race

Until recently, the U.S. and former Soviet Union were the only two space superpowers. Today, many countries have activated their own programs of sending spacecraft and satellites into space, to Mars, the Moon, and beyond. A new space race is underway, involving an increasing number of nations, organizations, institutions, companies,

[2]An example of these types of reports is entitled "NASA plans mission to asteroid that may hold treasure trove of minerals" CBS News This Morning (January 19, 2017), https://www.cbsnews.com/news/nasa-mission-16-psyche-asteroid-metals-worth-ten-thousand-quadrillion-dollars/, indicating that some scientists estimate, for example, an asteroid named 16 Psyche to be worth "$10,000,000,000,000,000,000, ten thousand quadrillion dollars". There are tens of thousands of asteroids in Near Earth orbit. Several companies such as Deep Space Industries and Planetary Resources, Inc. have formed and are articulating plans to lead the way in this new industry, https://www.youtube.com/watch?v=50g3yxVZRKk&t=35s [Accessed April 11, 2020].

[3] "World Space Agencies", United Nations Office for Outer Space Affairs https://www.unoosa.org/oosa/en/ourwork/space-agencies.html (Accessed 17 July 2021). Also see "List of Government Space Agencies" at: https://en.wikipedia.org/wiki/List_of_government_space_agencies.

[4] Thomas G. Roberts (January 4, 2021) "Spaceports of the World" *Report: Civil and Commercial SpaceSpace Security*, Aerospace Security; A Project of the Center for Strategic and International Studies at: https://aerospace.csis.org/data/spaceports-of-the-world/. Also see Stephanie Mlot (June 1, 2021) "SpaceX Confirms Construction of First Ocean Spaceport Has Begun", noting that two "offshore platforms will be ready for launch next year", *PC Mag.com*: https://www.pcmag.com/news/spacex-confirms-construction-of-first-ocean-spaceport-has-begun; *Spaceport* at: https://en.wikipedia.org/wiki/Spaceport; and KRQE Staff (Jul 14, 2021); "New partnership aims to grow New Mexico's space industry" KRQE at: https://www.krqe.com/news/politics-government/sen-heinrich-to-announce-partnership-to-grow-states-space-industry/; and https://en.wikipedia.org/wiki/Guiana_Space_Centre.

corporations, and entrepreneurs. There are many serious space tourism actors gearing up and taking steps toward the formation of a new industry. Space tourism is not a new concept, and indeed has been around since the 1950s or before; however, although until recently it was largely neglected, it has now already been initiated by private companies[5].

By space tourism, we refer to the notion that space is a place for laypeople (non-astronauts) to travel to, visit, and enjoy. This includes parabolic and suborbital flights, going into orbit (like the international space stations), or traveling to asteroids, the Moon, Mars or elsewhere. Regarding this concept, three stages may be distinguished:

- Suborbital day trips (joyrides)
- Short stays in space-based facilities (low Earth orbit)
- Longer stays in space – further into space or on other celestial bodies

In July of 2021, we witnessed the suborbital joy-ride into space by billionaire Sir Richard Branson on a Virgin Galactic spaceship, followed by Jeff Bezos on a Blue Origin spaceship. These events mark a new beginning of a new brand of private spaceship travel. Distinct from past private individual joy rides into space, these space travelers do not use government-funded vehicles: they used privately funded spaceships[6].

The U.S. Example: Economic Initiatives, Space Law, Space Policy

People from all backgrounds, fields of study, and professions, should realize that it is possible to locate, review, and understand space law, space policy, and economic initiatives. In so doing, a person can be empowered to figure out ways to produce unique cutting-edge insights on emergent trends, relevant for their fields of study and/or professional goals. Although this is a policy of the United States, there are nearly two hundred countries in the world of which the U.S. is just one, albeit currently the most powerful. With simple keyword searches, a person can investigate other nations' economic policies related to their space programs as well: the NASA Authorization Act of 2020 provides only one of many, many examples for study and analysis.

U.S. Economic Policy and Stated Goals

Plans for funding emerging outer space activities are researchable. In the midst of COVID just about everything has been placed on hold: except for plans towards outer space development[7]. NASA Authorization Acts are usually public knowledge and are typically made available via the Internet. For example, TITLE I Authorization of Appropriations, Section 101, authorizes that NASA be appropriated $22,629,000, 000 for fiscal year 2020, for a broad range of objectives. Each goal stated in the law provides a dollar amount allocated for the achievement of specified goals. The manner and method for their achievement is left up to the skills of those with the knowledge of the process to bring these goals to fruition. The wording assigned to various budget amounts suggests that opportunities exist for a wide range of skilled professionals who are bold enough to actively engage in the process of firming up plans regarding how to develop the outer space infrastructure.

In addition to economic initiatives, there are other space policies, domestic space law and international space law that scholars interested in understanding emerging trends must investigate. Architects of the future must be able to see what is coming. These trends are usually mapped out and written down with plans for funding well in advance of their manifestation.

Space Law

International treaties have been negotiated and written for outer space. The United Nations Office for Office Outer Space Affairs houses the five UN international outer space treaties and the five Declarations and Legal Principles for outer space[8]. But although space laws exist, most people do not know of them. From 1957 to 1967, for nearly 10 years, the majority of the nations of the world worked through the United Nations to create laws to govern outer space. The Outer Space Treaty of 1967 is the main treaty, which governs outer space. A key principle within the body ofinternational space law is that, as outer space is developed, all people from all nations are to benefit. Freshly traumatized by World War Two, key actors in the process of creating space law seemed focused on finding peaceful solutions and remedies for development and colonization scenarios.

Humankind can endeavor this time to do outer space development right, and to avoid many of the foreseeable problems which typically occur when a territory is "developed". By speaking to the many foreseeable newly emergent opportunities associated with space, and by considering past problems, we propose that by including more diverse views as we develop the final frontier we may be able to inspire the creation of new realities. It is clear from a review of the history of the international space law negotiations that this is what the framers of the Outer Space Treaty intended. Thus, the body of international space law states that "exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development"[9].

The basic foundation of international space law is laid in the five international space treaties, the main one being The Outer Space Treaty of 1967 ("The Constitution"). These treaties were purposefully left vague, especially the Outer Space Treaty. Commercial development issues were thought best left up to each nation's ability to draft their own domestic laws governing such activity. The Outer Space Treaty of 1967 is perceived as a Constitution for outer space activities. It was signed by ninety-eight nations when it opened for signature in 1967. This treaty deems that outer space belongs to the province of mankind—a term specifically created to ensure that both space superpowers at the time (the U.S. and U.S. S. R.) would sign. This term was never fully defined by the international space law community. These two legal principles "province of mankind" and "common heritage of mankind" must be clearly distinguished. The common heritage of mankind doctrine was derived from the Roman law concept res communis, which means that resources and territory designated in this way are classified as community property,

[5] For more information on the space tourism history, see http://www.spacefuture.com/tourism/timeline.shtml. andfor example, Space Adventures, Ltd.: http://www.spaceadventures.com.

[6] For more information see https://spaceadventures.com/. Also see Space Tourism at: https://en.wikipedia.org/wiki/Space_tourism.

[7] See 116th Congress, 2nd Session, S. 2800: reported to the U.S. Senate (09/08/2020) [Report No. 116–262] https://www.congress.gov/bill/116th-congress/senate-bill/2800/text and https://science.house.gov/imo/media/doc/NASA_AUTH_01_xml.pdf [Accessed November 6, 2020].

[8] The United Nations Office for Outer Space Affairs website at: http://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html [Accessed 23 September 2020]. For a downloadable book containing the outer space treaties and declarations in Arabic, Chinese, English, French, Russian, and Spanish go to:https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html.

[9]The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty", adopted by the General Assembly in its resolution 2222 (XXI)), opened for signature on 27 January 1967, entered into force on 10 October 1967, 98 ratifications and 27 signatures (as of 1 January 2003).

and as such cannot be owned by any state, individual(s), entity, or combination of entities [2]. In contrast, the 'province of mankind' principle was a legal term developed specifically during the Outer Space Treaty negotiations to avoid using the term common heritage of mankind[3]. The key actors who worked towards formulating these beautiful and awe-inspiring words and purposes truly hoped that outer space would be the great equalizer for humankind. They also seemed to believe that their efforts in drafting international space law would thwart World War Three[10].

The framers of the Outer Space Treaty initially focused on solidifying broad terms, with the intent to create more specific legal provisions later [4]. This is why the members of the Committee on the Peaceful Uses of Outer Space (COPUOS) later expanded the Outer Space Treaty norms by articulating more specific understandings which are found in the "three supplemental agreements" – The Rescue and Return Agreement of 1968, the Liability Convention of 1973, and the Registration Convention of 1976 (734). After these treaties were enacted, key actors involved in space law negotiations set out to establish and confirm a few more legal norms[11] which were to be embodied in the Moon Agreement, since important issues such as the environment, public health, and sharing to benefit all mankind were left open. Many of the terms written into the Moon Treaty were sticking points during earlynegotiations. The Common Heritage of Mankind principle, the equity clause, and the requirement to form an international regime have caused the Moon Treaty to be disliked. Generally, many opponents who lobbied against the Moon Treaty within the U.S. have articulated the beliefthat "such provisions are highly detrimental to a free enterprise system and would therefore have an adverse effect on America's future in space exploration"[4]. Despite the tremendous volume of publications suggesting that the Moon Agreement is a failed treaty due to its inability to gather widespread international acceptance and claiming that it is not recognized by space powers as a valid part of international space law, space law authorities do consider and treat the Moon Agreement as part and parcel of the body of international space law[12]. Many have written comments indicating a belief that since the Moon Agreement was not signed by the major spacefaring nations, it was never actually enacted. However, the Moon Agreement involves a formal written agreement: therefore, the requirement of widespread acceptance is irrelevant. Wiles [5] explains why and how the Moon Agreement went into force and effect upon the fifth signature and ratification, irrespective of their classification. The Outer Space Treaty explicitly required the involvement of the U.S.S.R., the U.K. and the U.S ., whereas the Moon Agreement did not.

Although from 1957 to 1967, for nearly 10 years, the majority of nations of the world, including the United States, worked through the United Nations to create laws to govern outer space, international space law is often misunderstood and misinterpreted. Outer space has been declared an international or global commons territory through a series of international treaties negotiated during that period and today it is common for people to use technologies—cell phones, the Internet, debit or credit cards and ATM machines—which are made available through the use of technologies located in the territory known as outer space. These technologies and connected satellite telecommunications industries were ushered in precisely via space law. Thus although space law sounds strange to many people, the first and second wave of outer space development have already happened. U.S. domestic law has in effect served as a trendsetter in space technology commercialization and the growth of space-related industries. Commercialization of the satellite industry is not new, since this process occurred during the first and second epoch with COMSAT and INTELSAT, corporate entities used to facilitate the commercialization of space telecommunications. More recently, INTELSAT and INMARSAT[13]were slated to go through the process of privatization through the mechanism of U.S. domestic law. U.S. legislation has been passed to privatize these intergovernmental organizations. INTELSAT and INMARSAT are two key fixed satellite operators, both intergovernmental organizations and both owned mainly by state actors. The international satellite communications industry is generally viewed as a success by the international community. It has been a very lucrative industry[14]and it provides the world with voice, data, and fax transmissions, credit/debit card and other bank transactions, the Internet, email and attachments, new varieties of telephone services including long distance and cell phones, new varieties of television options such as cable television and direct broadcasting, and remote sensing, mapping and GPS services. The goods and services provided from this form of commercialized space technology have a value amounting to hundreds of billions of dollars in annual revenues for a multitude of companies.

The International Realm: Example of Databanks of International Space Technology Trends Using the International Astronautical Federation Congress

Various nations on several continents appear on the list of attendees of past International Astronautical Congresses (IACs). The question and driving motivation behind research on space activities is this: How can people benefit if they are not aware of how to make outer space relevant for them? The 2020 71st IAC Congress took

[10] For a collection of official records of negotiations for the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space (The Outer Space Treaty of 1967), see the *TravauxPréparatoires* at: https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/travaux-preparatoires/outerspacetreaty.html [Accessed August 1, 2020]. Also see Jasentuliyana, Nandasiri and Roy S.K. Lee (1979–1981) *Manual on Space Law, Volumes I, II, III and IV* (Dobbs Ferry, New York: Oceana Publication, Inc., 1979–1981); Stephen E. Doyle, *Origins of International Space Law and the International Institute ofSpace Law of the International Astronautical Federation*Univelt, Incorporated: San Diego, California, 2002). Also see Howard E. McCurdy, *Space and the American Imagination* (The Smithsonian Institution Press, 1997).

[11] Antonella Bini, "The Moon Agreement in the 21st Century" *ActaAstronautica* Volume 67, Issues 3–4, August–September 2010, 496–501.

[12] See Von der Dunk, F. (2006) "The Acceptability of the Moon Agreement and the Road Ahead, International and Interdisciplinary Workshop on Policy and Law Relating to Outer Space Resources: Examples of the Moon, Mars, and Other Celestial Bodies", June 28–30, Montreal, Proceedings of the workshop Policy and Law Relating to Outer Space Resources: Examples of the Moon, Mars, and Other Celestial Bodies, McGill Institute of Air and Space Law, retrieved from http://www.mcgill.ca/files/iasl/Moon-Proceedings-Part_5_2006.pdf. Also see Tuerk, H. (2009), "The Negotiation of the "Moon Agreement",*Space Law Symposium on "30th Anniversary of the 'Moon Agreement': Retrospect and Prospects"*, sponsored by the International Institute of Space Law and the European Centre for Space Law, held on 23 March 2009, retrieved from http://www.unoosa.org/oosa/en/COPUOS/Legal/2009/symposium.html.

[13] In December, 2004 the U.S. Federal Communications Commission approved the sale of satellite operator Intelsat Ltd. to Zeus Holding Ltd., a consortium of private-equity companies. Intelsat "based in Bermuda and Washington announced in August that it had reached an agreement with Zeus Holding, in which Zeus will pay Intelsat shareholders about $3 billion as well as assume of $2 billion of net debt"; see Jason Bates (December 27, 2004) "U.S. Government Approves Sale of Intelsat to Private Equity Group", Space News Business Report at http://dev.space.com/spacenews/satellitecomm/intelsat_122704.html.

[14] For example revenues of the "Top 20 Fixed Satellite Operators" in 2003 were: SES Global (Luxembourg), $1.52 Billion, Intelsat (Bermuda), $1.1 Billion, Eutelsat S.A. (France), $954 Million, PanAmSat Corp. (U.S.), $831 Million, JSAT Corp. (Japan) $421 Million, Telesat Canada (Canada), $266.2 Million, Space Communications Corp. (Japan), $241.94 Million, New Skies Satellites N.V. (Netherlands), $214.9 Million, Loral Space Communications (U.S.), $152.4 Million, Shin Satellite (Thailand), $146.5 Million, Arabsat (Saudi Arabia), $140 Million, Star One (Brazil), $130.3 Million, Hispasat S.A. (Spain) $115.5 Million, AsiaSat (Hong Kong) $115.4 Million, KT Corp. (South Korea), $103.5 Million, SingTel Optus (Australia), $120.7 Million, Telenor Satellite Networks (Norway)$84.9 Million, Satmex (Mexico), $478 Million, Broadcast Satellite System Corp. (Japan), $74 Million, Nordic Satellite (NSAB)(Sweden) $63.4 Million, Russian Satellite Communications Co. (Russia) $60 Million, APT Satellite Holdings (Hong Kong), $38.9 Million, Measat Global Bhd. (Malaysia), $33.4 Million, Nahuelsat (Argentina), $17.7 Million. See "Top 20 Fixed Satellite Operators, 2004", *Space News, Business Report* at http://www.space.com/spacenews/top20_satellite_2004.html.

place in cyberspace on 12–14 October 2020. Yet very few people have ever even heard of the IAC. A key principle with the body of international space law is that, as outer space is developed, all people from all nations are to benefit, and this helps explain the many nations and continents appearing on the list of past IACs. Attending at the IAC allows a person to understand discussions on future plans and activities for outer space[15]. The event has been dubbed the "Olympic Games of space"[16], and a review of the Program Brochure helps us understand why this is. Flash reviewing the Agenda and the Program, in and of itself, can be life altering. Experts from around the globe come together to present and discuss cutting-edge developments related to a full range of outer space activities. During the weeklong series of activities, a person's brain changes: one can virtually see belief systems shifting, from viewing outer space development as a weird far-off situation, to being perceived as a way to connect personal aspirations to a their zenith.

For the first time in its prestigious history, the IAC in 2020 was virtual and free of charge[17]. The International Astronautical Federation (IAF) can offer a free registration to all for this most important annual event of the space sector. This is an unprecedented opportunity to attend the IAC and to discover how, since its first edition in 1950, the IAC has been the place for all space people to gather and forge the future of space.

Articulated Plans for Outer Space are Researchable

Although most people may not yet be in a position to perceive outer space as a territory *per se*, we propose that it is necessary to understand the full potential scale of emerging plans for outer space. Today, people are working to problem-solve humanity's lack of technology to get there and to stay there. We must realize and remember that at one time most people believed that the Earth was flat, and that people could not fly.

Researchable plans for outer space development have been articulated and are accessible with internet searches. Technology has been advancing exponentially in our lifetime and probably will continue to do so[18]. For example, Vallerani (2002) explains that the following are next steps:

- Creating various facilities in low Earth orbit
- Transferring payloads and people from one Earth orbit to another
- Developing the geostationary orbit with platforms such as solar power stations, depots for cryogenic propellants, and service stations for satellites or spacecraft
- Establishing human outposts at both the Earth-Moon and the Sun-Earth Lagrange points
- Developing nuclear propulsion systems for solar system exploration by human beings
- Establishing human outposts on the Moon and in-orbit around Mars
- Exploiting extraterrestrial resources such as water on the Moon or Mars for oxygen to breathe and hydrogen to burn as fuel, or platinum from an asteroid
- To explore the outer solar system in some detail using colonies of robotic spacecraft.

In addition, the geostationary orbit today is already a full house, and the intellectual and professional base for Astronautics has concluded that there is a need to coordinate new integrated space infrastructure initiatives (or space "assets") for all aspects of outer space development including the scientific, commercial, and military. This will mean an increasing amount of joint ventures, partnerships, and corporations combining resources and the use of assets in space. Space activities have always been extremely expensive, with costs well into the billions of dollars.

United States' Space Agency: Examples of NASA's Emergent Space Science and Technology Phenomena

NASA is creating the future of space exploration and colonization through its many emerging developments and innovations. Knowing the top 25 emerging NASA developments can inspire inventive and visionary people; the knowledge can open prospective minds to the reality of humanity's current technological state. NASA research has contributed to the development of many innovative concepts such as space communication technology, robotics, solar science, autonomous systems, eco-friendly technology, and other unique problem-solving designs.

The first promising area of study related to advancing outer space development is space communications. Examples of pioneering efforts to advance space communication include the Optical Ground Station 2 (OGS-2)[19], the Transiting Exoplanet Survey Satellite (TESS) [6][20], the deep-space atomic clock [7][21], and the Enhanced Tandem Beacon Experiment (E-TBEx) [8]. NASA's two Optical Ground stations[9] are aiming to achieve the goal of laser communication, believed to provide more accurate and efficient methods of transmitting and encoding data through outer space. TESS observes deep space in an ongoing search for life and life-supporting planets in the universe. It collects data on undiscovered planets orbiting 200, 000 of the brightest and closest stars in our solar neighborhood. The deep-space atomic clock is a spacecraft navigation system that allows for a spacecraft to calculate its trajectory, speed, and position using a moreindependent one-way communication system[22]. Spacecraft pilots previously had to learn their own trajectory/position by communicating with stations on earth; the deep-space atomic clock minimizes the dependence on earth communication stations and the time it takes to receive

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[15] For a list of locations for past IACs: https://en.wikipedia.org/wiki/International_Astronautical_Congress; also see https://lnkd.in/gDynPNN; and https://www.iafastro.org/about/history-and-missions.html.

[16] Press Release published by iafastro.org using the term "Olympic Games of space" at: http://www.iafastro.org/wp-content/uploads/2014/04/IAC-2016-Live-Webcast-of-all-Plenaries-Available.pdf.

[17] This was the 71st IAC, held 12–14 October, 2020: http://www.iafastro.org/events/iac/iac-2020/. The 72nd IAC was re-scheduled to take place in Dubai, UAE in 2021 25–29 October 2021: http://www.iafastro.org/events/iac/iac-2021/. The 73rd IAC is scheduled to place in Paris, France in 2022, 18–22 September 2022: http://www.iafastro.org/iac-2022-in-paris.

[18] E. Vallerani "The Need for a New Vision", Proceedings of the International Space University's 7th Annual Symposium, 4–7 June, Strasbourg, France, entitled *Beyond the International Space Station: The Future of Human Spaceflight* (Dordrecht: Kluwer Academic Publishers, 2002), pp. 1–2.

[19] "New Ground Station Brings Laser Communications Closer To Reality" by Rob Garner (August 20, 2020) NASA press release:https://www.nasa.gov/feature/goddard/2020/new-ground-station-brings-laser-communications-closer-to-reality [Accessed January 8, 2021].

[20] "Transiting Exoplanet Survey Satellite (TESS) Science Data Pipeline" by Rick Chen (April 11, 2018) NASA Ames press release:https://www.nasa.gov/ames/tess-pipeline [Accessed January 8, 2021]. Also see NASA Goddard video, "NASA's TESS Delivers New Insights Into an Ultrahot World":https://www.youtube.com/watch?v=bLMIo9Q5mDA&feature=youtu.be [Accessed September 29, 2020].

[21] " Robotic Tool Operations Bring In-Space Refueling Closer to Reality" by Karl Hille (Aug 16, 2019) NASA Goddard press release:https://www.nasa.gov/feature/robotic-tool-operations-bring-in-space-refueling-closer-to-reality [Accessed January 9, 2021]. Also see "Robotic Refueling Mission 3"https://nexis.gsfc.nasa.gov/RRM3.html.

[22] "Deep Space Atomic Clock Overview" by Lee Mohon (July 17, 2020) NASA press release:https://www.nasa.gov/mission_pages/tdm/clock/overview.html [Accessed January 9, 2021].

coordinates and direction. The E-TBEx studies bubbles that are in the Earth's ionosphere, which block and disrupt communication signals with the intent of understanding how to evade them or finding a frequency that can travel through them[23]. This development is beneficial to increasing the strength of communication signals sent to outer space recipients. NASA's efforts to technologically improve the simple concept of communication have yielded the beneficial results of discovering new planets and increasing communication in outer space. These recent communications developments allow the accuracy of laser and radio information collection between worlds.

The second innovative area is the development of robotics. This list of developments includes the third operation of Robot Refueling Missions (RRM3) [10], the Astrobee robots, the shape-shifting robots, the Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals (SHERLOC) device, and the Steam Propelled Autonomous Retrieval Robot for Ocean Worlds (SPARROW). The RRM3 strives to actualize the concept of autonomously/robotically refueling spacecraft with ice or methane. The Astrobee robots are a system of three flying robots [11] (Honey, Queen, and Bumble) with highly modular software that assist astronauts with missions and research[24]. The shapeshifting robots [12]are being designed to fly, roll, swim, float, and morph into one machine in order to traverse Saturn's moons[25]. The SHERLOC device uses chemical traces on Mars's surface to detect traces of pre-existing life [13] and was successfully implemented in the Mars 2020 mission[26]. The Steam Propelled Autonomous Retrieval Robot is a conceptual design with the goal of exploring planets with icyterrains[27] [14]. Though many of these robotic projects are in their early stages of development, they are technologically advanced and materialize the once-intangible concepts of robotic technology.

The third area of study related to outer space development is solar technology. New trends in solar science include the Solar Parker Probe, the advanced radiationdetectors [15], the Space Environmental Testbeds (SETs) [16], and the BioSentinal mission. The Solar Parker Probe is being designed to get within 8. 5 solar radii of the sun using layers of carbon[28]. In 2018, the initial Parker Solar Probe was launched; it was planned to approach the Sun to within 8. 5 solar radii of its surface: seven times closer than any previous mission. This level of proximity was significant in that it would allow first-time particle, radiation, and magnetic field measurements of the Sun's corona. The goal is to understand and explain the outstanding solar system mysteries such as the heating mechanism within the Sun's primary surface. This is challenging because the Sun's photosphere is extremely high in radiation. The goal of NASA's Innovative Advanced Concepts (NIAC) Program study - Phase 1 was to determine how near a spacecraft can get to the Sun, using a novel, high-reflectivity type of coating. NASA's NIAC Program "nurtures visionary ideas that could transform future NASAmissions with the creation of breakthroughs—radically better or entirely new aerospace concepts—while engaging America's innovators and entrepreneurs as partners in the journey"[29]. Advancing coating development for NIAC's proposed Phase 2 will focus on the optical and mechanical issues related to high temperature long-wave reflectors. This could prove to provide opportunities for those interested in contributing their knowledge and skill set to this and related programs. Advancing radiation detector technology is one of the many areas where creative minds will be in demand. As NASA is currently in the process of preparing to send the people to the Moon and to Mars, it is working to develop advanced radiation detectors [17] for the protection of astronauts and spacecraft systems from harmful solar storms. Invisible high energy particles of radiation released from our Sun can be extremely harmful to the health of people traveling into outer space, as well as damaging to spacecraft, electronics, and other systems[30]. The Space Environment Testbeds (SET) are being designed to study how to protect satellites from solar radiation[31]. The BioSentinel[18] mission studies how solar radiation affects living organisms through a microfluidics card containing yeast[32]. NASA's Radiation and Solar studies provide an opportunity to better understand our Sun and how to protect our equipment and ourselves from it.

NASA is developing numerous autonomous system technologies to improve the accuracy of missions and reduce the need for human aid. Examples of the recent autonomous developments are Non-piloted Precision Landing, Robotic Servicing Capabilities, Autonomous in-space assembly, and the pneumatic sampler collection system. The concept of Non-piloted Precision Landing[19] serves to conduct landing mechanisms with hazard-evading technologies[33]. This innovation improves landing safety on other planets, by using advanced algorithms and lasers. Robotic Satellite Servicing Capabilities and Autonomous in-space assembly are both concepts that focus on robotic systems performing in space operations such as: diagnosing, maintaining, and assembling [20] other space objects[34]. The Robotic Satellite Servicing aims to maintain a more affordable and sustainable

[23]"E-TBEx: Enhanced Tandem Beacon Experiment" by Rob Garner (June 20, 2019) NASA press release:https://www.nasa.gov/content/goddard/e-tbex-enhanced-tandem-beacon-experiment [Accessed January 9, 2020].

[24]"NASA's New Flying Robots: Bee-ing in Space for the First Time" by Rick Chen (June 17, 2019) NASA Ames press release:https://www.nasa.gov/feature/ames/nasa-s-new-flying-robots-bee-ing-in-space-for-the-first-time [Accessed January 9, 2021].

[25]"NASA Designing Shapeshifting Robots for Saturn's Moons" by Tony Greicius (October 1, 2019) NASA Jet Propulsion Laboratory press release:https://www.nasa.gov/feature/jpl/nasa-designing-shapeshifting-robots-for-saturns-moons [Accessed January 9, 2021].

[26]"Johnson-Built Device to Help Mars Perseverance Rover Search for Signs of Life" by Noah Michelsohn (July 7. 2020) NASA Johnson press release :https://www.nasa.gov/feature/johnson-built-device-to-help-mars-perseverance-rover-search-for-signs-of-life [Accessed January 9, 2021].

[27]"This Hopping Robot Could Explore the Solar System's Icy Moons" by Tony Greicius (June 24, 2020) NASA press release :https://www.nasa.gov/feature/jpl/this-hopping-robot-could-explore-the-solar-systems-icy-moons [Accessed January 9, 2021].

[28]"Solar Surfing" by Doug Willard and Loura Hall (April 10, 2019) NASA Kennedy Space Center at:https://www.nasa.gov/directorates/spacetech/niac/2019_Phase_I_Phase_II/Solar_Surfing/ [Accessed January 9, 2021].

[2]9For more information about the NASA Innovative Advanced Concepts (NIAC) Program see:https://www.nasa.gov/directorates/spacetech/niac/index.html [Accessed September 18, 2020].

[30]"NASA, CERN Timepix Technology Advances Miniaturized Radiation Detection" by Shanessa Jackson (October 21, 2019) NASA press release.

[31]"SET Mission Overview" by Rob Garner (June 13, 2019) NASA press releasehttps://www.nasa.gov/content/goddard/set-mission-overview [Accessed January 11, 2021].

[32]"BioSentinel" by Yael Kovo (April 17, 2019) NASA press release:https://www.nasa.gov/centers/ames/engineering/projects/biosentinel.html [Accessed January 11, 2021].

[33]"NASA Technology Enables Precision Landing Without a Pilot" by Loura Hall (September 22, 2020) NASA press release:https://www.nasa.gov/directorates/spacetech/NASA_Technology_Enables_Precision_Landing_Without_a_Pilot [Accessed January 11, 2021].

[34]"Testing Satellite Servicing Technologies" by Yvette Smith (April 26, 2019) NASA press release:https://www.nasa.gov/image-feature/testing-satellite-servicing-technologies [Accessed January 11, 2021]; "NASA Assemblers are Putting the Pieces Together for Autonomous In-Space Assembly" by Eric Gillard (December 13, 2019) NASA press release:https://www.nasa.gov/feature/langley/nasa-assemblers-are-putting-the-pieces-together-for-autonomous-in-space-assembly [Accessed January 11, 2021].

satellite system by repairing and refueling decommissioned satellites instead of replacing them. The pneumatic sampler collection system is being developed to collect soil samples from other planets and bring them back to earth for research [21][35].

NASA is striving to reduce the ecological footprint of its study, to combat it, they have developed eco-friendly technologies. Examples of these technologies are the Green Propellant Infusion Mission (GPIM) [22], the All-Electric X-57 X-Plane [23], the fungal mycelium habitats, the refabricator, and the Orbital Syngas/Commodity Augmentation Reactor (OSCAR) project. The Green Propellant Infusion Mission (GPIM) developed a new monopropellant called Advanced Spacecraft Energetic Non-Toxic (ASCENT) which is safer for the space environment and less toxic than the previousmonopropellant (hydrazine)[36]. The All-Electric X-57 X-Plane is a development that defies traditional fueling practices because they emit zero carbon emissions and run on electric energy[37]. The fungal mycelium habitats focus on eco-friendly habitats for humans using self-growing fungal material[24][38]. The refabricator [25]focuses on recycling 3D printed objects back into 3D printer ink for the continuous use of recycled matter[26][39]. Knowing that these technologies exist is beneficial, but also knowing that there are existing opportunities to contribute to missions is inspiring. NASA internships call for interns to contribute their ideas and aid to projects that are essential to actual missions. For example, the Orbital Syngas/Commodity Augmentation Reactor (OSCAR) project is one of the many projects that are available for interns to contribute their ideas to and engage in hands-on work. The OSCAR project plans to convert spacecraft trash [27] into either an eco-friendly breathable gas or spacecraft fuel[40]. NASA's many internship opportunities show that there are ways for visionary people to get involved and leave their mark on the future of space exploration and colonization.

Other noteworthy innovations include the Rapid Analysis and Manufacturing Propulsion Technology (RAMPT) [28], the Bulk Metallic Glass Gears (BMGG) project, and the pixel-based silicon detector. The Rapid Analysis and Manufacturing Propulsion Technology (RAMPT) is being developed to cut costs and improve the performance of rocket thrust chamber assembly by redesigning traditional methods[41]. The Bulk Metallic Glass Gears (BMGG) project has created a new material (metallic glass) to defy the freezing temperatures [29-31] of many moons for safer, expanded space exploration[42]. The new pixel-based silicon detector technology is being developed to detect highly energetic photons from the most powerful events in the universe, for example: colliding galaxies and black holes[43].

Conclusion

Our opinion is that unless all people, throughout all nations, are preparing for outer space development (as well as colonization in the Polar Regions), once again only a few nations are likely to benefit. International law, specifically the Outer Space Treaty of 1967, mandates that all nations should benefit. The world community created the international space laws decades ago, and today we can see how brilliantly foresighted they were in doing so. As it stands today, only a handful of people are aware about all the material covered in my research. This lack of awareness will further widen the already considerable inequality gaps. Gaining knowledge, information, and education—even self-study education—is the key to enabling more people to shape positive futures for themselves and to influence others.

This paper discusses a unique pedagogical approach to help mend the knowledge gaps and to suggest the possibility of preventing inequality gaps from emerging as outer space is developed. To achieve equality in outer space for future generations, we must begin fomenting a contagious desire for knowledge and a universal consciousness regarding newly emerging trends. This is an invitation for visionaries, people curious about newly emerging trends, and those who are concerned about dwindling opportunities during the dismal global economic recession, to understand and be exposed to what is happening today.

It is the eve of outer space development, but few people are aware of the potential for all of this. In the absence of awareness, people cannot prepare for the opportunities that will arise; and so, the vast new types of opportunities for human development may be stifled. International space law requires that space advancements benefit all people. However, how can all people benefit from space activities? The vast majority do not know it is happening and most do not care. This apathy exists because of a simple lack of information and inspiration. This purpose of this article is to help inspire visionary thinkers, scholars, educators, artists, or people with a` dream, to start preparing to contribute to outer space development. Emerging trends are researchable. Eventually this is likely to ensure that equality and diversity are a part of the process of outer space development.

People must be inspired and informed of emerging patterns and links in order to be aware of things before they happen, and this is certainly the case within the field of outer space development. More people need to be included in the planning stage of space industry creation, which may prove to be as powerful as the industrial revolution, as this process continues to evolve into a new frontier of development. Without this, public space programs are at risk of being defunded. People must be able to perceive a return on their taxpayer investment in order to keep the dream alive.

[35]"Sample Return Technology Successfully Tested on Xodiac Rocket" by Monroe Conner (June 14, 2018) NASA press release:https://www.nasa.gov/centers/armstrong/features/planetvac_tested_on_masten_xodiac.html [Accessed January 11, 2021].

[36]"NASA's Green Propellant Infusion Mission Nears Completion" by Jennifer Harbaugh (October 20, 2020) NASA press release:https://www.nasa.gov/mission_pages/tdm/green/gpim-nears-completion.html [Accessed January 11, 2021].

[37]"NASA's All-Electric X-57 X-Plane: A Cleaner Way to Fly" by Abigail Tabor (October 22, 2020) NASA press release:https://www.nasa.gov/image-feature/ames/nasa-s-all-electric-x-57-x-plane-a-cleaner-way-to-fly [Accessed January 11, 2021].

[38]"Myco-architecture Off Planet: Growing Surface Structures at Destination" by Lynn Rothschild and Loura Hall (March 29, 2018) NASA press release:https://www.nasa.gov/directorates/spacetech/niac/2018_Phase_I_Phase_II/Myco-architecture_off_planet/ [January 11, 2021].

[39]"Full Circle: NASA to Demonstrate Refabricator to Recycle, Reuse, Repeat" by Kristine Rainey (November 14, 2018) NASA press release:https://www.nasa.gov/mission_pages/centers/marshall/images/refabricator.html [Accessed January 11 2021]; "Combination 3D Printer will Recycle Plastic in Space" by Jennifer Harbaugh (November 21, 2018) NASA press release:https://www.nasa.gov/mission_pages/centers/marshall/combination-3d-printer-will-recycle-plastic-in-space.html [Accessed January 11, 2021].

[40]"NASA Technology Designed to Turn Space Trash into Treasure" by Loura Hall (June 5, 2020) NASA press release:https://www.nasa.gov/spacetech/NASA_Technology_Designed_to_Turn_Space_Trash_into_Treasure [Accessed January 11, 2021].

[41]"Rapid Analysis and Manufacturing Propulsion Technology (RAMPT)" by Eric Vitug (September 16, 2020) NASA press release:https://www.nasa.gov/directorates/spacetech/game_changing_development/projects/RAMPT/ [Accessed January 11, 2021].

[42]"New Gears Can Withstand Impact, Freezing Temperatures During Lunar Missions" by Eric Vitug (September 3, 2020) NASA press release:https://www.nasa.gov/feature/new-gears-can-withstand-impact-freezing-temperatures-during-lunar-missions [Accessed January 11, 2021].

[43]"Semiconductor Manufacturing Techniques Employed for New Gamma-ray Detector" by Lynn Jenner (August 6, 2020) NASA press release:https://www.nasa.gov/feature/goddard/2020/semiconductor-manufacturing-techniques-employed-for-new-gamma-ray-detector [Accessed January 11, 2021].

Co-writing this paper has allowed us to research areas of outer space development that I had previously believed were science fiction. I had access to information that I did not know was public, and suddenly I was immersed within NASA's plans for future development in outer space.

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