ENHANCING SAFETY FOR COMMERCIALIZED HUMAN SPACE TRAVEL AND COLONIZATION

By

JOSHUA ADAM LARSON

Bachelor of Science in Professional Aeronautics
Embry-Riddle Aeronautical University
Worldwide Campus
2000

Master of Science in Aerospace and Aviation Management
Embry-Riddle Aeronautical University
Worldwide Campus
2011

Master of Science in Aerospace and Systems Safety
Embry-Riddle Aeronautical University
Worldwide Campus
2011

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Dissertation Approved:

Dr. Mallory Casebolt

Dissertation Adviser

Dr. Timm Bliss

Dr. Jon Loffi

Dr. Kathryn Gardner-Vandy

Dr. Donita Shaw

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Abstract:

This study explored the lack of global standardization guidelines for space travel and colonization as the world begins commercializing human space travel operations. The safety issue posed with the future of commercial human space transportation is due to the independent functioning of national space agencies and private commercial space entities, despite the presence of international entities such as the United Nations Office for Outer Space Affairs (UNOOSA) and The Committee on the Peaceful Uses of Outer Space (COPUOS) (UNOOSA, 2021). Due to the lack of accepted minimum international standards and commercialized space travel guidelines, there is a need to explore the feasibility of establishing and prioritizing a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized human space travel and colonization between global governments and private entities. This study utilized a two-round Delphi design to investigate the need to establish and prioritize a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities.

Due to the lack of guidelines on space travel and colonization both for government and private purposes, the findings yielded from this study might help to provide guidance on how an agency or clearinghouse could be established to develop such guidelines. The study included the prioritization of issues relevant to the establishment of guidelines to regulate commercialized human space travel and colonization. There were 29 global expert participants from 10 different nations who participated in this research study. As a result of disseminating this study's findings, industry decision-makers may become more knowledgeable of safety concerns regarding human and spacecraft design, certification, training, and qualification approval. The results of this study include quantitative and qualitative data.

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CHAPTER I

INTRODUCTION

The national space agencies and private commercial space entities in the world function independently. Their independence, and the lack of any standardized, global guidelines, pose a potential problem for the future of commercial human space transportation. One could pose the question, does having a growing plethora of independently functioning worldwide national space agencies and private commercial space entities, with various undefined governing laws, policies, and procedures, pose a problem for future space exploration and colonization? This research seeks to answer that question and begin conceptualizing a global agency that can create safety standards grounded in evidence-based best practices for commercial and personal space travel. Because space is vast, many problems can occur regarding humans and spacecraft when there is no atmosphere. Furthermore, mechanical failures and existential threats are ever-present, which could result in fires or collisions with micrometeoroids or debris. This can cause loss of spacecraft pressure, spills, and collisions (NASA, 2007).

Background

The launch of society into space has entered a new era of transportation with commercial space travel (Reddy, 2018). The development of space travel leads to a space commerce industry, including space mining, space tourism, space defense, and much more. These will all be processed by the power of quantum computing, and the integration of more artificial

intelligent (AI) robots (Vanian, 2015). Some research suggests that the internet of things (IoT) might provide opportunities for digitally enhanced space living (Kua et al., 2021), as well as other research that has looked into how design should be considered when you are planning to create human-occupied spacecraft or colonies (Dominoni, 2021). A major development has revealed that colder temperatures might stave off the damage from living in a high radiation environment (Fukunaga, 2020).

When referencing the significant number of existing worldwide national space agencies and corporate space entities, it would seem reasonable that there needs to be some order, direction, and governing policy to ensure safety standards are being met for civilian consumers trying to access space travel. The United Nations (UN) has, to date, through separate entities, like the International Civil Aviation Organization (ICAO), the UN Office for Outer Space Affairs (UNOOSA), and the Committee on the Peaceful Uses of Outer Space (COPUOS), served as the international organization for the development of international space treaties and regulations. However, the researcher finds it beneficial for this study to explore the necessity for an international entity to serve as a clearinghouse function for all matters regarding space law, policy and procedures, operations, interagency relations, licensing, monitoring, enforcement, interdiction, training, testing/evaluation, and certification. Such guidance could potentially enhance the efficacy of space safety integration and interoperability that controls Earth's private citizens while utilizing a universal Space Traffic Management (STM) system that is governed and regulated by one policy and single controlling agency. By having a well-defined and established single set of regulated policies and procedures that govern doctrine and set universal, perpetual expectations, the spaceflight industry can capitalize on safety from the lessons learned over the last 118 years from the aviation industry just as organizations such as ICAO have

created a set of unified safety recommendations. These recommendations for commercial space would be similar to safety recommendations grounded in research. Therefore, it may be beneficial to establish one global/universal commercial space transportation guideline and governing policy with standardized emergency procedures and protocols on Earth, during spaceflight, and at every possible destination in space as a contingency.

Statement of the Problem

The problem explored in this study is the lack of global standardization guidelines as the world begins commercializing human space operations, including space travel and colonization. The issue defining the future of commercial human space transportation is centered around the independent functioning of national space agencies and private commercial space entities, despite the presence of international entities such as UNOOSA and COPUOS (UNOOSA, 2021). This issue is further exacerbated by the fact that many problems can occur for humans in spacecraft when there is no atmosphere and human bodies are exposed to various space radiations, microbes, and biofilms (Durante & Cucinotta, 2011; Landry et al., 2020; Sielaff et al., 2019; Stapleton et al., 2017; Vuolo et al., 2017). Whether public or commercial, continued space travel poses complex medical challenges (Galts, 2017; Sielaff et al., 2019). Furthermore, mechanical failures and existential threats are always present and pose a danger due to the need for in-flight maintenance and regulated control (Stapleton et al., 2017). Despite these risks, NASA has initiated a public-private partnership to continue deep space capabilities (Netea et al., 2020; Stapleton et al., 2017). Due to the lack of global international standards and commercialized space travel guidelines, it is beneficial to explore the development of a single global agency. Such lack of guidelines includes, but is not limited to, standardized safety integration and interoperability protocols, spacecraft, design, and certification requirements, as

well as personnel training and certification requirements. Such an agency could establish guidelines and act as a clearinghouse for the certifications, requirements, and ethical standards for space travel and colonization by both government and private entities on a global scale.

Purpose of the Study

The purpose of this Delphi study was to investigate international experts' thoughts regarding the need to establish and prioritize a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. Due to the lack of global international standards and commercialized human space travel guidelines, the research sought to explore the need for a single global agency's development that would establish guidelines and act as a clearinghouse for the certifications, requirements, and ethical standards for space travel and colonization by both government and private entities. The study included the prioritization of issues relevant to establishing guidelines to regulate commercialized human space travel and colonization.

Global governance theory and public space governance were used to guide this study. The research study included 29 global expert participants who were from 10 different nations. The participants included international experts that possessed knowledge and experience about aerospace and space through their experience in the space profession. The following areas of expertise included: astronauts, astronaut safety managers, aerospace medical doctors/officers, aerospace physiologists, aerospace safety engineers, chief aerospace/space executives, aerospace academia, aerospace training specialists, aerospace research scientist/analysts/experts, aerospace mechanics, aerospace program/project managers, aerospace manufacturers, aerospace communication operators, aerospace engineers, aerospace defense personnel, aerospace

integration/interoperability engineers, systems engineers, airline industry experts, aerospace tourism industry experts, aircraft crash/accident survivors, commercial and military pilots, commercial and military test pilots, intelligence analysts within the space arena, inspections/investigation experts, space journalist, space operations, spacecraft propulsion/launch vehicle engineers, deep space experts, as well as space law and policy experts.

Viewpoints of Aerospace & Space Professionals and Data Capture

The study measured how aerospace and space professionals view the future of commercial space tourism safety regarding human screening, selection criteria, and training certification and qualification standards before space entry.

Research Questions

To achieve the purpose of this study, the following research questions guided this study:

1. What are the priorities for the development of guidelines for space travel and or colonization as expressed by public (government) and private entities?
2. What is the feasibility of the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities?
3. What are practical solutions to the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities?

Significance of the Study

The findings of this research could potentially impact future global/universal policy regarding space safety operation matters and ultimately be responsible for placing humans in space, including training them and ensuring their health, wellbeing, survival, and perpetual

existence off-Earth. The information obtained by this research might also help facilitate further discussion and implement change within the global commercial and government space transportation industries. The study findings could be used to inform industry decision-makers about identified safety concerns and strategies regarding human and spacecraft certification and qualification approval before any human or spacecraft is allowed into space. Through a series of Delphi rounds, the objectives aimed to:

- Capture the global space professional community's consensus towards developing a possible single global agency or clearinghouse guideline to standardize certifications, requirements, and ethical standards for space travel and colonization between governments and private entities.
- Investigate the space community's consensus, potentially leading to enhanced, more regulated commercial spacecraft safety certification standards and routine maintenance inspection requirements under one governing global policy doctrine that allows for better overarching integration and interoperability.
- Possibly, under a single controlling entity/agency with a single set of universal operating policies and procedures, with a commercial and private unified diplomatic doctrine that allows humans the autonomy to freely integrate and interoperate in space; a baseline of safety could be established as humans start to begin to populate and expand deeper into space.

This research is valuable for the safety of commercial human space travel, exploration, and colonization of other worlds. It aimed to qualify and quantify the global community of space professionals' expertise regarding enhancing the future of safety in commercialized human space travel and colonization. It provides thoughtful insight from aerospace and space professionals'

regarding establishing better policies that foster ethical and safer operations regarding humans in space. As a final product of this research, the researcher aims to publish the findings' entirety and gain a peer review. Through a peer review and dissemination through the space professional and space policy industry, the aim is to strengthen the industry through diplomacy. The data herein will foster dialogue that will build partnership capacities globally, allow for deep thought, expanded discussion, and hopefully lead to new enhanced, safer international legislation and policy that will better allow future space travel and colonization to endure and thrive.

The researcher also intended to build the case to develop overarching Operational Risk Management (ORM) mitigation safeguards within a global/universal Space Traffic Management (STM) critical infrastructure system to ensure humans perpetually endure and thrive in space.

The researcher sought to bring awareness to the necessity for a fundamental conceptual understanding that commercial space transportation should be globally tied to one overarching critical end-to-end space-systems safety infrastructure. The overarching system must be continuously assessed, and risk mitigated with well-defined ORM logic tools governing a singular controlling policy.

Limitations and Assumptions of the Study

In this project, the researcher chose survey participants who had an existing profile created within LinkedIn and were willing to respond to the researcher, and therefore this is an inherent limitation of the study. The researcher assumed that participants were truthful in their responses and reflected their views on developing recommendations based on their views in each round of the Delphi study. The goal of this study's research was vital to reach an informed consensus to develop a guideline for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities,

based on the input of the expertise from the knowledge of study participants.

A related limitation in this study was that the potential guidelines and insights developed in this study were limited to the input and consensus reached among the study participants. Additionally, the study was limited to the expertise and perceptions of those included in the study. In a study with a larger sample size or one that is inclusive of other participants, the insights and recommendations may differ. Therefore, additional research may be beneficial to confirm the study findings' generalizability to the larger government and private community.

Definition of Terms

In this section, a definition of terms used throughout this research study is presented:

Artemis Program – The Artemis Program is a human spaceflight program by NASA. The missions in the program aim to explore the Moon, including crewed and robotic exploration of the lunar surface (NASA, 2020).

Certification – A certification is a voluntary program administered by a governmental or non-governmental organization and grants the use of a credential to individuals for a specific period (ISA, 2020). The certification is available to those who meet predetermined and standardized criteria for knowledge, skills, or competencies. The knowledge needed to pass a certification assessment is learned through self-study and experience. The assessment is conducted independently of a specific class, course, or another training program (ISA, 2020). The person holding the certification must meet renewal requirements as defined by policy requirements to retain the credential. For this study's purposes, a certification was related to certifying a commercial space traveler with no personal body of knowledge of commercial space procedure operations. Certification requirements have minimum continuing education standard requirements and associated expiration dates.

Cosmos – The universe (Merriam-Webster, n.d.).

Deep Space – This is the space that is well beyond the outside limits of the Earth's atmosphere; and where "well beyond" is considered the range that extends beyond the Earth's Moon.

Department of Transportation (DOT) – The Department of Transportation (DOT) is a federal Cabinet department of the U.S. government concerned with transportation. It was established by Congress's act on October 15, 1966, and began operation on April 1, 1967. The United States Secretary of Transportation governs it.

Federal Aviation Administration (FAA) – The FAA's responsibility related to space transportations is described as the following: "to ensure the protection of the public, property, and the national security and foreign policy interests of the United States during commercial launches or reentry activities" (FAA, 2020).

Hazardous Material (HAZMAT) – Hazardous material is a flammable or poisonous material that would be dangerous if released without proper precautions (Transportation Compliance Associates, 2019).

High Earth Orbit (HEO) – HEO is a geocentric orbit with an altitude entirely above a geosynchronous orbit (35,786 kilometers/22,236 mi) (Defense Intelligence Agency, 2019).

International Air Transport Association (IATA) – The IATA is the trade association for the world's airlines, representing about 290 airlines or roughly 82% of total global air traffic. They support vast aviation activities to help formulate industry policy on critical aviation issues.

International Civil Aviation Organization (ICAO) – ICAO is paid for and managed by 193 governments to help oversee cooperation in air transportation for commercial, research, or diplomatic reasons, to develop and perform policies and standards studies and analyses (ICAO).

Kármán Line – The Kármán Line is an attempt to define a boundary between Earth's atmosphere and outer space. It is an altitude of 100 kilometers (62 miles or 330,000 feet) above Earth's mean sea level (MSL).

Low Earth Orbit (LEO) – LEO is an Earth-centered orbit with an altitude of 2,000 km (1,200 mi) or less (Defense Intelligence Agency, 2019).

Medium Earth Orbit (MEO) – MEO, sometimes called intermediate circular orbit (ICO), is the region of space around Earth above low Earth orbit (altitude of 2,000 km (1,243 mi) above sea level) and below geosynchronous orbit (altitude of 35,786 km (22,236 mi) above sea level) (Defense Intelligence Agency, 2019).

National Aeronautics Space Administration (NASA) – NASA is an independent agency of the United States federal government responsible for the civilian space program, aeronautics, and space research (NASA, 2021).

Qualification – A qualification is a program administered by a governmental agency and is awarded for achieving a body of knowledge with learning objectives (ISA, 2020). Qualification requirements have minimum continuing education standard requirements and associated expiration dates.

System of Systems – A system of systems is a collection of task-oriented or dedicated systems that combine their resources and capabilities to create a new, more complex system that offers more functionality and performance than simply the constituent systems' sum (NATO-SoS, 2020).

United Nations, Committee on the Peaceful Uses of Outer Space (UN COPUOS) – The UN COPUOS was established to accomplish the following: “to govern the exploration and use of space for the benefit of all humanity: for peace, security, and development” (UNOOSA, n.d.).

United Nations General Assembly (UNGA) – The main policy-making body of the United Nations (un.org)

United Nations Office for Outer Space Affairs (UNOOSA) – The responsibility of UNOOSA is to promote the peaceful use and exploration of space through international cooperation (UNOOSA, n.d.).

United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN SPIDER) – Is a platform that facilitates the use of space-based technologies for disaster management and emergency response.

CHAPTER II

REVIEW OF THE LITERATURE

For the review of literature, keyword searches were conducted utilizing Google Scholar, Web of Science, and ResearchGate. The following terms, which were used both individually and in combinations, were used to identify relevant sources: *outer space and governance*, *space and governance*, *deep space and governance*, *outer space travel*, *deep space travel*, *space travel*, *outer space colonization*, *outer space*, and *deep space*. Only policy documents and peer-reviewed articles were used as part of the literature within this chapter. The researcher reviewed all sources identified from the searches conducted for quality and relevancy to the topic of interest.

In this chapter, the studies identified as relevant to this study are described. The literature is presented using the following categories: (a) challenges in space travel/colonization, (b) governance of outer space, (c) international agencies for outer space, (d) international space laws and policies, and (e) the growing outer space economy. After presenting the literature and relevant policies, a conclusion and summarization of all related literature are presented. The conclusion includes a summary of key findings and the gap in extant research addressed in this study.

Due to the lack of previously published literature concerning space governance theory, this study's framework was based on the theory of global governance and public space theory.

As deep space is a public space not owned by any single government or entity, it can be considered an international public space in which global governance applies. In this study, deep space was considered a public space that is not solely the responsibility of governments but also governed and impacted by private entities (Zamanifard et al., 2018). Public space governance is intended to holistically address political economy, power structure, and history of place (Zamanifard et al., 2018). As such, public space governance is inclusive of both public and private sector involvement and interest in public spaces (Zamanifard et al., 2018). In this study, public space governance theory was complemented by global governance theory.

According to Fioretos and Tallberg (2020) global governance theory was also determined to be appropriate for this study, as it included considerations regarding the legitimacy of the authority of global governance institutions. In this study, the feasibility of and the priorities pertaining to the development of an agency for the development of guidelines and regulations for space travel and or colonization was explored. Global governance theory is key in terms of establishing a global institution with the authority to develop such guidelines and regulations in space. Global governance theory is also applicable to understanding current international space agreements such as the Outer Space Treaty (OST; 1967) and the role of international organizations such as the United Nations General Assembly (UNGA), from which COPUOS was developed to ensure international cooperation and peace in outer space (UNOOSA, 2021). Based on global governance theory, international governance bodies such as COPUOS have authority for global governance as it relates to global issues. COPUOS, in particular, is responsible for the development of policies related to outer space for the UN Member States.

Challenges in Space Travel and Colonization

There are complex health challenges in providing healthcare in space (Galts et al., 2017).

Bone demineralization, cardiovascular dysfunction, and muscular atrophy occur due to the body's response to microgravity. Radiation exposure is also a significant hazard for those traveling to space (Galts et al., 2017). Radiation exposure negatively impacts fertility and can also result in birth defects (Barbrow, 2020). As reflected in this section, there are several opposing challenges associated with space travel, particularly health challenges and ensuring the wellness of those traveling to space (Barbrow, 2020; Galts et al., 2017). It is likely that issues are exaggerated with more extended missions (Galts et al., 2017) and would therefore be likely to continue with space colonization. A potential benefit of an international governing body would be to assist in safeguarding the health of space travelers.

Governance of Outer Space

Although international agencies exist, the "space race" involves both commercial and political representatives that are interacting in the international space law regime (Steer, 2020). The need for outer space governance is essential given the increase in outer space travel both by public and commercial entities: "developments in outer space have exploded in complexity, ambition, and commercial promise" (Durkee, 2019, p. 711). Currently, space governance is guided by international agencies and national governments that have implemented their own space laws and regulations for their own nation. Moreover, existing space treaties reflect the international desire to prevent space's militarization (Durkee, 2019). Despite a lack of central global governance, there are agencies for outer space and several policies and laws in place for various nations, but no universal global agency oversees commercial or personal spaceflight.

International Agencies for Outer Space

The international agencies for outer space include the United Nations Office for Outer Space (UNOOSA); the Committee on the Peaceful Uses of Outer Space (COPUOS), whose

subcommittees are the Scientific and Technical Subcommittee and the Legal Subcommittee. Other agencies include the Inter-Agency Space Debris Coordination Committee (IADC) and the Committee on Space Research (COSPAR). Each of these agencies and their initiatives is presented in this section to demonstrate the present entities and platforms available for outer space governance.

United Nations Office for Outer Space Affairs (UNOOSA)

The role and responsibility of UNOOSA is to:

Help all countries, especially developing countries, access and leverage the benefits of space to accelerate sustainable development. They work toward this goal through a variety of activities that cover all aspects related to space, from space law to space applications (UNOOSA, n.d.). The specific roles and responsibilities are as follows:

- Countries' capacity development
- Disaster risk reduction: UN-SPIDER helps countries use space data and technologies, such as satellite imagery, to prevent and manage disasters
- Help countries to draft national space laws and policies
- Support transparency in space activities, such as in the use of the Registry of Objects Launched in Outer Space, which is maintained by UNOOSA
- Promote sustainable development and sustainability of outer space activities
- Foster international solutions to problems in space
- Work with space agencies and space leaders to identify solutions to challenges that require an international response (UNOOSA, n.d.)

UNOOSA's role is to support countries in developing their own national space law and policy, rather than to create policies and laws that apply internationally. UNOOSA serves as the

"UN hub for space affairs" (UNOOSA, n.d.). The purpose of UNOOSA is "to deliver the benefits of space to everyone, everywhere" (UNOOSA, n.d.). As such, UNOOSA is composed of space agencies both on the national and regional levels. In UNOOSA, the Register of Objects Launched into Outer Space documents satellites, probes, landers, crewed spacecraft, and space station flight elements that are launched into space (UNOOSA, 2021).

Committee on the Peaceful Uses of Outer Space and its Subcommittees (COPUOS)

The COPUOS was established under the UN as a separate entity, to "govern the exploration and use of space for the benefit of all humanity: for peace, security and development" (UNOOSA, n.d.). This committee was commissioned to review international cooperation regarding the "peaceful uses of outer space, studying space-related activities that could be undertaken by the UN, encouraging space research programs, and studying legal problems arising from the exploration of outer space" (UNOOSA, n.d.). In 1958, one year before the first official year of establishing the COPUOS, 18 national member participants were involved (UNOOSA, n.d.). As of 2021, that number has grown significantly to 95, following the incorporation of member nations and their associated entities as part of the COPUOS (UNOOSA, n.d.).

As UNOOSA governs international space law, they provide a central location for such laws and agencies. As such, UNOOSA (n.d.) described the history and development of COPUOS as follows:

> The Committee on the Peaceful Uses of Outer Space (COPUOS) was set up by the General Assembly in 1959. Since its establishment, the Committee's membership has continued to expand. The Committee is the only committee of the General Assembly dealing exclusively with international cooperation in the peaceful uses of outer space, and

> its role as a forum to monitor and discuss developments related to the exploration and use of outer space has evolved alongside with the technical advancements in space exploration, geopolitical changes, and the evolving use of space science and technology for sustainable development. (UNOOSA, n.d., para. 1)

Continuing the overview of the history of COPUOS, UNOOSA (n.d.) further presented an overview of the objectives and responsibilities of COPUOS and its mandate as an international committee that "aims at strengthening the international legal regime governing outer space, resulting in improved conditions for expanding international cooperation in the peaceful uses of outer space" (UNOOSA, n.d., para. 2). The mandate also indicates that the committee ought to assist efforts "at the national, regional, and global levels, including those of entities of the United Nations system and international space-related entities, to maximize the benefits of the use of space science and technology and their applications" (UNOOSA, n.d. para. 2). The overall aim of the committee is "to increase coherence and synergy in international cooperation in space activities at all levels" (UNOOSA, n.d. para. 2)

The importance of COPUOS in maintaining peace within the international community, particularly in the context of outer space, is of particular importance in consideration of the mounting tensions in space as is outlined in a U.S. Defense Intelligence Agency report in terms of how space-based support has several militaries, commercial, and civilian applications and previous technological and cost barriers are being removed, so more countries and private enterprises can participate in "satellite construction, space launch, space exploration, and human spaceflight" (US-DIA, 2019, para. 1). The report further details the new opportunities and risks for space-enabled services and some of the benefits of operations happening in space. There is a concern as foreign governments are developing more advanced capabilities than their neighbors,

and they may threaten the developing capabilities of those countries.

Space 2030 Agenda: Space as a Driver for Peace

The "Space2030" agenda and implementation plan should highlight the unique role of the committee and its subcommittees. Supported by the UNOOSA, the committee and subcommittees are unique platforms for international cooperation in exploring and using outer space for peaceful purposes. The committee and subcommittees also support the global governance of outer space activities, the development of international space law, dialogue among spacefaring and emerging spacefaring nations, and the increased involvement of all countries in space activities, including through capacity-building initiatives. The "Space2030" agenda would also demonstrate the important role of space in supporting global development agendas, joint efforts, global partnerships, and strengthened cooperation among member States, UN entities, intergovernmental and non-governmental organizations, academia, research institutions, industry, and private sector entities (UNGA, 2019).

In June 2018, during a UN "Space2030," Working Group, the Working Group agreed that the future needs to view space "as unique platforms for international cooperation" as space exploration research and commerce emerge for peaceful purposes. Therefore, policy is needed for "the global governance of outer space activities, for developing international space law, for fostering dialogue among spacefaring and emerging spacefaring nations, and for promoting the increased involvement of all countries in space activities, including through capacity-building initiatives" (UNGA, 2019, para. 10).

In reviewing the Space2030 agenda within the UNGA (2019), the committee pointed out the following as related to the implementation and formation of the agenda:

The committee noted that a "Space2030" agenda and implementation plan was a

> collective effort by States members of the committee to develop a high-level, forward-looking and comprehensive document that highlighted the role of space and the broad societal benefits that it brought. Such an agenda and implementation plan should serve as an inspirational tool for a broader international community by promoting the use of space technologies and applications and space-derived data to further economic growth, sustainable development and prosperity.

The committee further noted that a "Space2030" agenda and implementation plan were intended to raise awareness of, promote and strengthen the use of space tools for the attainment of the global development agendas, in particular the 2030 Agenda for Sustainable Development and its goals and targets, as well as the Sendai Framework for Disaster Risk Reduction 2015–2030 and the commitments by States parties to the Paris Agreement on climate change.

The committee went on to argue that the "Space2030" agenda and implementation plan represented a unique opportunity to demonstrate the continuous relevance and the strengthening of the Committee on the Peaceful Uses of Outer Space and its subcommittees and the Office for Outer Space Affairs as unique platforms for international cooperation in the exploration and use of outer space for peaceful purposes and the global governance of outer space activities for the benefit of and in the interest of all humankind.

Presenting each of these points within the "Space2030" agenda is key as they demonstrate the ongoing intent to develop and implement international efforts in outer space. As noted within the UNGA (2019) report, the "Space2030" agenda has been placed as an item for consideration, development, and implementation within the UN. The "Space2030" agenda will be led by COPUOS and is intended to focus on the use of space for peaceful purposes. As expressed, the UN has positioned themselves as the platform for the global governance of outer

space activities.

Inter-Agency Space Debris Coordination Committee (IADC)

The Inter-Agency Space Debris Coordination Committee (IADC) was developed to govern the issue of space debris (IADC, n.d.). According to the agency's website, the IADC is described as:

> An international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space. The primary purposes of the IADC are to exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options. (IADC, n.d., para. 1 & 2)

Unlike the UN agencies for outer space, the focus of IADC is on space debris, and it centers on the environment, protection, and mitigation, rather than on maintaining peace in outer space. The member agencies of IADC are as follows:

- ASI (Agenzia Spaziale Italiana)
- CNES (Centre National d'Etudes Spatiales)
- CNSA (China National Space Administration)
- CSA (Canadian Space Agency)
- DLR (German Aerospace Center)
- ESA (European Space Agency)
- ISRO (Indian Space Research Organisation)
- JAXA (Japan Aerospace Exploration Agency)
- KARI (Korea Aerospace Research Institute)

- NASA (National Aeronautics and Space Administration)
- ROSCOSMOS (Russian State Space Corporation)
- SSAU (State Space Agency of Ukraine)
- UK Space Agency

COSPAR Committee on Space Research

COSPAR is an international agency responsible for space research. The committee has both National Scientific Institutions and International Scientific Unions as members. As noted by the committee, the purpose of COSPAR is to promote international scientific research in space with a focus on sharing and exchanging results, information, and opinions, as well as provide a forum for all involved scientists to create a vibrant international space research effort without impediment from geopolitical conflicts between countries. COSPAR has extremely high ethical standards for the research it publishes and discloses any financial support that might be seen as influencing its research or viewpoints. COSPAR promotes gender equality and diversity in its operations and does not tolerate discrimination or harassment. COSPAR also promotes roles and activities for young scientists as the future of space research (COSPAR, 2019).

As reflected in this section, there are several international agencies for the governance of different initiatives pertaining to outer space. The challenge with multiple agencies for outer space is a lack of coordination between agencies and the centralization of authority. International agencies, such as UNOOSA, work to foster communication and coordination between national agencies but do not hold the authority to develop space laws and policies that would have international application. Moreover, as reflected in the membership, many of the agency members are state actors, such as representatives of government space entities, with a limited representation of private entities.

International Space Law, Treaties, Principles, Declarations, & Policies

It is fundamental to understand that all the UN member States' agreements and treaties regarding outer space activities were based on adopting principles created from the UNGA beginning in the 1960s. In 1963, the UNGA convened, and it was called the "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space." This momentous event was the precursor and the fundamental building block for establishing "Space Law." The principles developed by the General Assembly for the governing of the activities of states in the exploration and use of outer space are as follows:

1. The exploration and use of outer space shall be carried on for the benefit and in the interests of all mankind.
2. Outer space and celestial bodies are free for exploration and use by all States on a basis of equality and in accordance with international law.
3. Outer space and celestial bodies are not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.
4. The activities of States in the exploration and use of outer space shall be carried on in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding.
5. States bear international responsibility for national activities in outer space, whether carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried on in conformity with the principles set forth in the present Declaration. The activities of non-governmental entities in outer space shall require authorization and continuing supervision by the State concerned. When activities

are carried on in outer space by an international organization, responsibility for compliance with the principles set forth in this Declaration shall be borne by the international organization and by the States participating in it.

6. In the exploration and use of outer space, States shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space with due regard for the corresponding interests of other States. If a State has reason to believe that an outer space activity or experiment planned by it or its nationals would cause potentially harmful interference with activities of other States in the peaceful exploration and use of outer space, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State which has reason to believe that an outer space activity or experiment planned by another State would cause potentially harmful interference with activities in the peaceful exploration and use of outer space may request consultation concerning the activity or experiment.
7. The State on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and any personnel thereon, while in outer space. Ownership of objects launched into outer space, and of their component parts, is not affected by their passage through outer space or by their return to the Earth. Such objects or component parts found beyond the limits of the State of registry shall be returned to that State, which shall furnish identifying data upon request prior to return.
8. Each State which launches or procures the launching of an object into outer space, and each State from whose territory or facility an object is launched, is internationally liable for damage to a foreign State or to its natural or juridical persons by such object or its component parts on the Earth, in air space, or in outer space.

9. States 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 a foreign State or on the high seas. Astronauts who make such a landing shall be safely and promptly returned to the State of registry of their space vehicle. (UNGA, 1963)

As reflected in these principles, the purpose of establishing such guidelines were to maintain peace through cooperation, mutual assistance, and sovereignty of individual states. Based on these initial principles developed by the UN, the treaties and agreements developed can be categorized as multilateral space treaties developed from 1967 to 1984 and the declaration of legal space principles developed between 1963 and 1996.

Multilateral Space Treaties (1967 to 1984)

This section presents an overview of the multilateral space treaties developed and entered into force between 1967 and 1984.

- 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), entered into force on October 10, 1967 (UNOOSA, n.d.).
- Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space (General Assembly resolution 2345 – XXII) entered into force on December 3, 1968 (UNOOSA, n.d.).
- Convention on International Liability for Damage Caused by Space Objects (General Assembly resolution 2777 – XXVI) entered into force on September 1, 1972 (UNOOSA, n.d.).
- Convention on Registration of Objects Launched into Outer Space (General

Assembly resolution 3235 – XXIX) entered into force on September 15, 1976 (UNOOSA, n.d.).

- Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (General Assembly resolution 34/68) entered into force on July 11, 1984 (UNOOSA, n.d.).

Declaration of Legal Space Principles (1963 to 1996)

The UN oversaw the drafting, formulation, and adoption of five General Assembly resolutions, including the Declaration of Legal Principles. These are:

- Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, adopted on December 13, 1963 (General Assembly resolution 1962 – XVIII; UNOOSA, n.d.).
- Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting, adopted on December 10, 1982 (General Assembly resolution 37/92; UNOOSA, n.d.).
- Principles Relating to Remote Sensing of the Earth from Outer Space, adopted on December 3, 1986 (General Assembly resolution 41/65; UNOOSA, n.d.).
- Principles Relevant to the Use of Nuclear Power Sources in Outer Space, adopted on December 14, 1992 (General Assembly resolution 47/68; UNOOSA, n.d.).
- 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 December 13, 1996 (General Assembly resolution 51/122; UNOOSA, n.d.).

United Nations Outer Space Treaty of 1967

The United Nations Outer Space Treaty (UNOST) of 1967 established principles for member States for outer space. UNOOSA (n.d.) presented an overview and description of the treaty. The Outer Space Treaty was first placed under consideration of the Legal Subcommittee in 1966 and was agreed upon by the General Assembly in the same year. It was primarily based on the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, which was adopted in 1962. The treaty was then opened for signature by the three depository Governments (i.e., the Russian Federation, the United Kingdom, and the United States of America) in January of 1967 before entering into force in October of the same year.

Further to the principles as outlined in the treaty, UNOOSA (n.d.) also noted the importance of the treaty in providing a foundation for international space law:

- the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
- outer space shall be free for exploration and use by all States;
- outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;
- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- The Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- Astronauts shall be regarded as the envoys of mankind;
- States shall be responsible for national space activities whether carried out by governmental or non-governmental entities;
- States shall be liable for damage caused by their space objects; and

- States shall avoid harmful contamination of space and celestial bodies.

The OST prohibits any State nation from staking claim or sovereignty any portion of in space. It also indicates that whenever a State nation or any private commercial entity from that State nation sends a spacecraft into space, the space mission is the State nation's sole responsibility (Kanchwala, 2020; UNOOSA, n.d.). In addition to the overview provided by UNOOSA (n.d.), a paraphrasing of the details of Article IX verbiage of the OST of 1967 describes the use of land as follows. In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall avoid their harmful contamination and also adverse changes in the environment resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, that would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies. (UNOST 1967, 1029; UNOOSA, n.d.)

Recognizing the UNOST as the foundation for regulations governing outer space, the oversight of the Astronaut Rescue Agreement of 1968 was facilitated by the UN.

The Astronaut Rescue Agreement of 1968

Further to the UNOST 1967, the Astronaut Rescue Agreement was developed in 1968. The Astronaut Rescue Agreement was presented by UNOOSA as follows: “The Rescue Agreement was considered and negotiated by the Legal Subcommittee from 1962 to 1967. Consensus agreement was reached in the General Assembly in 1967 (resolution 2345 (XXII),

and the Agreement entered into force in December 1968" (UNOOSA, n.d.). The astronaut rescue agreement was entered into force based on the agreement of member States. The Rescue Agreement of 1968, or Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, was the second treaty on outer space drafted by the United Nations Committee on the Peaceful Uses of Outer Space. A vote of 115-0 adopted it on December 19, 1967, opened for signature at Washington, London, and Moscow on April 22, 1968, and entered into force on December 3, 1968. As of January 2019, ninety-eight States have ratified the Rescue Agreement of 1968 (UNOOSA, n.d.).

In participating under the agreement, the responsibilities of member States for rescuing astronauts were presented as follows:

> States shall take all possible steps to rescue and assist astronauts in distress and promptly return them to the launching State, and that States shall, upon request, provide assistance to launching States in recovering space objects that return to Earth outside the territory of the Launching State. (UNOOSA, n.d., para. 1)

Following the Rescue Agreement of 1968, the liability convention was also led by the UN in 1972.

Liability Convention (1972)

According to UNOOSA (n.d.), "The Liability Convention was considered and negotiated by the Legal subcommittee from 1963 to 1972. Agreement was reached in the General Assembly in 1971 (resolution 2777 (XXVI)), and the Convention entered into force in September 1972" (UNOOSA, n.d., para 1). The Liability Convention is another development of the OST as reflected below:

> Elaborating on Article 7 of the Outer Space Treaty, the Liability Convention provides

> that a launching State shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft, and liable for damage due to its faults in space. The Convention also provides for procedures for the settlement of claims for damages. (UNOOSA, n.d., para. 1)

The Liability Convention (1972) is essential because it placed the responsibility on member States for any damage that resulted from space objects launched by member States, while the Registration Convention (1976) provided a means of registering objects launched into space by member States.

Registration Convention (1976)

As with the treaties described thus far, UNOOSA is also responsible for guiding the Registration Convention, which was considered and established by the Legal Subcommittee in 1962 before being adopted by the General Assembly in 1974 (General Assembly resolution 3235 (XXIX)). It opened for signature on 14 January 1975 and entered into force on 15 September 1976 (UNOOSA, n.d.).

As noted in the cases of other treaties, the Registration Convention (1976) again follows on from the OST as it builds upon the desire documented in the Outer Space Treaty, the Rescue Agreement, and the Liability Convention to produce a mechanism that gives States with a means to assist in identifying space objects with a registry. The Registration Convention expanded the scope of the United Nations Register of Objects Launched into Outer Space that was established by resolution 1721B (XVI) in December of 1961 and addressed issues relating to States Parties' responsibilities concerning their space objects. The Secretary-General was, once again, requested to maintain the Register and ensure full and open access to the information provided by States and international intergovernmental organizations (UNOOSA, n.d.).

Moon Agreement (1984)

In 1984, the Moon Agreement was developed to add more specificity to the agreements made for outer space governance. The Moon Agreement builds upon previous agreements. According to UNOOSA (n.d.), the Agreement:

> reaffirms and elaborates on many of the provisions of the Outer Space Treaty as applied to the Moon and other celestial bodies, providing that those bodies should be used exclusively for peaceful purposes, that their environments should not be disrupted, that the United Nations should be informed of the location and purpose of any station established on those bodies. In addition, the Agreement provides that the Moon and its natural resources are the common heritage of mankind and that an international regime should be established to govern the exploitation of such resources when such exploitation is about to become feasible. (UNOOSA, n.d., para. 1)

Other policies are presented with this overview of the international treaties governing outer space and led by the UN.

COSPAR Policy on Planetary Protection

The COSPAR Policy on Planetary Protection focuses on protecting outer space rather than governance for peace. COSPAR has also developed a policy on planetary protection developed by their Panel on Planetary Protection (Rummel et al., 2002). In 2020, the COSPAR Policy on Planetary Protection included the following recommendations:

COSPAR members are recommended to inform COSPAR when establishing planetary

protection requirements for planetary missions and that they do so within a reasonable timeframe not to exceed six months after launch about the computations and procedures to protect the planet for each flight and again within 12 months to monitor potential contamination. COSPAR will retain a collection of these annual reports and make them available to the public (COSPAR, 2019).

As with the other agencies, the policy developed by COSPAR include recommendations rather than enforceable laws or regulations. As reflected in this section, much of the existing laws and policies for space focus on supporting nations in protecting astronauts and maintaining peace in space. However, as with the agencies for outer space, there is a lack of policies and laws with international authority to govern space travel and colonization. With the perspective of outer space as an international public space, this study considered the need for laws and policies for space to govern space travel and colonization by both government and private entities.

The Space Race

Krause (2017) defined the space race as a Cold War competition between the Soviet Union and the United States to advance aerospace capacities in human spaceflight, unmanned space probes, and artificial satellites. The space race started after World War II, with the two countries trying to prove the superiority of political-economic systems, military firepower, and technology. Various factors played a crucial role in causing the Space Race, which helped develop many modern technologies for what they are today, and which private citizens use for everyday uses.

Causes of the 1950s 1960s Space Race

Tension resulting from the conflict between the United States and the Soviet Union is perceived as a significant cause of the space race in the 1950s and 1960s. According to Sagath et

al. (2018), in the 1950s, the Cold War between these two countries had penetrated the fabric of citizens' daily lives. The war in Korea fueled this war, a clash of ideas and words propagated by media outlets, an increasing threat of nuclear weapons, and the arms race (MacDonald, 2017). In the early 1960s, the war outbreak in Southeast Asia, the Cuban missile crisis, and the Berlin Wall construction enhanced the tensions between the United States and the Soviet Union, resulting in the Cold War's escalation.

Advances in space exploration played a significant role in the 1950s 1960s Space Race. According to Mieczkowski (2013), the launch of the world's first artificial satellite (Sputnik) served as a critical dramatic arena for the Space Race. This satellite's launch surprised many Americans who perceived space as the next frontier in continuing the country's tradition of exploration. Krause (2017) affirmed that the Sputnik satellite launch demonstrated a substantial power of the R-7 missile, capable of initiating a nuclear war into the United States airspace.

The creation of NASA was geared toward helping the country to explore space and compete effectively with the Soviet Union. According to Mieczkowski (2013), the creation of this space agency is perceived as the product of successful cooperation and planning between the administration of President Eisenhower and eminent scientists. Also noted is that those events of late 1957 would forever impact foreign relations regarding diverse foreign relations, education, and military planning. Eisenhower designed two national security-focused space programs that operated concurrently with NASA to enhance space exploration speed in the United States. These programs developed orbiting satellites to collect intelligence-related data from the Soviet Union and other countries that conflicted with the USA.

The Current Space Race

Advances in technology and growing interests in space exploration have extended the space race beyond the conflicts between the United States and the Soviet Union, including other countries, such as Japan, China, and India. Sagath et al. (2018) stated that the geopolitics dynamics had revolutionized the space race resulting in a shift from the communism versus capitalism battles to more economic-centered interests. Some of these interests include the chance to mine rare products from space and the opportunity to create new products in microgravity (Howell, n.d.). Although the current space race is economic-centered, there is also a national prestige tied to a nation's ability to explore space.

The desire to explore space for economic gains has compelled various nations to work together. For instance, Russia, the United States, China, and Japan formed a coalition in the tangible form of the International Space Station to exploit the Earth-orbit space economy (Howell, n.d.). This station focuses on telecommunication, surveillance, climate, and weather monitoring. In Asia, the current major parties in the Earth-orbit ecosystem include India, Japan, and China. Japan has successfully delivered H-II (HTV) cargo spacecraft and satellites into orbit (Howell, n.d.). China successfully launched the Chang Zheng satellites, which serve as orbit and earth communication boosters for civilian and military purposes. The Asian countries, together with the United States, have started to consider restarting the human Moon exploration, with a focus on human lunar landings (Howell, n.d.).

Trillion Dollar Space Economy

In this section, the growing space economy, from the perspective of policies in the United States, is presented. The Department of Commerce (DOC) highlighted the financial investment in outer space as emerging because:

> Multiple investment banks have forecast that the global space economy will surpass $1 trillion by 2040. The Commerce Department's Bureau of Economic Analysis has initiated its own research effort to measure the space sector's contribution to U.S. Gross Domestic Product (GDP). (Department-of-Commerce-Space-Policy, 2020, para. 1)

The U.S. the Department of Commerce (DOC) is the agency that is recently responsible for Space Traffic Management (STM), which includes space debris. The Department of Commerce (2020) has highlighted the importance of the 2020 National Space Policy to ensure that it is robust and innovated and allows for a competitive commercial space sector. The goal for the National Space Policy is that the United States government will facilitate spaced-based commerce and research that support the nation's interests and advances American leadership in new, emergent Global markets and innovation-driven entrepreneurship (Department-of-Commerce-Space-Policy, 2020).

Among other things, the new policy makes the following updates in support of space commerce:

- Directs the government to partner with the commercial space industry to gain innovation and cost savings.
- Calls for targeted investments to encourage commercial space innovation and entrepreneurship.
- Directs further regulatory streamlining to ensure timely, predictable, transparent, and flexible licensing processes that accommodate rapid innovation and adapt to market demands, consistent with Space Policy Directive-2 (SPD-2).
- Tasks the Commerce Department to develop a new process to review, authorize, and supervise space activities beyond the scope of existing federal authorizations.

- Reiterates the Commerce Department's role as the lead civil agency for providing space situational awareness (SSA) and collision warnings to commercial space operators, consistent with SPD-3.
- Underscores the need for responsible behavior in space (including the use of SSA data and services), which is essential to safe, sustainable space commerce.
- Calls for government and industry collaboration to secure the IT infrastructure for space systems, consistent with SPD-5.
- Promotes the development of commercial habitats in Earth orbit to eventually replace the International Space Station (Department-of-Commerce-Space-Policy, 2020).

The role of commercial actors is similarly limited in existing policies and regulations. However, commercial actors play an increasing role in outer space governance due to a growing outer space economy.

Commercial Space Act of 1998

The United States developed the Commercial Space Act of 1998 in response to the increase in commercial space development. As noted in the policy, the act was developed "[t]o encourage the development of a commercial space industry in the United States and for other purposes" (Commercial Space Act, 1998). The Commercial Space Act includes the commercialization of the space station and space launches and the acquisition of commercial space transportation services. For example, in the commercialization of the space station, Section 101 of the Commercial Space Act (1998) allowed the ISS to be involved in commercial enterprise.

The goal of the agreement was to increase the commercialization of outer space. The critical point is that Congress declared that the International Space Station should be for

economic development in the Act. However, the Commercial Space Act of 1998 is limited to the United States rather than the international commercialization of space and is therefore limited in terms of application to international commercial space entities.

International Civil Aviation Organization (ICAO)

An international construct may look something like that of the ICAO, yet the ICAO still has limited global authority as with other international organizations. As with COPUOS, ICAO is an entity under the UN. The ICAO website states, "Uniting Aviation," then under that slogan, it states, "A United Nations Specialized Agency" (ICAO, 2020). The strategic objectives of ICAO are:

- Safety
- Capacity and efficiency
- Security and facilitation
- Economic development
- Environmental protection

There are currently 193 ICAO member nations out of the 195 world nations in existence (as recognized by the United States; ICAO, 2020).

New Regulations Governing Private Human Space Flight Requirements for Crew and Space Flight Participants

In 2006, the Department of Transportation within the Federal Aviation Administration (FAA) developed human space requirements for space flight participants. These guidelines were developed to establish requirements for human space flight based on the Commercial Space Launch Amendments Act of 2004 (Federal Aviation Administration, 2006). Within these guidelines, in addition to developing compliance measures for cabin crew, pilots, and safety for travelers, and training requirements for space flight participants, the regulations include financial

responsibility and waiver of liability requirements for human space flight. Such a waiver provides guidance and restrictions on claims that can be made against the U.S. Government by space flight participants. Additionally, experimental permits were included as having separate guidance for rulemaking. The effective date of the amendments guiding human space flight, as regulated by the FAA, was February 13, 2007 (Federal Aviation Administration, 2006).

In a more recent order, the Department of Transportation (DOT), FAA Order 8800.2, titled “FAA Commercial Space Astronaut Wings Program,” presented as national policy on July 20th, 2021, the FAA developed a set of eligibility requirements for commercial crew. The requirements include (a) meeting flight crew regulation under Title 14 of the Code of Federal Regulations (14 CFR) part 460; (b) flight beyond 50 statute miles above the surface of the Earth; and (c) demonstrating that the activities conducted during flight were essential for public safety or human space flight safety (Federal Aviation Administration, 2021). An important note is that Order 8800.2 is a United States national policy and, therefore, does not have global application as a commercial space policy.

NASA Artemis Accords

On October 13, 2020, NASA Administrator Jim Bridenstine addressed the world online about the United States' position regarding collecting outer space resources and the mutual peaceful use of outer space for science, exploration, and more. This event was the global partnership and signing of the Artemis Accords. He advised that "countries and companies should be able to enjoy the fruits of their labor, and that any and all acts should and will be done in full compliance with the Outer Space Treaty (OST)" (NASA Artemis Accords, 2020).

NASA Administrator Jim Bridenstine also stated that:

We also need to abide by the principle of due regard and utilize safety zones, where a

> nation is responsible for public notification where they are operating and coordinate with any affected party to avoid harmful interference as required by the OST. (NASA Artemis Accords, 2020)

It is imperative to understand the principle of "due regard," which is defined by Zhang, 2014 in terms of its use in relation to marine research and enterprise.

> The term "due regard," derived from customary international law, international treaties and general legal principles, is a principle of UNCLOS, which is used to settle the conflict between the exercise of rights and freedoms. It is comprised of two components: 1) "regard", meaning that a State should respect and take into account the interests of other States whilst exercising its maritime rights or freedoms; 2) "due" regard. A State analyzes and balances the interests between exercising its own rights or freedoms and realizing and taking into account other states' interests to meet the criteria of due regard. The criteria of due regard are the weighing of interests by authoritative policymakers in the global community in accordance with internationally accepted criteria and actual conditions. "Due regard" is also applied in international law practices. (Zhang, 2014, p. 70)

The now-former NASA Administrator Bridenstine highlighted that the Artemis Accords fundamentally avoided conflict through transparency, public registration, and attempted to deconflict activities with proper lines of proactive communications and that these principles will preserve the peace. "The Artemis Accords are crafted to prevent conflict before it happens" (NASA Artemis Accords, 2020). Administrator Bridenstine stated that the "Artemis Accords are a beginning and are not an ending, and the experiences will help inform future multilateral discussions at the United Nations committee on the peaceful use of outer space and other

international forums" (NASA Artemis Accords, 2020). Profoundly he also noted that, "that the time has come to operationalize the Outer Space Treaty, and that is just what the Artemis Accords does" (NASA Artemis Accords, 2020). The U.S. is building a coalition of like-minded partners to go on this space mission to the Moon, Mars, and beyond. The Artemis Accords create an apparatus that allows international partners to maintain a sustainable human presence in outer space (NASA Artemis Accords, 2020).

Artemis includes numerous government and commercial partnerships. NASA states that we must do this together with the commercial industry and peacefully in global partnerships. The U.S. has already taken the lead; with the Artemis program and the global community involvement, there will be significant policy change regarding space exploration. On May 15, 2020, NASA Administrator Jim Bridenstine announced the Artemis Accords will base partnerships on shared understandings and shared commitments related to:

- Peaceful purposes
- Transparency
- Interoperability
- Emergency assistance
- Registration of space objects
- Release of scientific data
- Protecting heritage
- Space resources
- Deconfliction of activities
- Orbital debris and spacecraft disposal (Maday, 2020)

As of October 13, 2020, eight nations, including the United States, are signatory member

nations within the Artemis Accords (NASA Artemis Accords, 2020). This number seems remarkable because eight nations signed on as partners only five months after the Artemis Accords announcement. The nations that are part of the Artemis Accords are Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates (UAE), the United Kingdom (UK), and the United States of America (USA) (NASA Artemis Accords, 2020).

The United States, 14 Code of Federal Regulations (CFR) Chapter III – Commercial Space Transportation, Federal Aviation Administration, Department of Transportation (DOT), explains that the U.S. regulates human spaceflight. The problem is that because there is no commercial space transportation, passenger certification requirements, lawmakers have mandated that the DOT, through the FAA, via the commercial space transportation entity, at the discretion of the passenger willing to travel into space, sign a space flight participant waiver of claims against the U.S. Government. Therefore, the Artemis Accords are essential in understanding the potential regulation of human spaceflight in the future.

Further to the statements made by NASA Administrator Jim Bridenstine, the Artemis program highlights principles for a safe, peaceful, and prosperous future in outer space and notes a grounding in the UNOST of 1967:

> Via the Artemis program, NASA will land the first woman and the next man on the Moon by 2024, heralding in a new era for space exploration and utilization. While NASA is leading the Artemis program, international partnerships will play a key role in achieving a sustainable and robust presence on the Moon while preparing to conduct a historic human mission to Mars. With numerous countries and private sector players conducting missions and operations in cislunar space, it's critical to establish a common set of principles to govern the civil exploration and use of outer space. The Artemis

> Accords will describe a shared vision for principles, grounded in the Outer Space Treaty of 1967, to create a safe and transparent environment which facilitates exploration, science, and commercial activities for all of humanity to enjoy. (NASA, n.d.)

This excerpt from the NASA Artemis Accords is essential to note, as it highlights that the Artemis program will be led by NASA, a United States entity, but will build upon the UNOST, thereby acknowledging the importance of the UN agreements in providing a foundation for international governance of outer space. The Artemis Accords themselves include a purpose and scope as follows:

> The purpose of these Accords is to establish a common vision via a practical set of principles, guidelines, and best practices to enhance the governance of the civil exploration and use of outer space with the intention of advancing the Artemis Program. Adherence to a practical set of principles, guidelines, and best practices in carrying out activities in outer space is intended to increase the safety of operations, reduce uncertainty, and promote the sustainable and beneficial use of space for all humankind. (The Artemis Accords, p. 2)

Notably, the Artemis Accords include an implementation plan, including proposed means of binding states to the agreement:

1. Cooperative activities regarding the exploration and use of outer space may be implemented through appropriate instruments, such as Memoranda of Understanding, Implementing Arrangements under existing Government-to-Government Agreements, Agency-to-Agency arrangements, or other instruments. These instruments should reference these Accords and include appropriate provisions for implementing the principles contained in these Accords.

> (a) In the instruments described in this Section, the Signatories or their subordinate agencies should describe the nature, scope, and objectives of the civil cooperative activity;
>
> (b) The Signatories' bilateral instruments referred to above are expected to contain other provisions necessary to conduct such cooperation, including those related to liability, intellectual property, and the transfer of goods and technical data;
>
> (c) All cooperative activities should be carried out in accordance with the legal obligations applicable to each Signatory; and
>
> (d) Each Signatory commits to taking appropriate steps to ensure that entities acting on its behalf comply with the principles of these Accords. (The Artemis Accords, p. 2)

As evidenced in the purpose and scope, the Artemis Accords are relevant to only civil space agencies, thereby reflecting limitations in governing commercial entities – specifically, those outside of the scope of "civil space activities."

China and Russia Partnership

China and Russia have created a partnership for further activities in outer space as evidenced by the Russia-China proposal for an agreement named 'The Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, and of the Threat or Use of Force Against Outer Space Options' (Vasiliev, 2008). The draft treaty focuses on preventing the placement of weapons in outer space and the threat or use of force against outer space objects (Security in Space. The Next Generation. Conference Reports, p. 148). Going forward, Russia and China may create a mutual Lunar base, which was expressed in a Memorandum of

Understanding Regarding Cooperation for the Construction of the International Lunar Research Station (China National Space Administration, 2021). Although planned for the future, the planned Russia-China partnership in outer space may have implications for diplomatic affairs in outer space and the regulation and development of commercial policies guiding outer space.

Intergovernmental Agreement (IGA)

In addition to bilateral agreements, the implications for the International Space Station (ISS) development as an international science and engineering project for cooperation in space must be considered (NASA, 2018). The IGA established a cooperative framework and established criminal jurisdiction in outer space (NASA, 2018). Due to the importance of the IGA for establishing international collaboration in the ISS as the largest international space platform (NASA, 2018), implications for its use in governing activities in space must be considered.

The Way Forward

Despite multiple international agencies, treaties, and agreements, there remains a lack of clarity in space governance. As evident thus far, many of the existing policies pertaining to outer space focus on maintaining peace by preventing weaponization and militarization. Moreover, the international treaties that have been enacted are mostly non-binding or "soft policies." Ferreira-Snyman (2015) posits that after the end of the spaces treaties of the 60s and 70s, it has become obvious that States were unwilling to adopt further binding obligations or international laws that regulate space commerce or other activities, and as a result of their non-mandatory behavior they can be ignored.

This point made by Ferreira-Snyman (2015) is essential to note in consideration of potential ways forward regarding international governance of outer space. Despite the emphasis on preventing the militarization of outer space, other factors, such as protecting individuals from

the negative health impacts and the dangers of space, have been less explored.

Conclusion

As shown in this review of relevant literature, the existing space policies and agencies are reflective of the interest to prevent the misuse of space in terms of militarization and colonization (Durkee, 2019). Agencies such as COPUOS exist to maintain peace within outer space and are based on national space agencies' membership and coordination (UNOOSA, n.d.). The problem with existing agencies and policies for outer space is that the race to space, including space travel and colonization, includes both government and commercial actors (Durkee, 2019; Steer, 2020). There is currently a lack of a central agency to govern both commercial and government actors on an international level. Therefore, this study explored this issue by focusing on the feasibility of establishing and prioritizing a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized human space travel and colonization between global governments and private entities.

As reflected in this chapter, although multiple agencies exist for the governance of outer space, the UN is the international organization responsible for developing international space treaties and tasked with developing plans to both develop and implement such treaties. However, as reflected in the Artemis Accords' development, and the United States Space Force (USSF), the United States has also been positioned to lead outside space initiatives. In this study, the entity responsible for regulating outer space was also considered based on consensus using the Delphi method. In chapter 3, the methodology to be used for this study is described.

CHAPTER III

METHODOLOGY

This study utilized a Delphi study to investigate the need to establish and prioritize a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. Due to the lack of guidelines on space travel and colonization both for government and private purposes, the findings yielded from this study might help to provide guidance on how an agency or clearinghouse could be established to develop such guidelines. The study included the prioritization of issues relevant to the establishment of guidelines to regulate commercialized human space travel and colonization.

There were 29 anonymous global expert participants from 10 different nations who participated in this research study. However, it should be noted that one participant responded only to the first two questionnaire items in the first round of the Delphi study, so after the second item, the number of participants (N) is reduced to 28 active participants. Additionally, all participants continued to participate in the second round maintaining the N value consistently at 28 throughout round two of the Delphi study. Participants for this study were international experts that possessed knowledge and experience about aerospace and space through their experience in the space profession. The areas of expertise of participants were: astronauts, astronaut safety managers, aerospace medical doctors/officers, aerospace physiologists,

aerospace safety engineers, chief aerospace/space executives, aerospace academia, aerospace training specialists, aerospace research scientist/analysts/experts, aerospace mechanics, aerospace program/project managers, aerospace manufacturers, aerospace communication operators, aerospace engineers, aerospace defense personnel, aerospace integration/interoperability engineers, systems engineers, airline industry experts, aerospace tourism industry experts, aircraft crash/accident survivors, pilots, test pilots, intelligence analysts within the space arena, inspections/investigation experts, space journalist, space operations, spacecraft propulsion/launch vehicle engineers, deep space experts, space law, and policy experts. Global governance theory and public space governance were used to guide this study.

Research Design

A Delphi research approach was utilized in this study to identify and prioritize issues for decision-making through consensus among study participants (Okoli & Pawlowski, 2004; Sekayi & Kennedy, 2017). In the Delphi method, study participants should have knowledge and expertise in the field, commitment to the project, time availability, and effective communication skills (Okoli & Pawlowski, 2004). In the first round of the Delphi method, participants were asked to provide their inputs about the most critical issues related to the topic of interest, using a qualitative approach. The Delphi method's first phase is referred to as “brainstorming” (Okoli & Pawlowski, 2004).

In the second phase, the goal was to develop consensus among experts to narrow down the list through a selection process. After the initial " brainstorming phase, " the Delphi method's second phase involved ranking the factors based on the pared-down list (Okoli & Pawlowski, 2004). Researchers have recommended that at least 70% of experts agree in order for consensus to be met (Okoli & Pawlowski, 2004). As a result, Round 1 was used for brainstorming, Round 2

for "narrowing down" and ranking. The rounds utilized in this study are further described below.

In Round 1, a questionnaire comprising open-ended questions was developed to engage the expert panel in open-ended brainstorming on the topic for the purpose of developing a list of factors meriting further consideration in Round 2. In Round 2, a list of statements developed from the Round 1 findings was presented to all participants. Round 2 was quantitative, with participants being asked to rate their level of agreement with the statements on a series of 45 five-level Likert-like items. When the mean response to the questionnaire item across all 28 participants was 3.5 out of 5 (70%) or greater, this indicated that consensus in agreement with the statement was reached, as recommended by Okoli and Pawlowski (2004). A mean response of 1.5 or less out of 5 indicated consensus in disagreement with the statement. When a consensus was reached in relation to a statement on the questionnaire, the statement was considered endorsed by the expert panel.

Throughout this research, the epistemology regarding the acquisition of knowledge came from various sources, and within this research study, it utilized four categories of sourcing for knowledge acquisition. These categories were intuitive knowledge, authoritarian knowledge, logical knowledge, and empirical knowledge. It was essential to capture the survey participants' truthfulness through transparency throughout the data capture process and accurately document their findings within the conclusion of this document. It was also essential to understand variables and factors for knowledge sourcing for existential factors that could have influenced personalities or swayed survey participants' answers during survey questions to define the epistemological categories.

First, intuitive knowledge sourcing was based on the survey participants' beliefs, and that person's emotion influenced a more significant factor than factual data. Unfortunately, this was a

bias that had to be accepted, accounted for, and was uncontrollable. As such, this bias was also a limitation of this study, particularly to the transferability of the findings of this research. Second, authoritarian knowledge sourcing was gained from the information from the literature, data, research studies, and subject matter expertise. The knowledge derived herein, and the credibility and validity depended on these sources to ensure the comprehensive research study's credibility remained valid. Third, logical reasoning was gained and applied through knowledge sourcing and applied within findings and conclusions. Fourth and finally, through subject matter experts' perceptions, there was empirical knowledge sourcing gained. This knowledge provided relevant knowledge that reinforces the study's objective (Hasa, 2016).

The researcher performed a “subjectivist, epistemological study,” and attempted to capture the aerospace and space communities' rational beliefs via online survey questionnaires. A subjectivist epistemology rejects the idea that there is a single, objective trust existing independently of perception and instead indicates that every individual constructs their own understanding of the trust based on their unique history of interactions with others and with the environment (Thomas et al., 2020). The Round 1 questionnaire was comprised of open-ended questions. This purpose was to develop a comprehensive list of relevant factors from the experts’ responses and then group similar factors into themes. In Round 2, the close-ended items on the questionnaire allowed experts to indicate agreement or disagreement with the themes identified in Round 1. These questionnaires targeted the precise individuals, who are considered “subject matter experts” and whose creative thought added to overall data quality. The subjective data were individually captured, but additionally, all surveys were comprised as a compendium of overarching findings and conclusions of the social belief at the end of the study. It is essential to note that having a subjective epistemology study provides the reader's framework to understand

how to interpret the rational thought process of research methodology and logic and how this occurred when reading the findings and conclusions section. This understanding of the subjective theory epistemology helped the researcher understand the aerospace and space professionals' plausible perception regarding the study (Foley, 1987).

The study's qualitative portion of the methodology involved attempts to qualify a homogeneous purposive sampling of international aerospace and space professionals' perceptions of research data and provided a global industrial validation measurement to raise awareness of the results' findings. This study aimed to understand and conclude the general theory of knowledge (i.e., subjectivist epistemology) regarding private commercial space entities. The study captured qualitative data from the aerospace and space professional community, narrowed it down, and then ranked the data using a quantitative approach, which was captured using a Likert scale ranking (Okoli & Pawlowski, 2004). The goal was to understand the aerospace and space professional community's perception regarding the commercial space industry's ethical responsibility regarding human passengers before space entry and/or the policies and/or procedures that should be developed to enhance life and/or property. By accomplishing this Delphi research methodology, the researcher ensured the highest probability of success to understand what informed consensus by asking the most relevant overarching safety questions regarding commercialized human space travel and colonization that affect life and property. The questions were vetted by aerospace and space professionals, and the informed consensus was reached through two rounds of the Delphi study.

Additionally, the researcher aimed to understand the long-term exposure of space and colonization and which humans are best adaptively suited. This study aimed to conclude a delineation attempt of findings for the aerospace and space industries' perception of specific

research questionnaires.

Target Population and Participant Selection

The survey population of this study was international aerospace and space professionals both in the government and commercial/private sectors, which was considered a collective population in this study. In this study, the aerospace and space professionals were those who had some form of training, work experience, or background in the aerospace or space community throughout the globe. Based on the answers sought from the derived research questions presented herein, a homogeneous global judgment/purposive sampling method was chosen, and precisely defined aerospace and space professionals from the aerospace and space community were offered the chance to participate in this study.

Purposive sampling occurs when the researcher intentionally selects study participants based on their appropriateness for the research questions or phenomenon explored (Creswell & Creswell, 2018). The researcher chose purposive sampling because it was appropriate for the group of people surveyed and questioned since they are experts in the subject of aerospace and space. This was a confidential research study in which the dissertation committee knew the participant's real identities, but their identities would never be publicly disclosed. Informed consent was obtained from each participant before they participated in the study. Participant information was kept confidential, but anything publicized was kept anonymous or redacted.

The researcher selected and vetted the survey participants through the process of elimination by doing purposive sampling amongst the researcher’s LinkedIn contacts at the time just before commencing the study. The researcher also paid $79.99 for LinkedIn’s Sales Professional monthly subscription, allowing direct messages to anyone on LinkedIn that met the inclusion criteria even if they were out of the researcher’s network. The researcher searched for

key job titles within the aerospace and space industries and then expanded that search to include those positions within geographical locations. Within each LinkedIn contact, the researcher was able to identify other members who belonged to LinkedIn and met specific metric criteria for similar positions within those areas of expertise and relevant fields. The researcher was then able to identify those individuals' prior work experience, qualify their endorsements and accomplishments, and view various associated experiences, duties, positions, and body of knowledge the individual possessed. The researcher then contacted that person via LinkedIn and provided the Oklahoma State University (OSU) Institutional Review Board (IRB) documentation (see Appendix A) explaining the study and a request to participate. Each outreach email was tailored to each person. There were 102 initial outreach messages sent to selected individuals. Out of those 102, there were 49 people to whom the survey link was sent, and only 29 people actively chose to participate.

All participants possessed the contextual and subject matter expertise necessary to contribute valuable data. The guideline for participants sought were possible candidates who possessed the subject matter expertise in aerospace and/or space with at least 8 years of experience in the following areas: astronauts, astronaut safety managers, aerospace medical doctors/officers, aerospace physiologists, aerospace safety engineers, chief aerospace/space executives, aerospace academia, aerospace training specialists, aerospace research scientist/analysts/experts, aerospace mechanics, aerospace program/project managers, aerospace manufacturers, aerospace communication operators, aerospace engineers, aerospace defense personnel, aerospace integration/interoperability engineers, systems engineers, airline industry experts, aerospace tourism industry experts, aircraft crash/accident survivors, commercial and military pilots, commercial and military test pilots, intelligence analysts within the space arena,

inspections/investigation experts, space journalist, space operations, spacecraft propulsion/launch vehicle engineers, deep space experts, as well as space law and policy experts. Below is a list of aerospace and space professionals encompassing community professionals from whom survey participants were selected. The list below represents a sampling and not the complete list and is only indicated to highlight the critical agencies from where the professionals were recruited for participation in the study through the researcher's existing LinkedIn contacts.

- National Aeronautics and Space Administration (NASA)
- European Space Agency (ESA)
- Federal Aviation Administration (FAA)
- Department of Transportation (DOT)
- Department of Defense (DOD)
- Department of Commerce (DOC)
- National Oceanic and Atmospheric Administration (NOAA)
- White House Office of Science Technology and Policy (WHOSTP)
- United Nations (UN)
- International Civil Aviation Organization (ICAO)
- National Security Agency (NSA)
- The Airline Industry
- Various other Global Space Agencies
- Various Private Commercial Aerospace Companies
- Various Private Commercial Space Companies
- Various Global Educational Institutions

- Various Aerospace Community Professionals
- Various Space Community Professionals

Table 1 indicates the continents represented in the sample of 49 participants who received the survey link.

Table 1

Continents Represented by Participants Who Received the Survey Link

Continents	*n* of survey link recipients from area (*N*=49)	*%*
1. North America	36	74%
2. Europe	6	12%
3. Australia	1	2%
4. Asia	4	8%
5. Africa	2	4%
Totals:	49	100%

Table 2 indicates the qualifications and experience represented in the sample of 49 possible participants who received the survey link.

Table 2

Qualifications and Experience of Possible Participants That the Survey Link was Sent

	Sectors	Experience
1	Commercial Space Policy, Government Regulator, U.S. Department of State, International Affairs, Sustainability.	This possible participant has 40 years of U.S. Government experience in international space law and policy. Successfully led many decades of international cooperation engagement efforts regarding transparency and predictability for space operations, the long-term sustainability of space activities, space exploration, nuclear power sources in space, global navigation satellites, and remote sensing. U.S. Representative to U.N. Committee on the Peaceful Uses of Outer Space (UNCOPUOS). Specialize in international and domestic frameworks for new space commercial ventures under international space law.
2	Aviation, Aerospace, Aerospace Medicine, Aerospace Physiology, Aerospace Survival & Training, Defense, Military Officer.	This possible participant is a Board-Certified Aerospace Physiologist with over 25 years of experience as a military officer and Aerospace Physiologist. They are in a high level of authority at a military organization that ultimately controls the entirety of Aviation/Aerospace of that branch of military service. They also have extensive work experience in survival and training with flight crew members.

	Sectors	Experience
3	Aviation, Aerospace, Airline, Strategic Assessment & Analysis, Safety Risk Assessment, Research, Professor, Military Officer.	This possible participant is a Ph.D. and has more than 30 years of combined aviation and leadership experience as a military officer flying fighter aircraft and airline pilot. Additionally, they have more than 20 years of experience as a major airline first officer and more than three years as a Ph.D. teaching at an accredited university.
4	Aviation, Aerospace, Military Officer, Strategic Assessment & Analysis, Safety Risk Assessment, Technology, Research, Doctoral Candidate.	This possible participant has more than 20 years of active-duty military service as a fighter pilot, leader, and flying various aircraft. Additionally, this possible participant is an active-duty military officer and is a doctoral candidate majoring in Aviation and Space.
5	Aviation, Test Pilot School Graduate, Space Cadre, Safety Risk Assessment, Technology, Research, Military Officer.	This possible participant has more than 9 years of experience in the military, specifically in aviation and aircraft flight tests and operations involving various aircraft design characteristics. This possible participant participates in the Space Cadre, a military cross-functional community of professionals trained to plan and execute space operations. This possible participant is an expert in U.S. Navy aircraft carrier-based operations and communications, surveillance systems, aerospace systems engineering, and flight test.
6	Aviation, Space Safety, International Space Law & Policy, Author, Editor.	This possible participant has more than 20 years in the international space law and policy and space safety arenas. Additionally, this possible participant is an author and editor who writes articles and viewpoints on space law and policy.

	Sectors	Experience
7	Aviation, International Space Policy Diplomat and Expert, Various Appointments to National Security and Space Council Sectors, Research, Professor, International Affairs.	This possible participant is a Ph.D. and has more than 40 years of experience in the international space policy arena and is a Professor of Practice in International Affairs at a major accredited university. They have served as a private sector advisor to the U.S. Delegation to the UNCOPUOS in Vienna. Furthermore, this possible participant has served on the National Space Council as Executive Secretary and Deputy Assistant to the President of The United States of America. They worked directly for the Vice President of the United States as Chair of the National Space Council. Also, they served as the Associate Administrator for Program Analysis and Evaluation at NASA.
8	Aviation, Aircraft Maintenance Officer, Defense, Military Officer, Submariner, Nuclear Power Propulsion, Safety Risk Assessment, Director of Training, Director of Operations, Government Inspector, Investigator General.	This possible participant has more than 25 years of combined military and government service in various roles as an aircraft maintenance officer responsible for maintaining military fighter aircraft. This possible participant has been the Director for Operations and Training, responsible for dynamic stressful life-threatening situations, and rescue scenarios. This possible participant has qualifications and certification in military nuclear power propulsion and applied application within submarines. Additionally, this possible participant is a current investigator for the military as a government employee and investigates matters reporting fraud, waste, and abuse.

	Sectors	Experience
9	Aviation, Adjunct Professor, Space Defense Strategy, Research. Emerging Technologies, National Security Space Enterprise, Safety Risk Assessment, Training, Director of Operations, Test Pilot School Graduate, Flight Test.	This possible participant is a Ph.D. senior fellow and strategist for a private research firm focusing on enterprise space strategy, policy, and industrial base matters. They have more than 30 years of experience in the aviation, aerospace, space, and military industries. They are also an adjunct professor at a top-tier university where they teach international aspects of space technology and security. This possible participant has served on the board of directors for security organizations in the Washington, D.C. area and has worked in the private sector supporting the Department of Defense. This possible participant has authored and published multiple books regarding space policy, space strategy, and space defense.
10	Aviation, Space Law, Space Policy, Space Technology, Space Exploration, International Affairs.	This possible participant is the Founder and CEO of an international organization dedicated to the peaceful use of outer space. The possible participant has more than 7 years of experience in the field. The organization is focused on the demilitarization of outer space, removing nuclear sources from outer space, and space debris management. This possible participant has served on international space advisory councils and has a background in space law.

	Sectors	Experience
11	Aviation, Adjunct Professor, Space Defense Strategy, Research. Emerging Technologies, National Security Space Enterprise.	This possible participant is a Ph.D. and has over 25 years of experience in increasingly responsible positions as a national security educator, strategist, and policy expert. This possible participant is an internationally recognized board member, author, speaker, researcher, and subject matter expert on national security space policy. This possible participant is an author and subject matter expert on defense policy, professional military education (PME), homeland security, counterproliferation, and joint warfighting doctrine and operations. This possible participant is directly involved in developing and implementing major national security space policy initiatives.
12	Space Safety, Flight Safety, Human-Rated Systems, Spacecraft Re-entry, Space Debris, Nuclear Power Sources, Planetary Protection, Space Safety Design.	This possible participant has more than 40 years of experience working in the space safety industry. They have worked with the European Space Agency (ESA) after spending 13 years in the aeronautical industry. This possible participant played a critical role in European research missions for the International Space Station. This possible participant was also a key player in setting up the ESA Re-entry Safety Review Panel. This member continues to have a strong international voice and is a staunch advocate regarding space safety in the space community through the International Association for the Advancement of Space Safety (IAASS).

	Sectors	Experience
13	Aviation, Space, Space Law, Legal, Legal Review, Disaster Relief, Research, Academia, International Affairs.	This possible participant is a consultant in aviation and space law and an editorial board member for a space law academic publication. This possible participant has a strong academic background and has been on editorial review boards at several prestigious Universities in Southeast Asia. Additionally, they are the Head of Air and Space Law Studies at a University located within the Asian continent.
14	Aviation, Aerospace, Aviation Safety, Aviation Operations, Flight Instruction, Flight Test, Hazardous Material (HAZMAT) Flight Operations, Military Operations, National Security, Maritime Operations, Military Officer.	This possible participant is a military pilot, Mission Commander, Merchant Marine Graduate, a former Aircraft Carrier Mini-Boss, and a subject matter expert in complex and dynamic Aviation Safety, Training, and Operations. They have operational test pilot experience and HAZMAT flight operations. This possible participant has had leadership positions on aircraft carriers with over 6,500 personnel. This possible participant coordinated operational and maintenance functions of the ship's Air Department to include the administration, training, and morale & welfare of personnel across 22 different work centers, among other similar professional experiences.

	Sectors	Experience
15	Aviation, Maintenance, Airline, Marketing, Aviation Tourism, Education, Flight Instruction, Aircraft Crash Survivor, Military Officer.	This possible participant is an experienced military, commercial, airline pilot, and flight instructor with over 25 years of experience. They operate an aerial tour company with multiple aircraft. Additionally, this possible participant is an aircraft crash survivor, allowing for a unique ability to capture a perspective. This possible participant is a First Officer for a major commercial airline and an FAA Certified Flight Instructor and is considered an expert regarding flight training. Finally, they are a retired military officer.
16	Strategic Nuclear Command and Control, Missile Operations, Space Operations, Telecommunications, Network Support, Computer Networking, Data Reporting, Online Research, Strategic Planning, Technical Support, Intelligence, Cyber-Security.	This possible participant is an intelligence analyst who shifted to the information technology sector for a major telecommunications company. This possible participant has over 15 years of experience coordinating with multiple entities and works as a cyber security consultant. This possible participant has operational knowledge with strategic nuclear command and control regarding space missile operations, including tracking, orbital debris calculations, threat detection, and risk mitigation analysis.

	Sectors	Experience
17	Aviation, Airline, Aviation Safety, Maritime Forces, Naval Aviation Training Operations and Standardizations (NATOPS), Military Operations, Operational Planning, Military Officer.	This possible participant is a retired military officer and current major airline First Officer. This possible participant is a certificated U.S. Naval Aviation Safety Officer with over 20 years of experience as a naval officer; this possible participant is an experienced Instructor Pilot, Aircraft Commander, Mission Commander, and Aviation Safety Officer with worldwide flight experience and leadership roles. This participant is considered an expert at safety risk mitigation as a graduate of the U.S. Naval Aviation Safety Officer school.
18	Aviation, Aerospace, Branding, Business Administration, Business Development, Customer Service, Aerial Logistics & Operations-(involving live animals), Academia.	This possible participant has over 20 years of executive experience in general aviation, including Part 135 air-taxi, Part 91 aircraft management, air charter broker, aircraft sales, flight school, and Fixed Base Operations. They also have over 10 years of experience teaching undergraduate & graduate courses in aeronautical science at a major aeronautical university that is world-renowned. They are the Founder and CEO of a private jet company in the United States.

	Sectors	Experience
19	Aviation, Aerospace, Airline, Defense, Entrepreneur, Crisis Management, Training, Safety Risk Mitigation, Operations, Investment, Angel Investing, Military Officer.	This possible participant is a military officer and former fighter pilot with more than 25 years of experience. Additionally, they are a Captain for a major commercial airline with excellent proven leadership skills both in the military and airline. This possible participant is also an aerospace defense contractor that focuses on public safety and tactical trades sectors, specifically emergency services. They are considered an expert in their field as a crisis manager and safety risk mitigator.
20	Aviation, Space, Orbital Mechanics, Spacecraft Vehicle Design, Spacecraft Launch Vehicle Mission Design, Systems Engineering, Integration Engineering, Parabolic Flight Coach.	This possible participant has over 25 years combined experience, specifically 6 years' experience as a Senior Integration Engineer (SIE) for NASA's Launch Services Program and is currently a Mission Systems Engineer at NASA's Goddard Space Flight Center. This possible participant specializes in orbital mechanics, spacecraft and launch vehicle mission design, and systems engineering. They have acted as a flight coach for weightless parabolic flights with a private aerospace company that performed these flights. They are also certified in space systems engineering from an institute of technology.

	Sectors	Experience
21	Aviation, Aerospace, Aviation Safety, Aviation Operations, Flight Instruction, Flight Test, Flight Standards, Naval Aviation Training Operations Procedures and Standardizations (NATOPS), Military Operations, National Security, Military Officer.	This possible participant is a military officer and pilot. They have flown multiple aircraft and have over 3,000 flight hours with over 20 years of experience. They are a Mission Commander, a former Aircraft Carrier Mini-Boss, and are considered a subject matter expert (SME) in complex and dynamic Aviation Safety, Training, and Operations. They currently direct all facets of squadron operations to include all pilot instrument and aircraft Naval Aviation Training Operations Procedures and Standardizations (NATOPS), pilot check rides, standardization, safety, and training programs within their organization.
22	Aviation, Aerospace, Defense, Applied Physics, Contracting, Logistics, Technology, Engineering, Program Management, Risk Management, Professional Aviation Industry, Training, Academia, Military Officer.	This possible participant is a Project Manager at a prestigious U.S. university working on Applied Physics. Previously, this possible participant was a Senior Program Manager at a world-renowned U.S. Military Academy. This possible participant is a licensed and rated FAA Airline Transport Pilot (ATP) and FAA, Certified Flight Instructor (CFI) with Multi-engine/Instrument ratings/endorsements. They have 33 years of flying experience in both military and civilian aircraft. They are a former FAA Safety Counselor, a graduate of the U.S. Naval Aviation Safety School, and the President of an Aviation association.

	Sectors	Experience
23	Aviation, Space Law, Space Strategy, Military Space Regulation, Research, Military Officer, Doctoral Candidate.	This possible participant served as a Legal Officer in the Royal Australian Air Force for 22 years, domestically and overseas. This possible participant has made significant contributions to Australian defense policy regarding space law, especially in military and strategic concepts. Finally, they are a doctoral candidate.
24	Radiology, Neurology, Aviation, Aerospace, Aerospace Medicine, Aviation, Flight Surgeon, Research, Training, Safety.	This possible participant is a Medical Doctor (MD) who is a board-certified radiologist specializing in neuroradiology. This possible participant is a military pilot and a flight surgeon who has served at the executive level and possesses over 30 years of experience. This possible participant brings extensive military, aerospace, and medical experience to the study specializing in understanding traumatic brain injuries as key practices. Separately they can understand the long-term effects of human exposure in space for prolonged missions as they underwent an extensive isolated longevity study called the NASA HERA mission, an analog situation on Earth that affects the body similar to those experienced in space. This person has served in various upper leadership positions within the military, has been a military instructor pilot, and is shrouded in the aviation safety mindset.

	Sectors	Experience
25	Aviation, Safety & Standards, Engineer, European Safety Standards, International Standards.	This possible participant is an International Aerospace Engineer specializing in aviation and space safety, with over 30 years of experience in the aviation, aerospace, space, and defense industries. They work within two main domains of expertise, aviation, and space, by putting their knowledge and experience at the service of the aerospace industry and authorities in Europe and abroad, thus actively contributing to the safety of flights and the present and future of aviation and space. They have served as the Astronaut Safety Manager at a major space agency.
26	Aviation, Aeronautics, and Space, Administration, Healthcare, Emergency Medicine, Disaster Medicine, Aerospace Medicine, Space Medicine, Medical Management, Strategic Planning, Military Officer.	This possible participant is a Medical Doctor (MD) and holds an extremely important role in the medical community at NASA with over 25 years of experience in their field of expertise. This possible participant has served as a Senior Flight Surgeon to oversee astronauts and NASA employees' medical and occupational care.
27	Space Law, Space Research, Author/Publisher, Legal Security Sciences.	This possible participant is an international independent researcher focusing on Space Policy and Legal Security Sciences, with 10 years combined experience in their field of expertise. This possible participant is researching the application of a legal trust system for outer space.

	Sectors	Experience
28	Applied Physics, Systems Engineering, Academia, Structural Engineering, Transport, Security, Administration, Space.	This possible participant is on the Senior Professional Staff at a prestigious university where they work on space projects at the applied physics laboratory, with nearly 15 years combined experience in their field. This possible participant is a Systems Engineer for Force Projection performing definition and analysis of the system, hardware, and software requirements, including traceability, testability, interface, and architecture products.
29	Aviation, Space Travel, Commercial Space Transportation, Federal Aviation Administration. Airport Administration.	This possible participant works at a high level in the Federal Aviation Administration, with over 20 years of experience in their field. They work in the Commercial Space Transportation office.
30	Aviation, Space Strategy, International Policy, Space Policy, Human Rights, European Commission.	This possible participant is a Space Engineer and Space Strategy Consultant for two continents with nearly 5 years of experience in their field. This possible participant has ample experience working as a national point of contact for a certain nation to the Space Generation Advisory Council and serves as an advisor to the European Commission. This possible participant also works for the UNOOSA. They were one of the youngest people ever to be selected to become a delegate at the UNOOSA.
31	Aviation, Space Law, Space Policy, Intergovernmental Affairs, International Partnerships.	This possible participant works at a major space agency, is involved with international regulations, and attempts to build international partnerships. They have over 13 years of experience in their field of expertise.

	Sectors	Experience
32	Aviation, Space Systems, Aerospace Technology, Spacecraft Propulsion, Launch Vehicles, Space Engineering, Systems Engineering, Space Operations, Space Consulting, International Affairs.	This possible participant has over 30 years of experience as a program lead and engineer with a demonstrated history of working in the new space industry. They have proven strong professional skills in spacecraft Propulsion Systems, Systems Engineering, Rockets, Instrumentation, Fluid Systems, & Controls technologies.
33	Aviation, Aerospace, Defense, Avionics, Information Technology (I.T.) & Services, International Airline Operations, Systems Engineering, Research & Development, Project Management.	This possible participant is an entrepreneur working for a world-renowned multinational company that designs and builds electrical systems and provides services for the aerospace, defense, transportation, and security markets. Their specific area of expertise is pilot to aircraft integration and interoperability. They are responsible for developing avionics and apps to enhance the safety of flight. This possible participant is also an experienced Airline Operations Specialist with a history of working at the intersection of the Aviation, Avionics, and I.T. Service industries. This possible participant has over 16 years of professional work experience in their field of expertise.

	Sectors	Experience
34	Aviation, Space, Engineering, Physics, Project Management.	This possible participant is a Ph.D. and is an experienced Project Manager at NASA with a demonstrated history of working in the aviation and aerospace industry and various tangible stakeholders on many projects. They are skilled in Requirements Management, Engineering Management, Earned Value Management, Physics, and Requirements Analysis. This possible participant has nearly 40 years of professional work experience in their field of expertise.
35	Aviation, Naval Aviation, Combat Fleet Aviator, Test Pilot, Astronaut, Space Shuttle Pilot/Commander, Defense Contractor.	This possible participant is a Career Naval Aviator with over 7,000 flight hours in over 45 aircraft types. They are an experienced F/A-18 combat fleet aviator and test pilot. They are also a veteran Space Shuttle pilot/commander that assisted with assembling the International Space Station in Low Earth Orbit. They were an overseas deployed NASA research pilot with extensive experience commanding large organizations and managing budgets. This possible participant has over 30 years of professional work experience in their field of expertise.
36	Space Policy, Space Strategy, Space Regulation, Government Affairs, International Affairs, Executive at a Space Agency.	This possible participant is a high-level executive responsible for space policy and regulations for a space agency. This possible participant has over 17 years of professional work experience in their field of expertise.

	Sectors	Experience
37	Aviation, Aerospace, Space Operations, Training, Flight Safety, Security Instruction.	This possible participant worked as a pilot and has 25 years of professional experience in their field of expertise. They have flown various commercial airline aircraft. Their experience as a pilot instructor includes at a major airline and Boeing Flight Safety, and as a security instructor for The Transportation Security Administration (TSA). This possible participant is the CEO of an important private space company that will colonize space with one of the first private space station(s)/spaceport(s).
38	Aviation, Space Law, Space Security, Academia, International Space Institutes, UN COPUOS, Sustainability.	This possible participant is Ph.D. and is a full member of the International Academy of Astronautics (IAA). They work on designing themes for the annual IAC sessions and events on space security and work to develop strategies and annual work plans for the International Astronautical Federation (IAF) Space Security Committee. This possible participant has served as an expert member of the UNCOPUOS Working Group on Long Term Sustainability (LTS) for Outer Space Activities. This possible participant has nearly 17 years of professional work experience in their field of expertise.

	Sectors	Experience
39	Aviation, Aerospace, National Defense, Analytics, Maritime Security, Training, Military, Author/Publisher, Public Affairs, Media.	This possible participant has over 20 years of experience, has served as a Commanding Officer and fighter pilot in the military, and is a graduate of the U.S. Navy's Fighter Weapons School, i.e. (TOPGUN). They are an author/publisher of multiple books about Leadership and National Security, and policy. They are a CEO of small businesses within the defense industry. This possible participant is internationally recognized as an expert in aeronautical flight training, military strategy and known for their expert aerospace acumen and ability to employ fighter attack tactics. This person is well known within the Department of Defense and government for their viewpoints on public policy and strategy.
40	Aviation, Airline, Air Cargo Industry, Hazardous Material (HAZMAT) Supply Chain, Distribution, International Relations, Media, Government Relations, Military Officer.	This possible participant is a high-level executive within an important pilots' association. They have over 40 years of experience. They also serve as a Captain for a major air cargo carrier. They have extensive experience in supply chain and transportation logistics. This possible participant is very knowledgeable with Union contracts, large organizations, private industry to government affairs at the international level, regulations, standards, training, and certification requirements of flight crews. They have also served as a military officer.

	Sectors	Experience
41	Aviation, Space Law, International Space Policy Influencer, Research, Author, Military, Human Rights, Academia.	This possible participant is a Ph.D. and is the founding President and Chairman of an important international space law academy with over 20 years of experience. Their focus is on sustainable economic and human development. This person has served as a military officer, is an author, a researcher, and is very well respected within the international space policy community.
42	Aviation, Testing, and Evaluation, Program Management, Aircraft Operations Management, Business Development, Military Officer.	This possible participant has over 20 years of experience in the aviation industry, including 10 in aircraft test and evaluation and program management. This possible participant has been a Chief of Flight Operations, Chief Engineer, and Research Test Pilot for NASA and has prior experience as a corporate and military test pilot. They are a recognized expert in aircraft operations management, engineering management, flight test execution, uncrewed systems, and data analysis.
43	Aviation, Aerospace, Space Operations, Space Medicine, Medicine, Medical Advisor, Academia, International Affairs.	This possible participant is a Medical Doctor (MD) and is a senior medical advisor for major international aviation and aeronautical space enterprise with over 45 years of experience. Additionally, this possible participant is an adjunct professor at a well-known university.

	Sectors	Experience
44	Aviation, Human Space Operations, Space Operations Integration, Commercial Crew Programming, Commercial Space Travel, Executive Space Agency Leadership.	This possible participant is a NASA leader/manager/executive with more than 30 years of experience. They have demonstrated success in building, organizing, and enhancing programs, teams, and strategic initiatives throughout human spaceflight. They have highly technical skills in various NASA systems and flight control disciplines. They are skilled at identifying opportunities and determining strategic solutions across different levels of the agency and within government contracts. This possible participant is formally trained and practiced in NASA leadership and conflict resolution.
45	Aviation, Aerospace, Astronaut, Space Shuttle Pilot/Commander, Commercial Space, International Relations, Global Space Influencer, Defense, Military Officer.	This possible participant is an experienced astronaut with over 37 years in the aviation and space industry. They have flown various missions aboard the Space Shuttle and International Space Station (ISS). This possible participant is a commercial pilot and aerospace/STEM consultant. They specialize as a test pilot and work in business development for a major defense contractor in the United States. This possible participant also oversees the development and quality control of the astronaut and leadership training program at an international space exploration development organization.

	Sectors	Experience
46	Aviation, Space, Military, Aerospace Manufacturing, Logistics, Entrepreneur, Military Officer.	This possible participant is the Vice President of a private space company that manufactures parts. Additionally, this possible participant is an experienced business development entrepreneur who is experienced in raising capital for space engineering projects. They have experience with finance, logistics and have served on global advisory committees for technology. This possible participant served as a military officer who led all supply chain, finance, aviation to shipboard control, and anti-piracy operations. This possible participant has nearly 8 years of professional work experience in their field of expertise.
47	Aviation, Space Legal Issues, Commercial Space Policy, Politics, International Relations, Academia, Media.	This possible participant holds a Ph.D. in Space Studies and Space Policy from a major world-renowned university. This possible participant is the CEO of a space exploration and interplanetary transportation company. The author and published many articles regarding space policy/doctrine. This possible participant has nearly 9 years of professional work experience in their field of expertise.
48	Executive Level Government Leadership, Science, Technology, Space Policy, Commercial Space Transportation.	This possible participant represents the executive level of governments decision-making capabilities under the President of the United States of America.

	Sectors	Experience
49	High-level Government Leadership, Economy, Technology, Commercial Space Transportation, U.S. Department of Commerce.	This possible participant represents a high-level government agency involved in policy and regulation influence within the commercial space industry within the U.S. Department of Commerce. Space commerce is the main activity of concern for this possible participant agency, and the focus is to help foster conditions for the commercial space industry's economic growth and technological advance within the United States.

Description of the Research Questionnaire

Based on the Delphi method and consistent with the research questions, the research questionnaire (see Appendix B) was developed by first asking participants to provide three priorities for developing guidelines for space travel and/or colonization (using a free-text box in the survey to obtain input). Participants were asked to write (using a free-text box in the survey to obtain input) their responses regarding the following:

- Development of guidelines for space travel and or colonization
- Implications for the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and or colonization
- Practical solutions for the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and or colonization

All survey questions were tailored explicitly around the safety of human space travelers within the commercialized space industry. Before the first round of data collection began, to ensure the reliability of the survey questions. The researcher had multiple aerospace and space industry professionals review the survey questions and provide their feedback. The survey questions were then refined for clarity based on any ambiguities revealed. The participants that reviewed the questions did not participate in the study and were not a part of the study sample. The researcher conducted the field test by having an acquaintance with a degree in psychology and a business owner in the defense industry review the survey questions, and both provided their feedback. The survey questions were then refined for clarity based on any ambiguities revealed. The two participants in the field test did not participate in the study after that and were not a part of the study sample.

Procedure for Method

This methodology utilized was a mixed-method approach (Creswell & Creswell, 2018; Patton, 2015, p. 72) and Delphi research design (Okoli & Pawlowski, 2004; Sekayi & Kennedy, 2017). Triangulation of the data was used in this study in the processes of developing consensus. Triangulation involves comparing and analyzing the data using multiple data sources, which was conducted by reviewing the data obtained from different participants and comparing the findings obtained in the separate Delphi rounds. The mixed-method approach allowed the researcher to use qualitative and quantitative data to build an overarching picture that was better understood, analyzed, and prognosticated upon if needed (Creswell & Creswell, 2018; Patton, 2015). Moreover, a mixed-methods approach was appropriate in alignment with the Delphi research design selected for this study.

A mixed-methods approach allowed the researcher to incorporate both the in-depth aspects of the phenomenon available from qualitative methodology and the numerical exploration data yielded from quantitative methodology (Creswell & Creswell, 2018). The Delphi method design was selected due to the interest in developing consensus to explore and prioritize the factors relevant to the utility and need for an international agency or clearinghouse to standardize certifications, requirements, and ethical standards for commercialized human space travel and colonization between governments and private entities.

The Delphi method was developed to identify and prioritize decision-making issues through consensus (Okoli & Pawlowski, 2004; Sekayi & Kennedy, 2017). The Delphi method is a formal consensus method. As a systematic approach, the Delphi method provides a systematic means for researchers to develop and measure consensus among participants (Humphrey-Murto & de Wit, 2018). In the Delphi method, multiple steps are used to identify key issues, prioritize, and develop a concept or framework based on issues that are prioritized through consensus (Okoli & Pawlowski, 2004). In the study, the Delphi method was used to explore and prioritize the utility and need of an international agency or clearinghouse to standardize certifications, requirements, and ethical standards for commercialized human space travel and colonization between governments and private entities.

In the Delphi method, iterations of data collection from panel member participants are conducted (Sekayi & Kennedy, 2017). Two rounds of data collection were conducted in this study (Vogel et al., 2019). In consideration of COVID-19, all rounds for this Delphi study were conducted using online questionnaires. Researchers have recommended defining consensus as a 70-75% agreement among participants (Vogel et al., 2019). Therefore, the consensus in this Delphi study was defined as an agreement among 70% or more of the study participants.

In Round 2, a consensus was reached in relation to 28 out of 45 statements (62%). Consensus was not reached across all items, but the discrepancies between End-User Operators' and Academics/Regulators'/Policymakers' responses indicated that further Delphi rounds would be unlikely to increase the number of findings on which consensus was reached. Therefore, this Delphi study was completed after two rounds, consistent with the minimum of two rounds recommended by Vogel et al. (2019). In lieu of conducting a third round of data collection, the Round 2 data were divided according to the two participant categories represented, including End-user/Operators and Academics/Regulators/Policymakers.

An End-user/Operator group is effectively a survey participant who identifies as a pilot, astronaut, missile operator, weapon system operator, any type of Medical doctor, inspector, mechanic, or engineer.

Separating the two respondent categories in this way resulted in a consensus of 78% (35 out of 45) of the items within the End-user/Operator group. Reaching consensus in relation to more than three-quarters of the statements was determined as sufficient to conclude the study, as it would have placed an unnecessary burden on participants to continue conducting study rounds until a consensus was reached in relation to all items. As described above, the first round of data collection in this study was conducted using open-ended questionnaires to ask participants their views on each of the points related to the research questions of interest. Round 2 was conducted using close-ended questions to refine the results further. However, to allow further refining of the statements, free-text responses were used on six of the 45 questions to allow participants to reword, refine, and provide feedback in the Delphi rounds' progression.

The in-depth qualitative insights collected from study participants were presented to participants using quantitative methodology within the Delphi method. Using a quantitative

Likert scale, the researcher presented the participants' questions derived from the initial first round of the qualitative portion of the study. Later the participants were asked in the second round to rank each question in terms of importance from the participants' perspective. This data allowed the researcher to reach consensus by asking participants to determine which of the identified items, from participants' perspective, was essential regarding the feasibility of establishing and prioritizing a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized human space travel and colonization between global governments and private entities.

Procedure Statistical Analysis

For the quantitative portion of this study, an ordinal scale of measurement with a five-level Likert scale was used to measure the data, which was similarly used by the commercial space industry, and the survey participants were then asked to rate/rank their responses. This quantitative data was then used as a numerical baseline value for all future Likert comparisons. The Likert scale ranged from values of 1 through 5. Participants ranked the item along the numbered scale on a Likert scale, which allowed for ranking participant responses (Wittink & Bayer, 2003). A scale of measurement provided meaningful order and placement and allowed for ranking answers.

After Institutional Research Board (IRB) approval was received, participants for this study were initially contacted via a LinkedIn message or e-mail, which explained the research's purpose, collection of data, and how the findings would be utilized. Participants of this study were aerospace and space professionals, including End-users/Operators who were later grouped into a single grouping and academics/regulators/policymakers, who were also separately grouped after disparities were found between each group. Both groups' consensus was collectively

accounted for, assessed, and presented as a mutual consensus, and separately there was an assessment of each group's consensus, which was analyzed against each group to show a comparison of disparities.

Written assurances were made before and during each interview to protect sensitive information. Those willing to participate acknowledged their willingness by agreeing to the informed consent form at the beginning of the Qualtrics survey before starting the questions. Throughout the study, the researcher sent out reminders as the 15-day expiration limit approached since there was a 15-day expiration limit between Delphi round sessions, with approximately a two-week break in between each round.

After the 15-day expiration, the participants were sent a secure online survey link. The data collected represented quantitative and qualitative data from international commercial aerospace space professionals. The data was collected via a report generation download from Qualtrics for each survey, and then the data was further thematically analyzed, securely, via paper notes, Microsoft Word, and Microsoft Excel in a private room with no other person in that room while reviewing and processing the data was being executed. During the thematic analysis, themes were identified by patterns of words, phrases and then patterns emerged that created a synopsis of relevant topics for subsequent possible questions for the second round of the Delphi study. All participant data remained confidential in this study. All electronic media and paper notes were destroyed after the research data was evaluated and the dissertation successfully defended. Any information that was known to be sensitive was not included in the final study. A copy of the study was furnished to all survey participants, agencies, and entities that requested the information. The survey questions and data were generated, deployed, and collected on the website [https://login.qualtrics.com/]. The actual survey links were as follows:

- Round 1

  [https://corexmsfsh3gj4bpfwsg.qualtrics.com/jfe/form/SV_8JndKGRHoqCSL5A]

- Round 2

  [https://corexmsfsh3gj4bpfwsg.qualtrics.com/jfe/form/SV_0UPcWth2va9Fzfw]

Reliability, Validity, and Ethical Assurances

The reliability and validity of research findings are based on the research findings' accuracy, consistency, and stability (Creswell & Creswell, 2018). In this study, reliability and validity were addressed through two Delphi rounds and the use of ranking by study participants to develop consensus on the developments in the research findings. Additionally, as described previously, the reliability of this study was maintained by triangulating the data obtained from the qualitative and quantitative sources of evidence (Creswell & Creswell, 2018), and ensuring that the findings of the study were developed based on participant input and ranking.

The researcher obtained approval on application number IRB-21-251 from the Oklahoma State University (OSU) Institutional Research Board (IRB) before conducting any research or gathering data. During the study, every attempt was made by the researcher to avoid biases. However, research bias could not be discounted entirely because of the researcher's professional experience in the aerospace industry and because the researcher views safety as the most critical aspect of that industry. All precautions were ensured to protect the confidentiality and the anonymity of the study participants. Additionally, the demographic data of the participants were deliberately hidden to protect their identities.

Methodology Conclusion

One of this study's research goals was to make the survey participants' voices heard by expressing their views regarding international aerospace and space subject matter areas of

expertise through the survey questions. An additional goal was to reach a consensus among the participants in answering the research questions guiding this study. Using the Delphi method for consensus, a crucial expectation of this research was to understand how the global aerospace and space professional community collectively envisioned the feasibility and prioritization for the development of public and commercial human space travel policies. The data generated from this study might be valuable in exploring considerations to be made in allowing for safe outer space travel and regulation of both government and commercial entities.

CHAPTER IV

ANALYSIS AND FINDINGS

Introduction

The purpose of this Delphi study was to investigate international experts' thoughts regarding the need to establish and prioritize a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. The lack of global international standards and commercialized human space travel guidelines creates the need to explore the development of a single global agency that would establish guidelines and act as a clearinghouse for the certifications, requirements, and ethical standards for space travel and colonization by both government and private entities. The study included prioritizing issues relevant to establishing guidelines to regulate commercialized human space travel and colonization.

Data for the first round of this Delphi study was collected using an online questionnaire. The participants comprised 29 international experts on deep space and space law. However, one participant responded only to the first two questionnaire items, so after the second item, the number of participants was reduced to 28. Participants included international experts who are knowledgeable and experienced about space through their careers in the space profession. Responses were collected anonymously, so participants did not provide demographic data.

Data Collection Instrument Analysis

The Round 1 data collection instrument consisted of 21 open-ended items. This section is a presentation of the results from each of the questionnaire items. The responses under each item were analyzed thematically to cluster similar responses into thematic categories. This presentation indicates the themes identified under each item and the number of participants who attested to them.

1. From your perspective, what are the priorities for the development of guidelines for space travel and/or colonization as expressed by public (government) and private entities?

Responses to this item yielded qualitative data in which common themes of safety, development/profit, and environmental impacts were identified. In analyzing the responses to the first questionnaire item, similar responses were grouped to form the themes. The most frequently referenced theme under this questionnaire item was *safety*, with all participants referencing this topic. Paper notes, Microsoft Word, and Microsoft Excel was used to track the researcher's identification of codes and themes. Safety was the only theme where a significant consensus emerged among all participants. Only two other themes—development and profit and environmental impacts—had attestations from more than 33% of the participants. Thus, the significant themes indicated in participants' responses were as follows:

- All 29 (100%) participants indicated that safety should be a priority for developing guidelines, including health and safety, risk management, personnel safety, and safety of crews and the uninvolved public. Per the standard that 70% of the participants were needed to establish a consensus (Vogel et al., 2019), this was the only theme on which a consensus emerged. Sample quotes:

    - Priorities for life preservation and property safety should all fall under a master list of guidelines that manage and direct risk and establish priorities.
    - Physical and psychological (behavioral) effects of zero gravity and confined spaces on the human body.
    - Safety of the uninvolved public, and other Aircraft and Crews (Space-Air and Ground).
    - Thinking to a decade or two ahead... Global guidelines for a recovery system (i.e., a type of rescue space shuttle) should be on call [possibly on a rotational basis between large nations] to assist with reentry into Earth, should there be a damaged craft returning from a mission that can't structurally handle reentry. There also could be a standard explored for an earth exit vehicle and earth entry vehicle that could stop somewhere, like a Space station in orbit, to gather supplies/fuel/etc. at mission start and end.
- Ten out of 29 (34%) participants indicated that while safety should be the highest priority, the goal of ensuring safety should be balanced against the goal of enabling innovation, development, and profit, rather than stifling these forms of growth through excessive regulation. Below is a sample quote from the result to support the participant's perception of this balance.
    - The commercial space industry is still nascent, especially regarding manned space travel and colonization. A global regulatory agency could hamper innovation by creating additional barriers to entry for new commercial entities and increasing the time to market for commercial

services, especially when added to existing regulations in most spacefaring nations. However, an international committee could serve important functions in an advisory capacity by providing guidelines to help standardize technical, safety, and ethical norms for manned spaceflight.

- Ten out of 29 (34%) participants stated that environmental impacts should be prioritized, particularly regarding the mitigation of debris. Sample quote:
    - Planetary protection standards are next, not only to protect heavenly bodies we visit, but to prevent viruses, prions, or mutagenic bacteria from being brought back to Earth.

Other responses from a few participants (three or fewer) included standardized testing qualifications for flight certification, space law and procedures, liability standards, intellectual property protections, and space traffic management. Safety was the only theme from which a distinct conclusion could be drawn. That is, participants reached the consensus that the safety of persons should be among the highest priorities for the development of guidelines for space travel and or colonization.

2. What is the feasibility of the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities?

Two main themes emerged when similar responses to this item were grouped. Twenty out of 29 (68%) participants answered affirmatively, stating that developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities was feasible using relations between existing countries. However, nine out of 29 (30%) participants answered

negatively, expressing the perception that developing such an agency was not feasible tied to the idea of governments being unwilling to submit to a single agency's control over their airspace. The themes that emerged from the section question were as follows:

- Twenty out of 29 participants answered yes, indicating that developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities is feasible. Participants indicated that the feasibility of such an agency or clearinghouse is already demonstrated by existing agencies, notably the United Nations as a template for international cooperation and ICAO as a template for international cooperation specifically regarding standard aviation. Identified needs for developing such an agency included separating technical standards from ethical standards, involving the United Nations, facilitating international collaboration and information-sharing, and determining whether the standards would be new or modeled after existing laws and guidelines. Below are some sample quotes from the study results regarding the feasibility of the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities.
    - Similar to the United Nations' structure with voluntary participation based on experience. Formal guidelines and goal setting for all members. Profit-sharing agreements between private and governmental agencies.
    - I believe so. In the early times of space traffic management, there should be a single entity, or at least a harmonized common standard, to regulate

global space safety. The aviation world has succeeded with ICAO; why could it not be implemented for outer space. A perspective on the peaceful use of outer space must be brought so that those with technology (such as the USA, Russia, EU, Japan, China, India, etc.) could sit together. They will implement the space traffic management, whilst the regulation drafting should be open for all States.

    - Potentially, as the jurisdiction has not been well charted. Maritime law has been proposed as a baseline; that is, whichever country the launch was registered in and launched from would have jurisdiction. But space traffic agreements, orbital debris agreements, ethical paradigms, are still needed.

- Nine out of 20 (45%) participants indicated that developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities is not feasible. These participants indicated that developing such an agency might be feasible in the future but that at present, the standards were too inchoate and intergovernmental cooperation too tenuous for a single agency to supersede existing standards bodies and become a universally recognized authority. These participants indicated that regional agencies, such as one acting for Europe and another acting for Africa, were more feasible. Sample quotes concerning the feasibility of developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization included:

- Sovereign States with a direct stake in space safety will not cede decision-making to a single entity unless and until it serves their national objectives.
- No country would agree to a single entity. Keep in mind that only a handful of countries have civilian space programs. Most are military. Although countries might abide as signatories to space traffic management and orbital debris practices, it is doubtful that those countries with military space missions will allow the needed insight and transparency required to address space safety.

The number of responses indicating that the development of the agency or clearinghouse was feasible was 69%, representing a major theme close to consensus.

3. What are practical solutions to the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities?

A total of 27 of the participants responded to this item. No consensus of 70% or greater emerged for this question. Nine out of 27 (33%) participants responded similarly to their previous responses that developing an agency was unfeasible and undesirable, so they regarded the question of practical solutions as something not worth pursuing. The remaining 18 (67%) participants indicated that developing a single agency or clearinghouse was feasible, and their responses regarding practical solutions fell into two broad themes. Grouping the responses to this item resulted in the identification of three themes, as follows:

- Nine participants expressed that a united agency to regulate space travel is unfeasible and undesirable and regarded it as not worth pursuing. Their words

reveal the expense and problems that would arise as countries compete for access to space and the problems that would arise from creating a powerful regulatory agency.

    - Is there a need for a universal agency? I would say no at this time, as you have an amalgamation of government, military, and civilian spaceflight. I don't think the countries would agree to such a universal agency with such competing goals. Could treaties and principles be established? Yes. Will we eventually evolve to something like ICAO? Maybe. But we are a long way from that currently. Such a universal agency would give standards and requirements but not budget. Most countries do not like unfunded mandates from an outside source. You'd have to start with jurisdictional constructs first, international laws and conventions, and agreed-upon principles. From there, it would grow.

- Nine of 27 (33%) participants indicated that international collaboration is necessary and practical solutions for promoting this collaboration included transparency regarding research, international summits for policymakers and researchers, and the establishment of a board of representatives. It was remarked; that one means of initiating the collaboration process might be having a small contingent of interested nations who can volunteer to establish the structure and guidelines and then invite other nations to join voluntarily. Sample quotes indicating that international collaboration is feasible included:
    - The development of an agency or clearinghouse of this type is feasible. It should be non-governmental and apolitical, though it should seek expertise

from governmental and non-governmental space organizations. The agency or clearinghouse should be international if possible, and although global politics could hamper buy-in from rival nation states, some level of consensus might be achievable by experts and organizations from a number of spacefaring nations.

    - While a global mindset would seem to be needed, I believe it should be done by a single country or small contingent of democratic countries. Involving all countries and those without capitalistic economies or democracies will cloudy the water and prevent long-term success. A small contingent of countries could form the necessary structure and guidelines for success.

- Nine out of 27 (33%) participants indicated that existing international law already provides a template for the needed consensus and that a practical solution for developing an agency was to develop and formalize international law to encompass space exploration and colonization, using standards related to maritime and aviation law as models. Sample quotes indicating that existing international law already provides a template for the needed international consensus included:

    - By following the International Maritime Organization model, the United Nations, through agreement of member States, can serve as the governing body for developing international regulations. Another solution would be via international convention with periodic reviews by participating

nations. However, this could lead to exclusion or non-participation by spacefaring nations, and lack teeth from a legal perspective.

- Use the existing structures already set up (FAA and UN COPUOS). NASA could also have its charter expanded to participate in the formation of standards and requirements outside of just its own agency, and a formulation similar to ICAO could be made for space.

4. Does having multiple independently functioning worldwide national space agencies and private commercial space entities, with various undefined governing laws, policies, and procedures, pose a problem for future space exploration and colonization?

A total of 28 participants responded to this item. Grouping similar responses to this item resulted in the identification of two themes. No consensus of 70% or greater was established. Instead, participants were evenly divided between those who considered (first theme) independent functioning of multiple national space agencies worldwide as likely to be problematic and (second theme) those who did not believe it would be problematic because the alternative of a single agency would be less desirable. The two themes were:

- Fourteen out of 28 participants (50%) indicated that multiple, independently functioning worldwide, national, and private space entities would pose a problem. These participants believed that any activity in space could potentially affect any other activity in space. They also believed that standardization, particularly of safety guidelines, was necessary to ensure consensus and confidence regarding risks in a domain where, by nature, no national or private-entity boundaries existed. Sample quotes indicating that multiple, independently functioning worldwide, national, and private space entities would pose a problem included:

    - Yes, and it needs to happen quickly. Space exploration is happening with no governing safety policy. Like other domains, it will be easy for for-profit companies and countries to jeopardize safety and the environment, to forward their objectives.
    - As recently demonstrated by the uncertainty of a Chinese Long March 5B reentry, lack of regulation and, more importantly, accountability, will result in an even more hazardous space environment. We're at a critical moment in time, where space is still highly restricted to governments and very few commercial operators. However, as costs decrease through economy of scale and capitalism takes a foothold in space, not having clearly defined laws, policies, and procedures would result in a gold rush environment with catastrophic outcomes for lives and equipment in and out of Earth's atmosphere.
    - The current situation presents both challenges and opportunities. The challenges include underdevelopment of needed policies, laws, and governance structures and resulting lack of unity of effort. I believe this reality will endure unless or until the foundational parts of the space policy/legal regime (OST, etc.) are strengthened or replaced. There does not seem to be much appetite by states to strengthen this regime.
- Fourteen out of 28 participants (50%) indicated that multiple, independently functioning worldwide national and private space entities would not pose a problem. Participants stated that standardization under a single agency or clearinghouse was undesirable because it would impose a level of uniformity in

practice that would stifle meritocratic competition and innovation. Sample quotes indicating that multiple, independently functioning worldwide, national, and private space entities would not pose a problem included:

- No. Less government interference enables competition/advancement.
- I believe the development of an agency or clearing house for such standardization would not happen within the near future. Too much interest from spacefaring countries; bear in mind they are now facing space race 4.0, and such standardization potentially hampers their interest. I think States or regional jurisdictions should go along with private entities. They will lead the frontier, such as sub-orbital flights and space tourism. Commercially driven, a bottom to top approach looks feasible.

5. Is there a need to investigate the requirement for a single entity for global space safety?

The majority response to this item indicated a consensus among participants that the answer was negative; there is no need to investigate the requirement for a single entity for global space safety. Participants' reasons for this perception were sorted into three thematic categories. In relation to this question, some participants referenced more than one theme, bringing the total number of theme references to 32, or four more than the total number of participants. The three themes were:

- Thirteen out of 28 participants (46%) indicated that there was no need to investigate the requirement because bodies already exist to regulate space activities, including the United Nations Committee on the Peaceful Uses of Outer Space, the Commercial Spaceflight Federation, and the International Association

for the Advancement of Space Safety. Sample quotes indicating that there was no need to investigate the requirement because bodies already exist included:

  - None. Standards bodies already exist for space activities, from ISO to CCSDS. No single agency would be trusted, and no international clearinghouse is needed. To create such an entity would require states to relinquish sovereignty over their own regulatory authorities.
  - They already exist. NASA is not a regulatory agency. The FAA is charged with creating the standards and certifications for commercial spaceflight. The United Nations Committee on the Peaceful Uses of Outer Space already has a forum for agreements between nations. Commercial Spaceflight Federation is already a coalition between commercial spaceflight companies to lobby.

- Ten out of 28 (36%) participants indicated that there was no need to investigate the requirement because no single entity would be trusted by all parties. These participants indicated that a single entity would undermine national sovereignty to the degree that would make its establishment undesirable to most governments and that states would prefer to advance their own interests in space without ceding authority to an international body. Sample quotes indicating that there was no need to investigate the requirement because no single entity would be trusted by all parties included:

  - No, as it's not practical nor likely to be desired by most spacefaring states. Space safety will be the responsibility of states engaging in space activity

and moderated by the existing agreements such as the space liability convention.

    - No country would agree to a single entity. Keep in mind that only a handful of countries have civilian space programs. Most are military. Although countries might abide as signatories to space traffic management and orbital debris practices, it is doubtful that those countries with military space missions will allow the needed insight and transparency required to address space safety.

- Nine out of 28 participants (32%) indicated that it was too early to investigate requirements, in particular, because the United Nations, a model for any such effort, had not sufficiently standardized its own approach. A sample quote indicating that it was too early to investigate requirements was:
    - No, because technology is evolving too quickly for national regulations, much less international ones, to keep up. We already have space law through the treaty process. Again, we have not fully resolved several very large issues from the 1968 Outer Space Treaty, which is over 50 years old. Setting up a new organization will not solve that issue.

6. What are the needs in developing one global/universal commercial space transportation guideline and governing policy with well-defined, established emergency procedures and protocols on Earth, during spaceflight, and in space to preserve and protect life and property?

The results of this study indicated a lack of substantial consensus in relation to this item. The most significant theme to emerge implied that there were no needs because the development

indicated by the item was already occurring, with any remaining development likely to transpire naturally due to current, ongoing activities. Thirteen participants (46%) were not sufficient to identify a consensus; the standard stated was 70%. The remaining 15 participants who responded to this item provided unique answers, but no common themes were identified. Sample responses indicated needs such as global safety guidelines, an unspecified international consensus, a consensus among subscribing partners, interoperability and compatibility of docking mechanisms, flight safety protocols, accountability to all states, standardized measures such as the Universal Docking Mechanism, more data regarding the effects of space travel on human beings, the prioritization of life preservation, and transparency. The most significant theme in the responses was as follows:

- Thirteen out of 28 participants (46%) answered negatively, stating that there is no need to develop one global/universal commercial space transportation guideline and governing policy. These participants' answers were consistent with their responses to Item 5, with some referencing their previous responses. The participants in this category indicated that the guidelines currently under development were sufficient, including those developed by entities such as NASA, the United Nations Committee on the Peaceful Uses of Outer Space, the Commercial Spaceflight Federation, and the International Association for the Advancement of Space Safety. Sample quotes indicating that there is no need to develop one global/universal commercial space transportation guideline and governing policy included:
    - In the short-term, none. NASA is working with other countries' space agencies to ensure debris creation is minimized and mitigated, along with

ensuring no inter-planetary cross-contamination (to the other planet or to Earth). Liability and damages are already covered by the 1967 Outer Space Treaty, which is the responsibility of the launching state.

- In short, testing. Only ~550 people have been to space. Furthermore, man has only been as far as the moon (publicly known), landed, and returned. Yet each mission has challenges despite the crew training for years. Universal guidelines are still unclear, more data needs to be collected, and more missions will need to be completed for experimentation. For example, we need to study the effects space has on the human body in various durations, surgeries and blood transfusions in space, and artificial gravity. This is essential for humans to make the journey and complete 'deployments' at an outpost in another planet's orbit.

7. Is there a need to investigate the requirement for infrastructure to develop a universal Emergency Space Response Management System (ESRMS)?

Two major themes emerged from this question. First, participants identified a need to develop a universal ESRMS, and the second theme indicated that no need existed. Twenty out of 28 participants (71%) indicated that the need existed. Results from this question are summarized below.

- Twenty out of 28 (71%) participants stated that yes, the need existed. These participants believed that establishing the infrastructure necessary to protect life and property in space would be highly costly and that doing so was only feasible through an international effort that would involve investment and information-sharing from multiple nations. Participants suggested that NATO or the United

Nations Peacekeepers might provide a model for an international ESRMS entity that would otherwise resemble a space version of the U.S. Coast Guard. Regarding decision-making about the infrastructure, some participants suggested that votes should be allocated according to the size of each nation's investment. Sample quotes indicating that the need existed included:

  - AN ESRMS is absolutely required to rescue and recover individuals and property as needed. This will take time to establish and create; however, this infrastructure is paramount to achieve success. The international board of representatives would work together to achieve this ESRMS.
  - A version of the UN/NATO will work. Every country needs investment in order to have a voice. A percentage similar to NATO would be required to get voting rights.
  - Safety and profit don't mix well. Safety, even just a moderate amount, is extremely expensive. An independent organization should be established to ensure that human life is not traded for profit. How to organize and structure such a thing is very complicated. A single independent rescue mission to low earth orbit, for example, would be very expensive. I don't know how you would fund the ability to perform this task if a commercial entity were unable to do this themselves in the event it was needed. Maybe some kind of mandated insurance by everyone in the industry to help fund the costs of these kinds of rescue or recovery events?

- Six out of 28 participants (21%) indicated that no investigation was needed because a universal ESRMS was neither feasible nor necessary. Participants

believed that the cost of such a system would be prohibitive and that logistical problems related to launch locations and timings would be insurmountable on a global scale. Participants further indicated that different nations would likely have different risk tolerance levels and willingness or capacity to invest in such a system, making an international consensus difficult or impossible to achieve. They believed it would be more appropriate for individual nations to tailor their ESRMS systems according to their own resources and needs. Sample quotes indicating that no investigation was needed included:

- I don't believe a central infrastructure is needed at these early stages. Every space agency has different risk tolerances and budgets; the whole system would spend more money and resources on the risk-averse and low-budget space agencies.
- Such central infrastructure and global consensus is neither feasible nor necessary in the foreseeable future, though the next 50 years could see many changes. Political will to develop and fund an agency that might fulfill this role would be difficult to garner, particularly if there are no coherent, enforceable global regulations on space safety. An ESRMS may run into considerable technical difficulties as well, given the variety of potential trajectories it might need to service.

8. Is there a need to explore the feasibility of establishing and prioritizing a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities?

Of the 27 respondents who provided an answer to this item, 17 indicated that a need for the exploration existed, and 10 indicated that a need for the exploration did not exist. The number of affirmative responses, equivalent to 67%, fell short by one participant (3%) of the 70% guideline for identifying a consensus in the expert panel. The two major themes were as follows:

- Seventeen out of 27 participants (67%) stated that, yes, an exploration was needed. These participants cited the priority of protecting life as an urgent reason to move toward establishing international standards related to all aspects of safety. These participants further indicated that space law, policy and procedures, operations, interagency relations, licensing, monitoring, enforcement, interdiction, training, testing/evaluation, and certification were all issues that should be addressed. Other issues that participants raised included detection of space accidents, insurance and bond requirements, space traffic management, security to avoid hostile utilization of space, standardized testing, and intellectual property protection. Sample quotes indicating that exploration was needed included:
    - Space law and certain procedures need to be established to minimize piracy and maximize safety for life.
    - Yes. If an international agency is established, all of those issues will need to be addressed. Likely to be established within the law should be funding of the agency, safety/rescue, environmental policy (pollution, clean-up), issues related to capitalism in space, and national defense divisions as they related to scientific and commercial use of space.

    - Yes, there is a need to explore the feasibility of such an agency or clearinghouse to serve in an advisory rather than regulatory capacity for the foreseeable future. Guidelines for technical design (and in some cases, such as adapters, guidelines for technical design standardization) should be added as well.

- Ten out of 27 participants (37%) stated that, no, an exploration was not needed. These participants indicated that the need for a single agency or clearinghouse was far from established and that any potential need for the standardization of certifications, requirements, and ethical standards was too remote in the future to merit serious consideration in the present. Sample quotes that no exploration was needed included:
    - Very low. Congress has yet to act on fully fleshing out the provisions and responsibilities of the Outer Space Treaty of 1968, let alone coming up with a single, unified space travel certification agency that currently touches on FAA, Commerce, FCC, DOD, etc. in the United States, let alone worldwide. What is needed is a unified direction and capability in the U.S. first.
    - No, because technology is evolving too quickly for national regulations, much less international ones, to keep up. We already have space law through treaty process. Again, we have not fully resolved several very large issues from the 1968 Outer Space Treaty that is over 50 years old. Setting up a new organization will not solve that issue.

- The goal is to facilitate space travel and not create so much red tape and bureaucracy limiting or prohibiting the voyage before it can grow. Until we're approaching the Star Trek age, I'm not entirely sure this would be necessary for the short term. As mentioned previously in writing and via offline conversations, have the countries set their own rules for their citizens, or leave this entirely up to the companies conducting the space operations for tourism/space travel. Safety procedures will be outlined to avoid lawsuits and public trust. Then once there are enough individuals traveling in space with various companies, a baseline can be established for policy.

9. How do commercialized vessels manage inflight and off-Earth mechanical failures?

There was insufficient convergence in participants' responses to form themes under this item. None of the 25 participants who responded to this item provided responses sufficiently similar to one another to be grouped into an abstract but still meaningful thematic category. Thus, the finding in relation to this question was that no consensus emerged regarding how commercialized vessels manage inflight and off-Earth mechanical failures. Suggestions from participants (with each recommendation made by a different participant, and each made by only one participant) included having repair capabilities onboard, having hubs or space stations where repairs could be performed, making commercial entities responsible for their own collection and repairs, having written emergency procedures that would indicate the proper course of action, having systems redundancy to prevent a mechanical failure from disabling the vehicle, and using only experienced pilots and crews who would know how to respond. Sample quotes indicating how commercialized vessels manage inflight and off-Earth mechanical failures included:

- Redundancy in system design and effectual onboard fault analysis and failure modes are the best methods to manage mechanical failures. Given that a mechanical failure has occurred, it is imperative that both the crew and ground controllers are properly trained on mission impact as a result of the failure, and contingency operations.
- Avoid collision with Earth to the utmost. Any space debris that causes human death on Earth to non-participants shall be extremely costly.
- Safety Centered Maintenance is a process we studied at ESA to minimize spare parts mass and maintenance crew time. It requires a specific design solution to allow safe testing after task completion. It may be supported by some additive manufacturing capabilities onboard at the level of crew time.

10. How do commercialized vessels manage inflight and off-Earth uncontrolled fires?

A total of 23 participants (82%) responded to this item. Eight of those 23 participants (35%) repeated their responses verbatim from the previous item and did not give a response specific to this item. As with the previous item, there was not enough convergence in the data to facilitate the identification of common themes. The conclusion that may be drawn with respect to this item is that no consensus emerged regarding how commercialized vessels manage inflight and off-Earth uncontrolled fires. Some recommendations, each of which was provided by one participant, included having safety protocols in place to indicate how the crew should respond, installing automatic fire suppression systems, sectioning ships with fire barriers, training crews to respond to fires, selective depressurization of affected modules, and having manually operated fire suppression tools onboard. Sample quotes indicating how commercialized vessels manage inflight and off-Earth uncontrolled fires included:

- Prevention is the first priority – systems must be designed to minimize fire risk, and training must be provided to personnel to minimize fire risk. Given that a fire has occurred, expeditious execution of emergency procedures, including by automation when practical, will improve the chance of recovery.
- Sectioned ships with manual and automatic fire suppression systems. Similar to an aircraft carrier.
- Escape capsule/reentry vehicles shall be required similar to current cruise line requirements.

11. How do commercialized vessels manage inflight and off-Earth collisions with micrometeoroid and orbital debris (MMOD), leading to a major loss of cabin pressurization?

Twenty-one out of 28 participants (75%) responded to this item. Eight of those 21 participants (38%) copied their responses verbatim from the previous item and did not provide responses specific to this item. As with the preceding two items, there was no convergence in participants' responses, and no common themes were identified in the data. Recommendations, each given by one participant, included training crews to respond to collisions, having patch kits onboard, deploying shields, segmenting ships to contain depressurization, developing ship-construction materials to minimize damage from MMOD, having a standardized set of MMOD protection requirements, mandating the sharing of space debris maps between nations, modeling procedures after those used when submarine hulls are breached, and redundancy of systems. Sample quotes indicating how commercialized vessels manage inflight and off-Earth collisions included:

- Crewed systems have to meet a variety of requirements for MMOD damage. See the commercial crew standards for probability of loss of mission and probability

of loss of crew. Some systems, like Orion, can survive loss of cabin pressurization with the crew in suits.

- Segmented ships, airtight doors. Onboard Repair facilities
- Radar sensing system to ensure that MMOD are avoided throughout travel.

12. How do commercialized vessels manage inflight and off-Earth collision with a visiting vehicle?

Twenty-two out of 28 participants (79%) responded to this item. Nine of those 22 participants (41%) copied their response from the preceding question verbatim into this response and did not provide a unique response specific to this item. However, one theme emerged in relation to this item. The theme was as follows:

- Nine of the 13 participants (69%) who gave an item-specific response indicated that the focus should be on preventing inflight and off-Earth collisions with visiting vehicles rather than managing such collisions after they occurred. Participants recommended that prevention should involve stringent space traffic management, modeled after the existing air traffic control for standard aviation through the FAA. All craft should have devices such as transponders to provide advance warning of another craft's approach, and space traffic control should be focused in part on plotting flight vectors to avert collisions in advance. Craft should also be equipped with RADAR or LIDAR to detect incoming vehicles. The theme that prevention rather than management of collisions should be the focus of inquiry received attestation from 69% of the 13 participants who provided item-specific responses, close enough to the 70% cutoff to indicate a

consensus. Sample quotes indicating that the focus should be on preventing inflight and off-Earth collisions with visiting vehicles included:

- Enable similar space transponder similar to current FAA manned and unmanned requirements.
- They have Kurs and laser approach radar and lidar. The approach plates should be well known and the delta V for closure should not be that high. If for some reason they collided (a stuck thruster) then the docking port would be closed off via its hatch to the rest of the spacecraft until the pressure and stability of the docking port was known.
- Ground monitoring and telemetry would be effective in this regard where possible. However, given the situations in which this is not possible, it is advisable to develop a system for spacecraft designed for this purpose – an ADSB-out (Mode S) for spacecraft, transmitted by an omnidirectional beacon. As the preponderance of commercial vehicles grows, with relatively fewer classified spacecraft, this will become an increasingly attractive option to keep crew commanders informed and able to execute emergency deconfliction procedures if required.

13. How do commercialized vessels manage inflight and off-Earth toxic spills that endanger the people onboard or off-Earth?

A total of 22 out of 28 participants (79%) responded to this item. Nine of those 22 participants (41%) copied their responses verbatim from previous items and did not provide responses specific to this item. There was insufficient convergence in the responses to this item for meaningful, common themes to be identified, so as with some previous items, the conclusion

drawn with respect to this item was that no consensus emerged. Participants' recommendations, each of which was provided by one participant, included containment of the spill by isolating the area, donning of HAZMAT suits or other PPE, vacuuming up the spilled material and triple-bagging it to prevent off-gassing, having redundant emergency systems in the craft, neutralizing toxic spills in advance by storing containers of toxic materials in locked storage containers, having segmented ships with life-support systems capable of filtering out toxic materials, following existing military guidelines (not specified), and using escape capsules to abandon the contaminated craft. Three of the participants who responded to this item recommended cleaning up the spill without indicating how to do so. However, this small number of participants was not sufficient to establish a theme. Sample quotes indicating how commercialized vessels manage inflight and off-Earth toxic spills included:

- Hazardous material reviews are part of the normal payload review process for getting a launch license. Commercial platforms could start with the reviews that are already done for government space facilities.
- HAZMAT teams have experience here and the military has a wealth of knowledge.
- Containment by design if the concentration is above the SMAC value, plus sensors and emergency procedures. The ECLS should be designed to be capable of scrubbing toxic contaminants.

14. What safety equipment should be required on all spacecraft for inflight/spaceflight operations, and what governing guidelines doctrine and agency should have the oversight to ensure that there is a universal minimum standard level of safety equipment onboard?

Twenty-five out of 28 participants (89%) responded to this item. Although small numbers

of participants provided similar responses to this item, none of the responses were sufficiently frequent to support the identification of a common theme potentially representing a consensus. Six out of 25 participants (24%) recommended that spacesuits should be required, and six participants recommended that pressurized oxygen and oxygen masks should be required. Five out of 25 participants (24%) recommended that fire suppression equipment be required. Three participants (12%) recommended that all craft be required to have a transponder or locator beacon. Two participants (8%) recommended escape capsules, and two participants recommended first aid kits. Other responses were each provided by only one out of 25 participants (4%), and none of the response categories approached the frequency of 70% required for observation of consensus. Four participants indicated that they did not have sufficient information about the nature of the craft, its contents, or its mission to give a meaningful response to the question. Most participants did not address the second half of the item, which asked what governing guidelines doctrine and agency should have oversight. Among those who did, no common theme emerged. Responses included a global space agency, national space agencies, an unspecified government body, an unspecified international organization, the FAA, and NASA. Sample quotes indicating what safety equipment should be required on all spacecraft included:

- There is no one-size-fits-all response. The closest analog I can think of is the Soyuz survival kit in the event of an emergency landing. It includes a satellite phone, flares, a survival rifle, and other wilderness gear.
- Redundant systems, engineering, nav, environmental. Probably need orbiting emergency stations with supplies and personnel. Again, NASA and some private

companies have space experience, and their consultation would be key. Escape pods to get to orbiting emergency stations would make sense.

- It is likely there will be significant distinctions between these requirements for human and robotic spaceflight. I'd start with exploring the benefits and drawbacks of requiring something like a transponder for orbital flight before getting into human safety requirements.

15. Should there be a universal minimum standard for screening, selection, training, and certification for all commercialized humans before space travel?

Of the 25 out of 28 participants (89%) who responded to this item, 18 answered in the affirmative, indicating that there should be a universal minimum standard. The remaining seven out of 25 participants (28%) answered in the negative, that there should not be a universal minimum standard. The 18 out of 25 responding participants represented a percentage of 72%, which was greater than the standard of 70% for identifying a consensus. Therefore, a consensus was reached with respect to this item, indicating that there should be a universal minimum standard for screening, selection, training, and certification for all commercialized humans before space travel. The two themes identified when similar responses are clustered are as follows:

- Eighteen out of 25 responding participants (72%) answered yes; there should be a universal minimum standard. These participants indicated that such a standard was needed and that it should address medical, psychiatric, and training requirements. A medical examination was needed to ensure that travelers were in adequate health to endure the physical conditions of the flight. A psychiatric examination may be needed to ensure the traveler’s capability of enduring any

emotional strain associated with the flight. Participants agreed that some basic level of training was needed, but they differed markedly regarding how much training should be needed to meet a universal minimum standard, with responses ranging from no more training than a commercial airline passenger receives too significant advance training that would draw on some aspects of the training astronauts receive. Participants expressed that the amount of training and screening may reasonably depend on the nature and duration of the flight, with universal minimum standards for a flight involving only a few minutes in space being less stringent than those for a flight that would involve, for example, several orbits around the earth. Participants also indicated that the need for a universal minimum standard was likely to change over time as spaceflight capabilities advanced, with future passengers perhaps needing no training or medical evaluation at all when the craft was known to be as reliable as commercial airlines. Sample quotes indicating that there should be a minimum universal standard included:

- Yes, there should be universal minimums for screening, selection, training, and certification. However, as commercial spaceflight becomes more common (and assuming it becomes more safe), these standards should correspondingly be reduced in scope. Bare minimums for spaceflight include psychological evaluation, medical evaluation, and comprehensive training in emergency procedures. However, corporations and individuals should be allowed the capacity to accept certain levels of risk, given that the participating individuals are properly informed.

    - There should be standards which can differ for pilots, aircrew, and the basic riding, paying passengers. Pretty sure the riders will all sign legal waivers to sign their life away, but it is good business to have most up to date systems, qualified personnel, etc.

- Seven out of 25 responding participants (28%) indicated that no universal minimum standard should be imposed. These participants expressed a preference for standards set by individual, national agencies according to craft capabilities and risk tolerance. One participant pointed out that space travel is inherently risky and that travelers would implicitly be assuming some amount of that risk if they chose to take a space flight. Participants also expressed concern that universal regulations would stifle innovation, that an international consensus regarding acceptable risk was unlikely to be achievable, and that risk and any corresponding minimal standard were so dependent on the nature of the specific spacecraft in question that development of minimum standards that could be meaningfully applied to a significant number of flights was likely unfeasible. Sample quotes indicating that no universal minimum standard should be imposed included:
    - No, because who is making that standard? Should we use the Chinese? We don't currently have one in the U.S. My recommendation is that space is inherently risky. We do not know today what we don't know, and too much regulation will kill the industry at this time in the U.S. The alternative is we regulate now, and commercial space business goes overseas to other countries, along with a lot of jobs. Countries that may not ever want to develop regulations. So let's continue to protect the

public, acknowledge the risk, and as we learn over time, and the public becomes more involved as passengers, then increase the regulations.

- This could be an interesting discussion, but spaceflight is a long way from air travel. As a result, each launching state will set its own qualification standards. One difficult question is how to provide enough sense of the risks involved to ensure informed consent by the participants.

16. Should there be different screening, selection, training, and certification criteria based on the person's function in space, i.e., tourist, flight crew, employee, colonist, etc.?

A total of 25 out of 28 participants (89%) responded to this item. Eighteen of those 25 participants responded affirmatively, indicating that there should be different criteria depending on the person's function in space. A consensus emerged among the 18 out of 25 responding participants (72%) that was sufficient to exceed the standard of 70% for identifying a consensus in the expert panel. The consensus was as follows:

- Eighteen out of 25 responding participants (72%) indicated that differentiated criteria should exist. These participants were consistent in stating that the lowest thresholds should be applied to passengers, and particularly to passengers on short flights (one participant noted that conditions such as extreme nausea were likely to occur on longer flights in zero gravity). These participants indicated that criteria for other persons should depend on how critical their function was to the mission. Crew members such as pilots or those responsible for docking should have to meet the most rigorous criteria, while tourists should have the least rigorous criteria. The same general rule should apply to colonists, participants indicated, with the rigor of the criteria depending on the difficulty and criticality

of the individual's duty. Several participants indicated that while universal, differentiated criteria dependent on function were desirable, they were unlikely to be established on an international basis because they were highly dependent on the nature of craft, the available safety resources, the nature of missions, and the levels of risk tolerance, all of which might vary widely between countries. Corporate entities, a few participants noted, would have an incentive to make the criteria for passengers as low as possible to expand their potential customer base. Sample quotes indicating that differentiated criteria should exist included:

- I believe this would be mission/operation dependent. If a tourist wants to stay in a hotel on the Moon or in lunar orbit for a few days, he/she would not need the level of certifications and training as a crew member traveling to Mars or to be an engineer on the Moon.
- Yes. A person's role in a space mission, particularly as these missions grow in size and diversity of personnel, should affect their screening, selection, training, and certification. Flight crew should be subject to the most strenuous training and should be properly qualified, just as they are in commercial air travel. Employees, colonists, and tourists should have lower levels of training and less strenuous qualification requirements, but will still require more intensive processes than are applied in commercial aviation. For instance, psychological evaluations will be particularly important on longer missions to include colonization. There should be a universal policy that provides recommendations for these criteria, however, the dynamic nature of the immature commercial space industry

means that it is not yet prudent to create enforceable regulations with respect to these criteria.

- Seven out of 25 responding participants (28%) answered negatively, that differentiated criteria should not exist. No theme emerged among the responses of participants who answered in the negative, with responses indicating that differentiated criteria would eventually be desirable but that consideration of what they should be was premature (three participants), that differentiated criteria already exist (two participants), or that no universal set of differentiated criteria should exist (two participants). Sample quotes indicating that differentiated criteria should not exist included:
    - There already are differences. E.g., shuttle pilots were different from mission specialists, who were different from spaceflight participants. Government agencies have these already for government employees and persons flying on government spacecraft. Private systems will set their own criteria, in consultation with the FAA for licensing.
    - The need for this type of requirement will become clearer once activities begin in earnest.

17. Should space entry for all commercialized travelers be specifically categorized, i.e., tourist, an employee with defined role and responsibility, flight crew, colonist (Lunar or Deep Space, i.e., Mars "longevity trip"), etc.?

Twenty-six out of 28 participants (93%) responded to this item. A consensus emerged among the 20 out of 26 responding participants who answered affirmatively that space entry for all commercialized travelers should be specifically categorized. The percentage of respondents

answering affirmatively (77%) exceeded the standard of 70%, indicating consensus in the expert panel that space entry should be specifically categorized for commercial travelers. The responses of the six participants (23%) who answered negatively that space entry should not be specifically categorized did not endorse a common theme beyond their negative response. The two themes identified through the grouping of similar responses to this item were as follows:

- Twenty out of 26 responding participants (77%) indicated that space entry should be specifically categorized. These participants were consistent in noting that space travel was likely to involve an element of danger for the foreseeable future until craft became as reliable as commercial airlines. During this early stage of space travel, passengers were likely to require some level of training to prepare them to perform certain tasks and duties, although participants did not specify what these might be. Passengers' specific category of space entry would determine the nature of the responsibilities for which they would need to be prepared. Passengers' category would also determine their rights in the event of injury during the flight, whether detected at the time or years afterward (one participant cited NASA's policy of remaining responsible for cancer resulting from radiation exposure in space throughout astronauts' lives). The passenger's category would also be needed to determine which of their rights, if any, they could waive and under what conditions. For example, as one participant noted, recreational travelers might have fewer rights and a greater capacity to waive them than travelers engaged in scientific research. Participants indicated that specific categories for commercial travelers should be standardized, at least at the national level. Sample quotes indicating that space entry should be specifically categorized included:

- All commercialized travelers should be specifically categorized for each mission, not necessarily for space entry. For instance, a flight crewmember of a Series A spacecraft should be allowed to embark on a Series B spacecraft as a passenger, travel to a space station, and embark on a Series A spacecraft to conduct duties as flight crew. This type of categorization, division of labor, and defined responsibilities enable more proficient personnel in each role with great expertise in their respective field. There should be minimum requirements for knowledge, training, and medical and psychological condition prior to embarking on spacecraft, however, these should be tailored to each traveler's categorization.
- Depends on if you are government or commercial. The government is responsible for exposures for the astronaut's lifetime. A cancer from radiation during a space mission cannot be waived. Whereas a commercial entity could have someone sign such a waiver and forego responsibility. The longer the spaceflight and the further away from Earth, folks will have to be cross trained so that the crew themselves represent a sort of fault tolerance.

- Six out of 26 responding participants (23%) answered negatively, that space entry for commercialized travelers should not be specifically categorized. Four of the participants in this category answered in one word, "No." The remaining two out of six participants in this category indicated that consideration of traveler classification was premature at present. Sample quotes indicating that space entry should not be specifically categorized included:

- No, space travel should be open to those that are qualified.
- Too early to tell. What is the benefit of categorization today?

18. Should all spacecraft greater than X number of passengers onboard be required to carry an onboard medical officer? If so, what should that X number be?

Twenty-two out of 28 participants (79%) responded to this item. No consensus emerged among the responding participants. The largest category was affirmative responses, with twelve participants (55%) indicating, yes, flights should be required to carry an onboard medical officer. Another eight out of 22 participants (36%) indicated that a medical officer should only be required under certain circumstances, and two out of 22 participants (9%) indicated that a medical officer should not be required. In more detail, the grouping of similar responses to this item are as follows:

- Twelve out of 22 responding participants (55%) stated, yes, a medical officer should be mandated in all or most cases. Of the participants who specified the number of passengers that should trigger the requirement for a medical officer, one stated that there should be a medical officer regardless of the number of passengers, three stated that there should be one medical officer for every 10 passengers, one stated that there should be one medical officer for every 20 passengers, and one stated that there should be a medical officer for every 30 passengers. Participants qualified their consensus in several ways, however. Two participants noted the ambiguity in the term “medical officer” and noted that the type of medical officer, whether a surgeon, a Medical Doctor (MD) or a Registered Nurse (RN), should depend on the condition of the passengers (as assessed through pre-flight examination) and the nature of the flight. Two

participants expressed the opinion that telemedicine might be an acceptable substitute for the physical presence of a medical officer. Participants also noted that the duration of the flight should be considered in determining whether and how many medical officers were needed, with flights lasting only minutes being unlikely to need one regardless of the number of passengers and with longer flights justifying the physical presence of an MD. Sample quotes indicating that a medical officer should be mandated included:

  - Yes, depending on trip duration and crew categorization. Trips greater than 24 hours with more than 10 personnel embarked AND non-qualified passengers aboard should be required to carry a medical professional (RN, MD, or similar). Trips with no passengers aboard and more than 10 personnel should ensure that all flight crew have minimum medical training, and should also carry a medical professional, but it should not be a requirement.
  - All space flights should have a medical officer on board regardless of the number of passengers.

- Eight out of 22 responding participants (36%) indicated that whether a medical officer was required could not be determined without further information but should instead be assessed on a case-by-case basis, according to the number of passengers, the duration of the flight, the distance of the flight, and the nature of the passengers (e.g., whether they are military personnel in prime physical condition, or elderly or handicapped persons, etc.). Sample quotes indicating that further information was needed to determine a requirement included:

    - Medical officers should be used on a case-by-case basis depending on the crew makeup and if passengers are being carried.
    - Depending on the duration of the flight, yes, it might be required but First Aiders may be enough (just like for Aviation Cabin Crew today) and telemedicine might be of great help there. 1 First Aider per 10 PAX might be a good ratio, for longer trips 1 for 5 PAX.
- Two out of 22 responding participants (9%) indicated no, medical officers should not be required. One of those two participants indicated that a medical officer should not be required, but that first aid capability of the kind found on boats should be required. The other participant indicated that the requirement for a medical officer should be determined by the agency or company launching the flight. A sample quote indicating that a medical officer should not be required was:
    - No, that should be determined by the launching state or company conducting the launch.

19. Is there a need to investigate better long-endurance (greater than one day in space) passenger and crew requirements, crew rest and seating accommodations, and amenities onboard commercialized spacecraft?

Twenty-four out of 28 participants responded to this item. Of the responding participants, two-thirds (*n*=16) answered affirmatively, stating that there was a need to investigate better long-endurance requirements. At 67%, this number of participants was insufficient for a consensus to be identified, so the conclusion with respect to this item was that no conclusion was reached. The remaining eight out of 24 responding participants indicated that consideration of the question

was premature at this time. The two themes identified when similar responses were grouped are as follows:

- Sixteen out of 24 responding participants (67%) indicated, yes, there is a need to investigate better long-endurance requirements. These participants consistently noted that space travel can be highly stressful, both physically and psychologically, and that the mental and physical demands on passengers are to some extent proportional to flight duration. These participants stated that the safety of all passengers was the primary consideration and that single passengers succumbing to inflight stressors could potentially affect everyone onboard. Investigation of better long-endurance requirements was perceived as necessary to ensure safety. Sample quotes indicating a need to investigate included:
    - Absolutely. Most people traveling either fly or road trip, both of which are relatively short durations compared to space. In addition, space is scary and, dare I say, "unnatural" to many; therefore, ensuring it is as comfortable and accommodating as possible would reduce potential incidences and promote customer service.
    - This should be allowed to be driven by two factors: safety and the market. Safety should drive basic requirements and the "nice to have's" should be driven by the consumer need and desire to pay for such amenities.
- Eight out of 24 responding participants (33%) answered negatively, stating that no investigation was needed at this time. These participants indicated that further information about other factors, such as the nature of flights and the effects of zero gravity on the general population, was needed to determine whether such an

investigation was necessary. Sample quotes indicating that no investigation was needed included:

- Research needs to be conducted in this area with recommendations for regulations for commercial certification of each spacecraft and crew for duty hours and rest.
- Unknown, at this time there has not been enough data to support the need for a universal standard.

20. What are the top three things that may lead to an onboard accident in spacecraft resulting in death and or property loss?

All 28 (100%) participants responded to this item. There was insufficient convergence in participants' responses to identify common themes. The three response categories were too infrequent to justify theme formation, and the remainder of the responses appeared only once each in the response set. The first response category emerged from human error (including pilot error and deficient maintenance), with six out of 28 participants (21%) attesting. The second response category was depressurization, including depressurization due to MMOD, with five out of the 28 participants (18%) attesting. Three participants (11%) cited structural failure. The frequencies of these categories did not approach the threshold of 70% needed to identify a consensus in the expert panel, so the conclusion for this item must be that no consensus emerged. Other responses, each provided by one out of 28 participants (4%), included terrorism, faulty systems, "unknown events," cost-saving materials of low quality, collision, fire, explosion, reentry, launch, radiation, toxic contamination, malfunction of life support systems, inadequate training of crew resulting in poor emergency response, medical emergency, intoxication due to loss of Oxygen, and unspecified mechanical events. Sample quotes indicating the top three

things that may lead to an onboard accident included:

- Human error, external factors, system failures.
- 1) Explosion during launch 2) Power failure (electrical or mechanical) during flight 3) Structural failure upon return to Earth
- Malfunction of life support systems, intentional hostile action taken by one or more people, unintentional actions.

21. What are the top three things that will lead to an off-Earth, i.e., on another planetary body accident (not including a spacecraft accident) resulting in death and or loss of property?

All 28 participants (100%) responded to this item. Two significant themes were identified in the response set for this item, but neither theme was sufficiently common for a consensus to be achieved. Fifteen out of 28 participants (54%) indicated that human error would be among the top three causes of off-Earth accidents, and 10 participants (36%) indicated that mechanical failures would be among the top three causes. Neither theme was prevalent enough to surpass the 70% standard for consensus. The participants typically did not elaborate on these responses, referencing them only as "human error" or "mechanical failure," respectively. The breakdown of themes was as follows:

- Fifteen out of 28 participants (54%) cited "human error" as among the top three causes of off-Earth accidents.
- Ten out of 28 participants (36%) cited "mechanical failure" as among the top three causes of off-Earth accidents.
- All other responses to this item were unique, referencing causes such as terrorism, unpredictable factors associated with unfamiliar conditions, puncturing of

spacesuits, crashing of rovers, radiation, toxic spills, dust, crash upon landing, depletion of supplies, and medical emergencies. Sample quotes indicating the top three things that will lead to an off-Earth accident included:

- 1) Improper training or human error; 2) vehicle malfunction leading to environmental control, life support, or propulsion issues that harm and/or strand crew; 3) psychological episode of space tourist or colonist on long-duration mission.
- Failure to understand the various aspects of that planet's environment, to include working with other spacecrafts that are not properly equipped or have procedures in place that allow for the effective safety and security of the crew and craft.
- Sabotage, procedural error, medical emergency/accident

Round 2 Questionnaire

In the second round, the goal was to develop consensus among experts to narrow down the list through a selection process. After the initial " brainstorming phase, " the Delphi method's second phase involved ranking the factors based on the pared-down list (Okoli & Pawlowski, 2004). In Round 2, a list of statements developed from the Round 1 findings was presented to all participants. Based on the findings from Round 1 of this Delphi study, 45 five-level Likert-like items were developed for the Round 2 questionnaire. The Likert levels were as follows: 5 = Strongly agree; 4 = Somewhat agree; 3 = Neither agree nor disagree; 2 = Somewhat disagree; 1 = Strongly disagree. A total of 28 participants completed the questionnaire who identified themselves as either an End-user/Operator or someone in the Academic/Regulator/Policymaker fields.

For each of the 45 questionnaire items, a mean was calculated across all 28 participants ("N value" for total sample size). A mean of 3.5 or higher was the standard for consensus in agreement with the item. A mean of 1.5 or lower was the standard for consensus in disagreement with the item. No items yielded a consensus of disagreement. Round 2 was expanded after an initial brainstorming of Round 1 results, so there are additional items. Table 3 indicates the means for each of the 45 Likert-like items:

Table 3

Mean Round 2 Responses Across All 28 Participants

Item #	Item text	Mean (*N*=28)	Consensus reached?
Q1	The development of universal global guidelines for space travel and colonization is desirable at the present time.	4.0	Yes
Q2	Substantial development of universal global guidelines for space travel and colonization is feasible at the present time.	3.3	No
Q3	The development of an agency or clearinghouse for the standardization of certifications and technical requirements for space travel and colonization is desirable at the present time.	4.1	Yes
Q4	The development of an agency or clearinghouse for the standardization of ethical standards for space travel and colonization is desirable at the present time.	3.9	Yes
Q5	The development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at the present time.	3.4	No
Q6	I do not believe that the development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at present. However, I believe that developing a regional agency of allied nations for standardizations of certifications and technical requirements is feasible.	3.9	Yes
Q7	Substantial development or defining of a global agency or clearinghouse for the standardization of ethical standards for space travel and colonization is feasible at the present time.	3.3	No
Q8	I do not believe that the development of an agency or clearinghouse for the global standardization of ethical standards for space travel and colonization is feasible at the present time. However, I believe that the development of a regional agency of allied nations for standardizations of ethical standards is feasible.	3.0	No

Item #	Item text	Mean (*N*=28)	Consensus reached?
Q9	Regardless of feasibility or desirability, the safety of persons and preservation of life should be the highest priority in developing universal guidelines for space travel or colonization.	4.2	Yes
Q10	Regardless of the desirability of developing a global agency or clearinghouse for the standardization of certifications and technical requirements, organizations such as the United Nations and/or ICAO provide a sufficient template for doing so.	3.4	No
Q11	Regardless of the desirability of developing universal guidelines for space travel and or colonization as expressed by public (government) and private entities, existing guidelines from agencies such as the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), the Commercial Spaceflight Federation (CSF), and the International Association for the Advancement of Space Safety (IAASS), would provide the baseline for further guidelines to be developed.	4.0	Yes
Q12	Multiple, independently functioning, worldwide national space agencies and private commercial space entities, each with their own governing laws, policies, and procedures, would be more effective in promoting the advancement of space travel and colonization than a single, global agency or clearinghouse.	2.8	No
Q13	Further investigation is needed to determine whether a single entity for global space safety would be optimal for promoting the advancement of space travel and colonization.	3.8	Yes
Q14	If an infrastructure to develop a universal Emergency Space Response Management System (ESRMS) is developed through international collaboration and investment, the influence of individual governments over decision-making related to the project (e.g., number of votes) should be proportional to each government's investment in the project.	3.6	Yes
Q15	If a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities is developed, participation should be optional—that is, sovereign states should be able to opt-in or opt-out.	3.6	Yes
Q16	There should be a universal minimum medical standard for screening, selection, training, and certification for all commercialized humans before space travel.	3.6	Yes
Q17	There should be a universal minimum training standard for screening, selection, training, and certification for all humans before commercialized space travel.	3.6	Yes

Item #	Item text	Mean (*N*=28)	Consensus reached?
Q18	At least while space travel is still in an early stage, there should be different screening, selection, training, and certification criteria based on the person's function in space, i.e., tourist, flight crew, employee, colonist, etc., and one of the primary purposes of such classification should be to assign individual responsibilities and/or assess fitness to fulfill them.	4.5	Yes
Q19	There should be different screening, selection, training, and certification criteria based on an individual's function in space, i.e., tourist, flight crew, employee, colonist, etc., even if the criteria are to some extent dependent on mission variables such as duration, distance, and the nature of the craft.	4.6	Yes
Q20	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such categorization should be to assess the individual's fitness for fulfilling any associated responsibilities.	4.1	Yes
Q21	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such classification should be to determine the individual's rights and/or their ability to waive their rights.	3.1	No
Q22	At least while space travel is still in its early stages (i.e., before it is developed to a level akin to commercial air travel), all spacecraft with 10 or more passengers onboard should be required to carry an onboard medical officer.	3.2	No
Q23	Spacecraft with human passengers should be required to carry an onboard medical officer when a planned space travel duration exceeds a defined time.	3.6	Yes
Q24	All spacecraft with any number of human passengers should only be required to carry a first aid kit as the minimum medical equipment needed for spaceflight certification.	3.3	No
Q25	All spacecraft with any number of passengers onboard should be at minimum required to have automatic fire suppression system(s).	4.1	Yes
Q26	Whenever feasible, all spacecraft should be segmented to allow containment of events such as fires, depressurization due to meteorite or debris collisions, or toxic spills.	4.0	Yes
Q27	Human error will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4.0	Yes
Q28	Mechanical or systems failures will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4.3	Yes
Q29	Depressurization will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and or property loss.	3.8	Yes

Item #	Item text	Mean (*N*=28)	Consensus reached?
Q30	Universal guidelines for passenger and crew requirements associated with long-endurance spaceflight (greater than thirty days in space) should be developed and accepted globally as a standard.	4.0	Yes
Q31	Guidelines for passenger and crew requirements for long-endurance spaceflight (greater than thirty days in space) should only be developed and accepted as a standard at the national or regional level.	2.9	No
Q32	Additional data about the effects of physical and psychological stressors on the general population are needed to determine whether and to what extent guidelines for passenger and crew requirements for long-endurance spaceflight should be developed.	3.7	Yes
Q33	One of the most significant disadvantages to developing a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that one-size-fits-all regulation would hamper meritocratic competition to an extent detrimental to the overall advancement of space travel and colonization.	3.4	No
Q34	One of the greatest barriers to the development of a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that nations will not be willing to relinquish sovereignty in their pursuit of space travel and colonization goals.	4.1	Yes
Q35	With the recent launch of Virgin Galactic and Blue Origin reaching different altitudes during their space flights, the argument of which crews actually or theoretically reached space presents more need to define the globally recognized requirement boundary for a defined entry into space?	3.4	No
Q36	It is feasible to define the space flight boundaries as quantified series of three zones instead of a singular line with separate governing rules, regulations, and requirements, which could ease the restrictions on suborbital and low Earth orbital flights.	3.9	Yes
Q37	Space regulation and policy governance should continue solely under the United Nations and be perpetually known as the single regulatory entity responsible for Earth's space policy regulations and legislation matters?	2.5	No
Q38	It is ideal for keeping the global space governing regulation policymaking under the United Nations (UN) and expand global operational authority and responsibility under the International Civil Aviation Organization (ICAO) for all future space operations as it has done for global aviation. However, ICAO should remain unbiased and apolitical.	2.6	No
Q39	As a result of international space regulations, the International Civil Aviation Organization (IACO) name should be amended to the International Civil Aerospace Organization (ICAO) better to describe a possible overarching industry/community inclusion.	3.1	No

Item #	Item text	Mean (*N*=28)	Consensus reached?
Q40	There should be a space tourism tax as part of space tourism, which all spacefaring nations within the United Nations pay to fund the ICAO commercial space office to develop, support, and sustain the infrastructure of commercialized human space safety.	3.0	No
Q41	The Artemis Accords should serve as the vessel that operationalizes the Outer Space Treaty (OST) of 1967 and allows space policy regulation to evolve and mature in today's modern era. This allows for universal cooperation from all participant nations to agree to work together for the better good of the peaceful use of space.	3.7	Yes
Q42	There is a need to create an International Space Academy to develop and train our next generation to ensure the highest level of success before any off-Earth colonization and/or longevity endurance space travel commences in the Cosmos.	3.6	Yes
Q43	A single universal entity infrastructure with overarching responsibility for all space emergencies and rescues should be developed to ensure the highest probability of survival to human life and recovery of property is assured.	3.1	No
Q44	There is a need for a unified global space safety regulation that the global community uses as the universal standard regarding commercial crews, passengers, and vessels. This list would include but is not limited to the designated maximum allowable space flight times for awake duty cycles for crewmembers and non-crewmembers, sleeping accommodation requirements, spacecraft minimum equipment lists, radiation exposure monitoring standards, onboard medical care requirements, and emergency procedures/protocol for flight crews and ground support crews/staff.	3.8	Yes
Q45	If life support cannot be maintained and/or space flight cannot continue, there should be an escape craft capable of sustaining all onboard passengers' and their life support requirements to the intended point of destination, with maneuvering capabilities.	3.6	Yes
	n of items on which a consensus was reached (*N*=45):		28

Based on the responses across all 28 participants, a consensus was reached in relation to 62% of the items. However, a somewhat different pattern emerged when separate means were calculated for the responses of End-users/Operators and Academician/Policymakers/Regulators. Table 4 is a comparison of the mean responses from each participant group.

Table 4

Comparison of Means by Participant Group

Item #	Item text	Mean for end-users (n=13)	Consensus reached?	Mean for policymakers (n=15)	Consensus reached?
Q1	The development of universal global guidelines for space travel and colonization is desirable at the present time.	4.4	Yes	3.6	Yes
Q2	Substantial development of universal global guidelines for space travel and colonization is feasible at the present time.	3.7	Yes	2.9	No
Q3	The development of an agency or clearinghouse for the standardization of certifications and technical requirements for space travel and colonization is desirable at the present time.	4.4	Yes	3.9	Yes
Q4	The development of an agency or clearinghouse for the standardization of ethical standards for space travel and colonization is desirable at the present time.	4.0	Yes	3.8	Yes
Q5	The development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at the present time.	3.6	Yes	3.2	No
Q6	I do not believe that the development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at the present time. However, I believe that the development of a regional agency of allied nations for standardizations of certifications and technical requirements is feasible	4.2	Yes	3.6	Yes
Q7	Substantial development or defining of a global agency or clearinghouse for the standardization of ethical standards for space travel and colonization is feasible at the present time.	3.5	Yes	3.1	No
Q8	I do not believe that the development of an agency or clearinghouse for the global standardization of ethical standards for space travel and colonization is feasible at the present time. However, I believe that the development of a regional agency of allied nations for standardizations of ethical standards is feasible.	3.6	Yes	2.5	No
Q9	Regardless of feasibility or desirability, the safety of persons and preservation of life should be the highest priority in developing universal guidelines for space travel or colonization.	4.3	Yes	4.1	Yes

Item #	Item text	Mean for end-users (*n*=13)	Consensus reached?	Mean for policymakers (*n*=15)	Consensus reached?
Q10	Regardless of the desirability of developing a global agency or clearinghouse for the standardization of certifications and technical requirements, organizations such as the United Nations and/or ICAO provide a sufficient template for doing so.	3.6	Yes	3.1	No
Q11	Regardless of the desirability of developing universal guidelines for space travel and or colonization as expressed by public (government) and private entities, existing guidelines from agencies such as the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), the Commercial Spaceflight Federation (CSF), and the International Association for the Advancement of Space Safety (IAASS), would provide the baseline for further guidelines to be developed.	4.2	Yes	3.9	Yes
Q12	Multiple, independently functioning, worldwide national space agencies and private commercial space entities, each with their own governing laws, policies, and procedures, would be more effective in promoting the advancement of space travel and colonization than a single, global agency or clearinghouse.	2.8	No	2.9	No
Q13	Further investigation is needed to determine whether a single entity for global space safety would be optimal for promoting the advancement of space travel and colonization.	4.4	Yes	3.3	No
Q14	If an infrastructure to develop a universal Emergency Space Response Management System (ESRMS) is developed through international collaboration and investment, the influence of individual governments over decision-making related to the project (e.g., number of votes) should be proportional to each government's investment in the project.	3.5	Yes	3.7	Yes
Q15	If a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities is developed, participation should be optional—that is, sovereign states should be able to opt-in or opt-out.	3.0	No	4.1	Yes
Q16	There should be a universal minimum medical standard for screening, selection, training, and certification for all commercialized humans before space travel.	3.8	Yes	3.5	Yes
Q17	There should be a universal minimum training standard for screening, selection, training, and certification for all humans before commercialized space travel.	3.8	Yes	3.4	No

Item #	Item text	Mean for end-users (*n*=13)	Consensus reached?	Mean for policymakers (*n*=15)	Consensus reached?
Q18	At least while space travel is still in an early stage, there should be different screening, selection, training, and certification criteria based on the person's function in space, i.e., tourist, flight crew, employee, colonist, etc., and one of the primary purposes of such classification should be to assign individual responsibilities and/or assess fitness to fulfill them.	4.5	Yes	4.5	Yes
Q19	There should be different screening, selection, training, and certification criteria based on an individual's function in space, i.e., tourist, flight crew, employee, colonist, etc., even if the criteria are to some extent dependent on mission variables such as duration, distance, and the nature of the craft.	4.6	Yes	4.5	Yes
Q20	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such categorization should be to assess the individual's fitness for fulfilling any associated responsibilities.	4.5	Yes	3.8	Yes
Q21	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such classification should be to determine the individual's rights and/or their ability to waive their rights.	3.0	No	3.3	No
Q22	At least while space travel is still in its early stages (i.e., before it is developed to a level akin to commercial air travel), all spacecraft with 10 or more passengers onboard should be required to carry an onboard medical officer.	3.5	Yes	3.0	No
Q23	Spacecraft with human passengers should be required to carry an onboard medical officer when a planned space travel duration exceeds a defined time.	4.0	Yes	3.3	No
Q24	All spacecraft with any number of human passengers should only be required to carry a first aid kit as the minimum medical equipment needed for spaceflight certification.	3.2	No	3.3	No
Q25	All spacecraft with any number of passengers onboard should be at minimum required to have automatic fire suppression system(s).	4.3	Yes	4.0	Yes
Q26	Whenever feasible, all spacecraft should be segmented to allow containment of events such as fires, depressurization due to meteorite or debris collisions, or toxic spills.	4.1	Yes	4.0	Yes
Q27	Human error will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4.0	Yes	3.9	Yes

Item #	Item text	Mean for end-users (n=13)	Consensus reached?	Mean for policymakers (n=15)	Consensus reached?
Q28	Mechanical or systems failures will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4.5	Yes	4.1	Yes
Q29	Depressurization will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and or property loss.	3.7	Yes	3.8	Yes
Q30	Universal guidelines for passenger and crew requirements associated with long-endurance spaceflight (greater than thirty days in space) should be developed and accepted globally as a standard.	4.4	Yes	3.6	Yes
Q31	Guidelines for passenger and crew requirements for long-endurance spaceflight (greater than thirty days in space) should only be developed and accepted as a standard at the national or regional level.	3.1	No	2.7	No
Q32	Additional data about the effects of physical and psychological stressors on the general population are needed to determine whether and to what extent guidelines for passenger and crew requirements for long-endurance spaceflight should be developed.	3.7	Yes	3.7	Yes
Q33	One of the most significant disadvantages to developing a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that one-size-fits-all regulation would hamper meritocratic competition to an extent detrimental to the overall advancement of space travel and colonization.	3.2	No	3.6	Yes
Q34	One of the greatest barriers to the development of a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that nations will not be willing to relinquish sovereignty in their pursuit of space travel and colonization goals.	3.9	Yes	4.2	Yes
Q35	With the recent launch of Virgin Galactic and Blue Origin reaching different altitudes during their space flights, the argument of which crews actually or theoretically reached space presents more need to define the globally recognized requirement boundary for a defined entry into space?	3.7	Yes	3.1	No
Q36	It is feasible to define the space flight boundaries as quantified series of three zones instead of a singular line with separate governing rules, regulations, and requirements, which could ease the restrictions on suborbital and low Earth orbital flights.	4.1	Yes	3.7	Yes

Item #	Item text	Mean for end-users (*n*=13)	Consensus reached?	Mean for policymakers (*n*=15)	Consensus reached?
Q37	Space regulation and policy governance should continue solely under the United Nations and be perpetually known as the single regulatory entity responsible for Earth's space policy regulations and legislation matters?	2.2	No	2.7	No
Q38	It is ideal for keeping the global space governing regulation policymaking under the United Nations (UN) and expand global operational authority and responsibility under the International Civil Aviation Organization (ICAO) for all future space operations as it has done for global aviation. However, ICAO should remain unbiased and apolitical.	2.6	No	2.6	No
Q39	As a result of international space regulations, the International Civil Aviation Organization (IACO) name should be amended to the International Civil Aerospace Organization (ICAO) better to describe a possible overarching industry/community inclusion.	3.3	No	2.9	No
Q40	There should be a space tourism tax as part of space tourism, which all spacefaring nations within the United Nations pay to fund the ICAO commercial space office to develop, support, and sustain the infrastructure of commercialized human space safety.	3.2	No	2.9	No
Q41	The Artemis Accords should serve as the vessel that operationalizes the Outer Space Treaty (OST) of 1967 and allows space policy regulation to evolve and mature in today's modern era? This allows for universal cooperation from all participant nations to agree to work together for the better good of the peaceful use of space.	3.8	Yes	3.6	Yes
Q42	There is a need to create an International Space Academy to develop and train our next generation to ensure the highest level of success before any off-Earth colonization and/or longevity endurance space travel commences in the Cosmos.	4.2	Yes	3.2	No
Q43	A single universal entity infrastructure with overarching responsibility for all space emergencies and rescues should be developed to ensure the highest probability of survival to human life and recovery of property is assured.	3.7	Yes	2.7	No

Item #	Item text	Mean for end-users (*n*=13)	Consensus reached?	Mean for policymakers (*n*=15)	Consensus reached?
Q44	There is a need for a unified global space safety regulation that the global community uses as the universal standard regarding commercial crews, passengers, and vessels. This list would include but is not limited to the designated maximum allowable space flight times for awake duty cycles for crewmembers and non-crewmembers, sleeping accommodation requirements, spacecraft minimum equipment lists, radiation exposure monitoring standards, onboard medical care requirements, and emergency procedures/protocol for flight crews and ground support crews/staff.	4.2	Yes	3.3	No
Q45	If life support cannot be maintained and/or space flight cannot continue, there should be an escape craft capable of sustaining all onboard passengers' and their life support requirements to the intended point of destination, with maneuvering capabilities.	3.9	Yes	3.4	No
	n of items on which a consensus was reached (*N*=45):		35		23

Thus, when viewing the breakdown of responses between the End-users/Operators (End-users) and the Academic/Regulator/Policymakers (Policymakers) group, it is interesting to note that the End-users reached a consensus on 78% of the items while the Policymakers reached a consensus on 51% of the items. Given that a consensus was reached on more than half of the items among all 28 participants, and among the Policymaker group, and that the End-user group reached consensus on more than three-quarters of the items, a sufficient level of consensus has been achieved such that no further rounds of the study were conducted after the second round. Table 5 illustrates a hierarchical ranking of each item based on the level of consensus achieved.

Table 5

Level of Agreement with Individual Items in Descending Order

Item#	Question	Consensus Value	Was Consensus Met?
Q19	There should be different screening, selection, training, and certification criteria based on an individual's function in space (i.e., tourist, flight crew, employee, colonist, etc.), even if the criteria are to some extent dependent on mission variables such as duration, distance, and the nature of the craft.	4.6	Yes
Q18	At least while space travel is still in an early stage, there should be different screening, selection, training, and certification criteria based on the person's function in space (i.e., tourist, flight crew, employee, colonist, etc.); and one of the primary purposes of such classification should be to assign individual responsibilities and/or assess fitness to fulfill them.	4.5	Yes
Q28	Mechanical or systems failures would be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4.3	Yes
Q9	Regardless of feasibility or desirability, the safety of persons and preservation of life should be the highest priority in developing universal guidelines for space travel or colonization.	4.2	Yes
Q3	Developing an agency or clearinghouse for the standardization of certifications and technical requirements for space travel and colonization is desirable at present.	4.1	Yes
Q20	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist); and one of the purposes of such categorization should be to assess the individual's fitness for fulfilling any associated responsibilities.	4.1	Yes
Q25	All spacecraft with any number of passengers onboard should, at the minimum, be required to have automatic fire suppression system(s).	4.1	Yes
Q34	One of the greatest barriers to developing a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that nations will not be willing to relinquish sovereignty in their pursuit of space travel and colonization goals.	4.1	Yes
Q1	Developing universal global guidelines for space travel and colonization is desirable at present.	4	Yes
Q11	Regardless of the desirability of developing universal guidelines for space travel and or colonization as expressed by public (government) and private entities, existing guidelines from agencies such as the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), the Commercial Spaceflight Federation (CSF), and the International Association for the Advancement of Space Safety (IAASS), would provide the baseline for further guidelines to be developed.	4	Yes

Item#	Question	Consensus Value	Was Consensus Met?
Q26	Whenever feasible, all spacecraft should be segmented to allow containment of events such as fires, depressurization due to meteorite or debris collisions, or toxic spills.	4	Yes
Q27	Human error would be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4	Yes
Q30	Universal guidelines for passenger and crew requirements associated with long-endurance spaceflight (greater than thirty days in space) should be developed and accepted globally as a standard.	4	Yes
Q4	Developing an agency or clearinghouse for the standardization of ethical standards for space travel and colonization is desirable at present.	3.9	Yes
Q6	I do not believe that the development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at present. However, I believe that developing a regional agency of allied nations for standardizations of certifications and technical requirements is feasible.	3.9	Yes
Q36	It is feasible to define the space flight boundaries as quantified series of three zones instead of a singular line with separate governing rules, regulations, and requirements, which could ease the restrictions on suborbital and low Earth orbital flights.	3.9	Yes
Q13	Further investigation is needed to determine whether a single entity for global space safety would be optimal for promoting the advancement of space travel and colonization.	3.8	Yes
Q44	There is a need for a unified global space safety regulation that the global community uses as the universal standard regarding commercial crews, passengers, and vessels. This list would include but is not limited to the designated maximum allowable space flight times for awake duty cycles for crewmembers and non-crewmembers, sleeping accommodation requirements, spacecraft minimum equipment lists, radiation exposure monitoring standards, onboard medical care requirements, and emergency procedures/protocol for flight crews and ground support crews/staff.	3.8	Yes
Q29	Depressurization would be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and or property loss.	3.8	Yes
Q32	Additional data about the effects of physical and psychological stressors on the general population are needed to determine whether and to what extent guidelines for passenger and crew requirements for long-endurance spaceflight should be developed.	3.7	Yes

Item#	Question	Consensus Value	Was Consensus Met?
Q41	The Artemis Accords should serve as the vessel that operationalizes the Outer Space Treaty (OST) of 1967 and allows space policy regulation to evolve and mature in today's modern era? This allows for universal cooperation from all participant nations to agree to work together for the better and peaceful use of space.	3.7	Yes
Q14	If an infrastructure to develop a universal Emergency Space Response Management System (ESRMS) is developed through international collaboration and investment, the influence of individual governments over decision-making related to the project (e.g., number of votes) should be proportional to each government’s investment in the project.	3.6	Yes
Q15	If a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities is developed, participation should be optional—that is, sovereign states should be able to opt-in or opt-out.	3.6	Yes
Q16	There should be a universal minimum medical standard for screening, selection, training, and certification for all humans before commercialized space travel.	3.6	Yes
Q17	There should be a universal minimum training standard for screening, selection, training, and certification for all humans before commercialized space travel.	3.6	Yes
Q45	If life support cannot be maintained and/or space flight cannot continue, there should be an escape craft capable of sustaining all onboard passengers' and their life support requirements to the intended point of destination, with maneuvering capabilities.	3.6	Yes
Q23	Spacecraft with human passengers should be required to carry an onboard medical officer when a planned space travel duration exceeds a defined time.	3.6	Yes
Q42	There is a need to create an International Space Academy to develop and train our next generation to ensure the highest level of success before any off-Earth colonization and/or longevity endurance space travel commences in the Cosmos.	3.6	Yes
Q5	Developing an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at present.	3.4	No
Q10	Regardless of the desirability of developing a global agency or clearinghouse to standardize certifications and technical requirements, organizations such as the United Nations and/or ICAO provide a sufficient template for doing so.	3.4	No

Item#	Question	Consensus Value	Was Consensus Met?
Q33	One of the most significant disadvantages to developing a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that a one-size-fits-all regulation would hamper meritocratic competition to an extent detrimental to the overall advancement of space travel and colonization.	3.4	No
Q35	With the recent launch of Virgin Galactic and Blue Origin reaching different altitudes during their space flights, the argument about which crews actually or theoretically reached space presents more need to define the globally recognized requirement boundary for a defined entry into space.	3.4	No
Q2	Substantial development of universal global guidelines for space travel and colonization is feasible at present.	3.3	No
Q7	Substantial development or defining of a global agency or clearinghouse for the standardization of ethical standards for space travel and colonization is feasible at present.	3.3	No
Q24	All spacecraft with any number of human passengers should be required to carry a first aid kit as the minimum medical equipment needed for spaceflight certification.	3.3	No
Q22	At least, while space travel is still in its early stages (i.e., before it is developed to a level akin to commercial air travel), all spacecraft with 10 or more passengers on board should be required to carry an onboard medical officer.	3.2	No
Q21	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such classification should be to determine the individual's rights and/or their ability to waive their rights.	3.1	No
Q39	As a result of international space regulations, the name, International Civil Aviation Organization (IACO), should be amended to the International Civil Aerospace Organization (ICAO), to better describe a possible overarching industry/community inclusion.	3.1	No
Q43	A single universal entity infrastructure with overarching responsibility for all space emergencies and rescues should be developed to ensure that the highest probability of survival to human life and recovery of property is assured.	3.1	No
Q8	I do not believe that developing an agency or clearinghouse for the global standardization of ethical standards for space travel and colonization is feasible at present. However, I believe that developing a regional agency of allied nations for standardizations of ethical standards is feasible.	3	No

Item#	Question	Consensus Value	Was Consensus Met?
Q40	There should be a space tourism tax as part of space tourism, and all spacefaring nations within the United Nations should pay to fund the ICAO commercial space office to develop, support, and sustain the infrastructure of commercialized human space safety.	3	No
Q31	Guidelines for passenger and crew requirements for long-endurance spaceflight (greater than thirty days in space) should only be developed and accepted as a standard at the national or regional level.	2.9	No
Q12	Multiple, independently functioning, worldwide national space agencies and private commercial space entities, each with their own governing laws, policies, and procedures, would be more effective in promoting the advancement of space travel and colonization than a single, global agency or clearinghouse.	2.8	No
Q38	It is ideal to keep the global space governing regulation policymaking under the United Nations (UN) and expand global operational authority and responsibility under the International Civil Aviation Organization (ICAO) for all future space operations, as it has done for global aviation. However, ICAO should remain unbiased and apolitical.	2.6	No
Q37	Space regulation and policy governance should continue solely under the United Nations and be perpetually known as the single regulatory entity responsible for Earth's space policy regulations and legislation matters.	2.5	No
	n of items on which a consensus was reached (*N*=45):		28

End-User Operator to Regulators Disparity Conclusion

Table 6 shows the categorized hierarchy order of precedence, from the highest to the lowest (top to bottom) numerical values. This table is based on the survey population's consensus from the second round of the Delphi study and shows the End-user Operators (EOU) to Academic/Regulators/Policymakers disparity ("Regulators" for simplicity of the Table 6 readability and reference purposes). The closer the disparity is to zero would mean that the more equal a consensus occurred. The numerical value further away from zero up to a maximum of plus (+) or minus (-) one reflects the most significant numerical disparity between the EOU and Regulators. It is essential to note that the positive and negative one would effectively be the same disparity order of difference from 0 and considered the same numerical position of disparity disagreement for ordering measurements. However, the numerical values are on opposite sides of the range spectrum. Effectively any plus or minus numerical value also follows this same principle herein. The table also has a specific column that identifies if a mutual EOU to Regulator consensus was reached and is labeled; "Was Mutual Consensus Met."

Conclusively, out of the 45 questions surveyed in round two of the Delphi study, questions 8, 13, and 15 had the most significant numerical value of disparity between EOU and Regulators, which did not reach consensus individually.

Conclusively, out of the 45 questions surveyed in round two of the Delphi study, questions 18, 32, and 38 were the only three questions that reached consensus and indicated a zero value with no reflected disparity between EOU and Regulators.

Conclusively, out of the 45 questions surveyed in round two of the Delphi study, questions 12, and 24 were the only two questions that nearly reached consensus but fell short and showed 0.1. Still, it is important to note that both parties mutually agreed that the consensus for

the answer for both questions was "No." The only other questions that occurred throughout the study were 21, 31, 37, 39, and 40.

Table 6

Categorization of the Hierarchy of Precedence

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q8	I do not believe that the development of an agency or clearinghouse for the global standardization of ethical standards for space travel and colonization is feasible at the present time. However, I believe that the development of a regional agency of allied nations for standardizations of ethical standards is feasible.	3.6	Yes	2.5	No	1.1	No	
Q13	Further investigation is needed to determine whether a single entity for global space safety would be optimal for promoting the advancement of space travel and colonization.	4.4	Yes	3.3	No	1.1	No	
Q15	If a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities is developed, participation should be optional—that is, sovereign states should be able to opt-in or opt-out.	3	No	4.1	Yes	-1.1	No	
Q42	There is a need to create an International Space Academy to develop and train our next generation to ensure the highest level of success before any off-Earth colonization and/or longevity endurance space travel commences in the Cosmos.	4.2	Yes	3.2	No	1	No	
Q43	A single universal entity infrastructure with overarching responsibility for all space emergencies and rescues should be developed to ensure the highest probability of survival to human life and recovery of property is assured.	3.7	Yes	2.7	No	1	No	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q44	There is a need for a unified global space safety regulation that the global community uses as the universal standard regarding commercial crews, passengers, and vessels. This list would include but is not limited to the designated maximum allowable space flight times for awake duty cycles for crewmembers and non-crewmembers, sleeping accommodation requirements, spacecraft minimum equipment lists, radiation exposure monitoring standards, onboard medical care requirements, and emergency procedures/protocol for flight crews and ground support crews/staff.	4.2	Yes	3.3	No	0.9	No	
Q1	The development of universal global guidelines for space travel and colonization is desirable at the present time.	4.4	Yes	3.6	Yes	0.8	Yes	
Q2	Substantial development of universal global guidelines for space travel and colonization is feasible at the present time.	3.7	Yes	2.9	No	0.8	No	
Q30	Universal guidelines for passenger and crew requirements associated with long-endurance spaceflight (greater than thirty days in space) should be developed and accepted globally as a standard.	4.4	Yes	3.6	Yes	0.8	Yes	
Q20	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such categorization should be to assess the individual's fitness for fulfilling any associated responsibilities.	4.5	Yes	3.8	Yes	0.7	Yes	
Q23	Spacecraft with human passengers should be required to carry an onboard medical officer when a planned space travel duration exceeds a defined time.	4	Yes	3.3	No	0.7	No	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q6	I do not believe that the development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at the present time. However, I believe that the development of a regional agency of allied nations for standardizations of certifications and technical requirements is feasible.	4.2	Yes	3.6	Yes	0.6	Yes	
Q35	With the recent launch of Virgin Galactic and Blue Origin reaching different altitudes during their space flights, the argument of which crews actually or theoretically reached space presents more need to define the globally recognized requirement boundary for a defined entry into space?	3.7	Yes	3.1	No	0.6	No	
Q3	The development of an agency or clearinghouse for the standardization of certifications and technical requirements for space travel and colonization is desirable at the present time.	4.4	Yes	3.9	Yes	0.5	Yes	
Q10	Regardless of the desirability of developing a global agency or clearinghouse for the standardization of certifications and technical requirements, organizations such as the United Nations and/or ICAO provide a sufficient template for doing so.	3.6	Yes	3.1	No	0.5	No	
Q22	At least while space travel is still in its early stages (i.e., before it is developed to a level akin to commercial air travel), all spacecraft with 10 or more passengers onboard should be required to carry an onboard medical officer.	3.5	Yes	3	No	0.5	No	
Q45	If life support cannot be maintained and/or space flight cannot continue, there should be an escape craft capable of sustaining all onboard passengers' and their life support requirements to the intended point of destination, with maneuvering capabilities.	3.9	Yes	3.4	No	0.5	No	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q37	Space regulation and policy governance should continue solely under the United Nations and be perpetually known as the single regulatory entity responsible for Earth's space policy regulations and legislation matters?	2.2	No	2.7	No	-0.5	No	But it was mutually agreed upon that it was NO from both sides
Q5	The development of an agency or clearinghouse for the global standardization of certifications and technical requirements for space travel and colonization is feasible at the present time.	3.6	Yes	3.2	No	0.4	No	
Q7	Substantial development or defining of a global agency or clearinghouse for the standardization of ethical standards for space travel and colonization is feasible at the present time.	3.5	Yes	3.1	No	0.4	No	
Q17	There should be a universal minimum training standard for screening, selection, training, and certification for all humans before commercialized space travel.	3.8	Yes	3.4	No	0.4	No	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q31	Guidelines for passenger and crew requirements for long-endurance spaceflight (greater than thirty days in space) should only be developed and accepted as a standard at the national or regional level.	3.1	No	2.7	No	0.4	No	But it was mutually agreed upon that it was NO from both sides!
Q28	Mechanical or systems failures will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4.5	Yes	4.1	Yes	0.4	Yes	
Q36	It is feasible to define the space flight boundaries as quantified series of three zones instead of a singular line with separate governing rules, regulations, and requirements, which could ease the restrictions on suborbital and low Earth orbital flights.	4.1	Yes	3.7	Yes	0.4	Yes	
Q39	As a result of international space regulations, the International Civil Aviation Organization (IACO) name should be amended to the International Civil Aerospace Organization (ICAO) better to describe a possible overarching industry/community inclusion.	3.3	No	2.9	No	0.4	No	But it was mutually agreed upon that it was NO from both sides!
Q33	One of the most significant disadvantages to developing a	3.2	No	3.6	Yes	-0.4	No	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
	single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that one-size-fits-all regulation would hamper meritocratic competition to an extent detrimental to the overall advancement of space travel and colonization.							
Q11	Regardless of the desirability of developing universal guidelines for space travel and or colonization as expressed by public (government) and private entities, existing guidelines from agencies such as the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), the Commercial Spaceflight Federation (CSF), and the International Association for the Advancement of Space Safety (IAASS), would provide the baseline for further guidelines to be developed.	4.2	Yes	3.9	Yes	0.3	Yes	
Q16	There should be a universal minimum medical standard for screening, selection, training, and certification for all commercialized humans before space travel.	3.8	Yes	3.5	Yes	0.3	Yes	
Q25	All spacecraft with any number of passengers onboard should be at minimum required to have automatic fire suppression system(s).	4.3	Yes	4	Yes	0.3	Yes	
Q40	There should be a space tourism tax as part of space tourism,	3.2	No	2.9	No	0.3	No	But it

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
	which all spacefaring nations within the United Nations pay to fund the ICAO commercial space office to develop, support, and sustain the infrastructure of commercialized human space safety.							was mutual ly agreed upon that it was NO from both sides!
Q21	Space entry for all commercialized travelers should be specifically categorized (e.g., flight crew, tourist, or colonist), and one of the purposes of such classification should be to determine the individual's rights and/or their ability to waive their rights.	3	No	3.3	No	-0.3	No	But it was mutual ly agreed upon that it was NO from both sides!
Q34	One of the greatest barriers to the development of a single agency or clearinghouse for the standardization of certifications, technical requirements, and ethical standards is that nations will not be willing to relinquish sovereignty in their pursuit of space travel and colonization goals.	3.9	Yes	4.2	Yes	-0.3	Yes	
Q4	The development of an agency or clearinghouse for the standardization of ethical standards for space travel and colonization is desirable at the present time.	4	Yes	3.8	Yes	0.2	Yes	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q9	Regardless of feasibility or desirability, the safety of persons and preservation of life should be the highest priority in developing universal guidelines for space travel or colonization.	4.3	Yes	4.1	Yes	0.2	Yes	
Q41	The Artemis Accords should serve as the vessel that operationalizes the Outer Space Treaty (OST) of 1967 and allows space policy regulation to evolve and mature in today's modern era? This allows for universal cooperation from all participant nations to agree to work together for the better good of the peaceful use of space.	3.8	Yes	3.6	Yes	0.2	Yes	
Q14	If an infrastructure to develop a universal Emergency Space Response Management System (ESRMS) is developed through international collaboration and investment, the influence of individual governments over decision-making related to the project (e.g., number of votes) should be proportional to each government's investment in the project.	3.5	Yes	3.7	Yes	-0.2	Yes	
Q19	There should be different screening, selection, training, and certification criteria based on an individual's function in space, i.e., tourist, flight crew, employee, colonist, etc., even if the criteria are to some extent dependent on mission variables such as duration, distance, and the nature of the craft.	4.6	Yes	4.5	Yes	0.1	Yes	
Q26	Whenever feasible, all spacecraft should be segmented to allow containment of events such as fires, depressurization due to meteorite or debris collisions, or toxic spills.	4.1	Yes	4	Yes	0.1	Yes	
Q27	Human error will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and/or property loss.	4	Yes	3.9	Yes	0.1	Yes	

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q29	Depressurization will be among the top three causes of onboard accidents in spacecraft and off-Earth accidents resulting in death and or property loss.	3.7	Yes	3.8	Yes	-0.1	Yes	
Q24	All spacecraft with any number of human passengers should only be required to carry a first aid kit as the minimum medical equipment needed for spaceflight certification.	3.2	No	3.3	No	-0.1	No	But it was mutually agreed upon that it was NO from both sides!
Q12	Multiple, independently functioning, worldwide national space agencies and private commercial space entities, each with their own governing laws, policies, and procedures, would be more effective in promoting the advancement of space travel and colonization than a single, global agency or clearinghouse.	2.8	No	2.9	No	-0.1	No	But it was mutually agreed upon that it was NO from both sides!

Item#	Question	EUO Survey Consensus Numerical Value	EUO Consensus Met	Regulator Survey Consensus Numerical Value	Regulator Consensus Met	Disparity Numerical Value Between EUO and Regulators	Was Mutual Consensus Met?	Notes
Q18	At least while space travel is still in an early stage, there should be different screening, selection, training, and certification criteria based on the person's function in space, i.e., tourist, flight crew, employee, colonist, etc., and one of the primary purposes of such classification should be to assign individual responsibilities and/or assess fitness to fulfill them.	4.5	Yes	4.5	Yes	0	Important to note that this was agreed upon, and the consensus was met	
Q32	Additional data about the effects of physical and psychological stressors on the general population are needed to determine whether and to what extent guidelines for passenger and crew requirements for long-endurance spaceflight should be developed.	3.7	Yes	3.7	Yes	0	Important to note that this was agreed upon, and the consensus was met	
Q38	It is ideal for keeping the global space governing regulation policymaking under the United Nations (UN) and expand global operational authority and responsibility under the International Civil Aviation Organization (ICAO) for all future space operations as it has done for global aviation. However, ICAO should remain unbiased and apolitical.	2.6	No	2.6	No	0	It is important to note that this was agreed upon, but the consensus was NOT met!	
	n of items on which a consensus was reached (*N*=45):		35		23			

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This chapter contains an elaboration on the nature and significance of the findings. An interpretation of these findings and a comparison with literature presented in chapter two is presented first. Recommendations that can be made and implications of these findings for research, practice, and social change, are then discussed. This chapter concludes with a summary and outline of key points that the average reader can easily understand in a less academic tone.

Purpose of the Study

The purpose of this Delphi study was to investigate international experts' thoughts regarding the need to establish and prioritize a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. Due to the lack of global international standards and commercialized human space travel guidelines, the research sought to explore the need for a single global agency's development that would establish guidelines and act as a clearinghouse for the certifications, requirements, and ethical standards for space travel and colonization by both government and private entities. The study included the prioritization of issues relevant to establishing guidelines to regulate commercialized human space travel and colonization.

Global governance theory and public space governance were used to guide this study. The research study included 29 global expert participants who were from 10 different nations. The participants included international experts that possessed knowledge and experience about aerospace and space through their experience in the space profession. The following areas of expertise included: astronauts, astronaut safety managers, aerospace medical doctors/officers, aerospace physiologists, aerospace safety engineers, chief aerospace/space executives, aerospace academia, aerospace training specialists, aerospace research scientist/analysts/experts, aerospace mechanics, aerospace program/project managers, aerospace manufacturers, aerospace communication operators, aerospace engineers, aerospace defense personnel, aerospace integration/interoperability engineers, systems engineers, airline industry experts, aerospace tourism industry experts, aircraft crash/accident survivors, commercial and military pilots, commercial and military test pilots, intelligence analysts within the space arena, inspections/investigation experts, space journalist, space operations, spacecraft propulsion/launch vehicle engineers, deep space experts, as well as space law and policy experts.

Interpretation of the Findings

Question 19 had the highest consensus on the necessity for different screening, selection, training, and certification criteria based on an individual's function in space, illustrating the importance experts placed on these issues. Conversely, question 37, on space regulation and policy governance under the United Nations, had the lowest consensus. This discrepancy reflects the value that experts place on training, but also the necessity for international distinctions and heterogeneous training to impact how training is implemented and regulated. With respect to safety, experts most highly valued those factors which influenced loss of life or property. For example, a high level of consensus was found in regard to the likelihood of mechanical systems

failures being among the top three causes of accidents.

Additionally, there was a high level of agreement regarding human error and depressurization causing loss of lives and onboard accidents. This section includes a discussion of the common themes that emerged from the data. Responses to the first item pertaining to priorities for development yielded qualitative data in which common themes were identified. In analyzing the responses to the first questionnaire item, similar responses were grouped to form the themes. The most frequently referenced theme under this questionnaire item was *safety*, with all participants referencing this topic. Safety was the only theme on which a significant consensus emerged. Only two other themes, development and profit, and environmental impacts, were the only two with attestation from more than 33% of participants. As shown in chapter two, safety was also found to be a theme mentioned by the ICAO (2020) in its strategic objectives. These existed along with capacity and efficiency, security and facilitation, economic development, and environmental protection. It is evident that these themes align with those presented in previous research.

These themes (Hassan et al., 2000) also reflect an emphasis on development and environmental impacts that support the literature presented in chapter two. In addition to bilateral agreements, the implications for the International Space Station (ISS) development as an international science and engineering project for cooperation in space must be considered (NASA, 2018). The IGA established a cooperative framework and established criminal jurisdiction in outer space (NASA, 2018). Unlike the UN agencies for outer space, the focus of IADC is on space debris and centers on the environment, protection, and mitigation, rather than on maintaining peace in outer space (Stapleton et al., 2017). States Parties to the Treaty shall avoid their harmful contamination and also adverse changes in the environment resulting from

the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, that would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies (UNOST 1967, 2019; UNOOSA, n.d.). Additionally, the Artemis Accords describe a shared vision for principles, grounded in the Outer Space Treaty of 1967, to create a safe and transparent environment which facilitates exploration, science, and commercial activities for all of humanity to enjoy (NASA, n.d.).

Two main themes emerged when similar responses to the second item pertaining to the development of an agency or clearinghouse were grouped. First, 20 out of 29 participants (69%) answered affirmatively, stating that the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities. Second, nine out of 29 participants (31%) answered negatively, expressing the perception that the development of such an agency was not feasible. The United States, 14 Code of Federal Regulations (CFR) Chapter III – Commercial Space Transportation, Federal Aviation Administration, Department of Transportation (DOT), explains that the U.S. regulates human spaceflight.

The problem is that because there is no commercial space transportation, passenger certification requirements, lawmakers have mandated that the DOT, through the FAA, via the commercial space transportation entity, at the discretion of the passenger willing to travel into space, sign a space flight participant waiver of claims against the U.S. Government (Sagath et al., 2018). Therefore, the Artemis Accords are essential in understanding the potential regulation of human spaceflight in the future. As shown in this review of relevant literature, the existing space

policies and agencies are reflective of the interest to prevent the misuse of space in terms of militarization and colonization (Durkee, 2019). Agencies such as COPUOS exist to maintain peace within outer space and are based on national space agencies' membership and coordination (UNOOSA, n.d.).

The problem with existing agencies and policies for outer space is that the race to space, including space travel and colonization, includes both government and commercial actors (Durkee, 2019; Steer, 2020). Prior to this study, there was a lack of a central agency to govern both commercial and government actors on an international level (Patton, 2015; Powell, 2019). This study illustrates current concerns associated with the feasibility of establishing and prioritizing a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized human space travel and colonization between global governments and private entities.

A total of 27 of the participants responded to the third item pertaining to practical solutions to the development of an agency or clearinghouse. No consensus of 70% or greater emerged in relation to this question. Nine out of 27 participants (33%) responded in accordance with their previous responses that the development of an agency was unfeasible and undesirable, such that they regarded the question of practical solutions as moot. The remaining 18 participants (67%) indicated that the development of a single agency or clearinghouse was feasible, and their responses regarding practical solutions fell into two broad themes. According to Fioretos & Tallberg (2020) global governance theory was also determined to be appropriate for this study, as it included considerations regarding the legitimacy of the authority of global governance institutions. In this study, the feasibility of and the priorities pertaining to the development of an agency for the development of guidelines and regulations for space travel and or colonization

was explored. Global governance theory is key in terms of establishing a global institution with the authority to develop such guidelines and regulations in space (Kminek et al., 2017; Mendenhall, 2018).

A total of 28 participants (100%) responded to the fourth item pertaining to having multiple independently functioning worldwide national space agencies and private commercial space entities. Grouping similar responses to this item resulted in the identification of two themes. No consensus of 70% or greater was established. Instead, participants were evenly divided between those who considered independent functioning of multiple national space agencies worldwide as likely to be problematic and those who did not believe it would be problematic because the alternative of a single agency would be less desirable. The creation of NASA was geared toward helping the country to explore space and compete effectively with the Soviet Union. According to Mieczkowski (2013) the creation of this space agency is perceived as the product of successful cooperation and planning between the administration of President Eisenhower and eminent scientists. Despite multiple international agencies, treaties, and agreements, there remains a lack of clarity in space governance (Jakhu, 2006; Maday, 2020; Vasiliey, 2008). As evident thus far, many of the existing policies pertaining to outer space focus on maintaining peace by preventing weaponization and militarization.

Grouping of similar responses to the fifth item pertaining to the need to investigate the requirement for a single entity for global space safety indicated a consensus among participants that the answer was negative; there is no need to investigate the requirement for a single entity for global space safety. Participants' reasons for this perception were sorted into three thematic categories. It should be noted that for this question, some participants referenced more than one theme, bringing the total number of theme references to 32 (119%), or four more than the total

number of participants. Issues with safety present conflicts between national and commercial space policy, as indicated in chapter two. Current requirements include (a) meeting flight crew regulation under Title 14 of the Code of Federal Regulations (14 CFR) part 460; (b) flight beyond 50 statute miles above the surface of the Earth; and (c) demonstrating that the activities conducted during flight were essential for public safety or human space flight safety (Federal Aviation Administration, 2021). The extent to which these trends reflect contemporary needs requires future research. There is also the need to abide by the principles of due regard and utilize safety zones, where a nation is responsible for public notification of where they are operating and coordinating with any affected party to avoid harmful interference as required by the OST (Galts, 2017; NASA Artemis Accords, 2020).

Grouping similar items indicated a lack of substantial consensus in relation to the sixth item pertaining to the needs in developing a global/universal commercial space transportation guideline. The most significant theme to emerge indicated that there were no needs because the development indicated by the item was already occurring, with any remaining development likely to transpire naturally as a consequence of current, ongoing activities. Thirteen participants (48%) were not sufficient to identify a consensus, the standard for which was stated as 70%. The remaining 15 participants (54%) who responded to this item provided unique answers in which no common themes were identified. Sample responses indicated needs such as global safety guidelines, an unspecified international consensus, a consensus among subscribing partners, interoperability and compatibility of docking mechanisms, flight safety protocols, accountability to all states, standardized measures such as the Universal Docking Mechanism, more data regarding the effects of space travel on human beings, the prioritization of life preservation, and transparency. Consensus regarding aspects of space travel has been achieved in the past, such as

in the case of the astronaut rescue agreement of 1968. The Astronaut Rescue Agreement was presented by UNOOSA as follows: “The Rescue Agreement was considered and negotiated by the Legal Subcommittee from 1962 to 1967. Consensus agreement was reached in the General Assembly in 1967 (resolution 2345 [XXII]), and the Agreement entered into force in December 1968” (UNOOSA, n.d., para. 1). The astronaut rescue agreement was entered into force based on the agreement of member States (Dolado-Perez et al., 2015).

Clustering similar responses to the seventh item pertaining to whether or not there is a need to investigate the requirement for the need for an infrastructure to develop an ESRMS resulted in the identification of two major themes. A consensus was identified in relation to the first theme, in which 20 out of 28 participants (71%) indicated that the need existed. Of the 27 respondents who provided an answer to the eight items pertaining to the need to explore the feasibility of establishing and prioritizing a guideline for the development of an agency or clearinghouse, 17 (61%) indicated that a need for the exploration existed, and 10 (37%) indicated that a need for the exploration did not exist. The number of affirmative responses, equivalent to 67%, fell short by one participant of the 70% guideline for identifying a consensus in the expert panel. Despite multiple international agencies, treaties, and agreements, there remains a lack of clarity in space governance (Cheney et al., 2020). Ferreira-Snyman (2015) highlighted the potential ways forward regarding international governance of outer space. Despite the emphasis on preventing the militarization of outer space, other factors, such as protecting individuals from the negative health impacts and the dangers of space, have been less explored. As shown in this study and the evidence presented in chapter two, the existing space policies and agencies are reflective of the interest to prevent the misuse of space in terms of militarization and colonization (Durkee, 2019). The following section contains a discussion of limitations that may have

influenced these results.

Recommendations

Results from this study illustrate the level of consensus regarding the necessity for standardized certifications and guidelines related to space travel. One potential direction for future research is to identify key areas of existing guidance that are agreed upon and which must be retained when drafting future standards for space travel. Some topics of interest that could be explored are safety concerns regarding human and spacecraft design, certification, training, and qualification approval, especially in interoperability and integration. Furthermore, environmental protection mitigation protocols and procedures on Earth and off-Earth would also be beneficial research opportunities to explore. Finally, debris mitigation, onboard early warning detection, and avoidance, and possibly elimination capabilities would also be feasible areas of interest to explore.

Additionally, the application of these policies to practice is necessary in order to gain an understanding of how they influence operational conduct within the aerospace industry and to resolve any discrepancies or gaps that are identified. Furthermore, efforts are needed to improve the generalizability of these findings to broader settings and contexts. A large, quantitative survey that contains items based on the themes of this research can be presented to a much broader sample of experts in the aerospace industry in order to determine the extent to which they can, and should, be applied to practice. Cross-cultural and transnational comparisons of expert insight into the requirements for standardization of policies and guidelines for space travel also represent another logical extension of this research.

Implications

The findings of this research can potentially impact future global/universal policy

regarding space safety operation matters for placing humans in space. The information obtained by this research may help facilitate further discussion and implement change within the global commercial and government space transportation industries. The study findings may be used to inform industry decision-makers about identified safety concerns and strategies regarding human and spacecraft certification and qualification approval before any human or spacecraft is allowed into space.

Findings from this study capture the global aerospace and space professional community's consensus, which may lead towards developing a possible single global agency or clearinghouse guideline to standardize certifications, requirements, and ethical standards for space travel and colonization between governments and private entities. Additionally, results from this study are among the first investigations of the aerospace and space community's consensus, which may lead to enhanced, more regulated commercial spacecraft safety design and certification standards and routine maintenance inspection requirements under one governing global policy doctrine that allows for better overarching integration and interoperability. A single controlling entity/agency with a single set of universal operating policies and procedures could possibly enhance safety and establish a baseline of safety as humans begin to populate and expand deeper into space.

This research is valuable for the safety of commercial human space travel, exploration, and colonization of space. It aimed to qualify and quantify the global community of space professionals' expertise regarding enhancing the future of safety in commercialized human space travel and colonization. It provided thoughtful insight from aerospace and space professionals' regarding establishing better policies that foster ethical and safer operations regarding humans in space. As a final product of this research, the researcher aims to disseminate the evidence by publishing the findings' entirety and gaining a peer review. By employing peer review and dissemination through the space professional and space policy industry, the dissertation aims to

strengthen the industry through diplomacy. The data herein are intended to foster dialogue that will build partnership capacities globally, allow for deep thought, expanded discussion, and hopefully lead to new enhanced, safer international legislation and policy that will better allow future space travel and colonization to endure and thrive.

This research also intends to build the case to develop standardized Operational Risk Management (ORM) mitigation safeguards within a global/universal Space Traffic Management (STM) critical infrastructure system to ensure humans perpetually endure and thrive in space. Finally, this research sought to bring awareness to the necessity for a fundamental conceptual understanding that commercial space transportation should be globally tied to one overarching critical end-to-end space-systems safety infrastructure. The overarching system must be continuously assessed, and risk mitigated with well-defined ORM logic tools governing a singular controlling policy.

Conclusion

What did the Research Study Find?

The FAA states that to become an astronaut, a person flying into space must also serve a purpose that enhances the science of space safety. Additionally, signing the FAA waiver of liability for space flight participants is not a safety mechanism but only a legal document that prevents a party from suing the U.S. government when a tragedy occurs. This is not a safety policy nor enhances spaceflight or promotes the preservation of life or property. Therefore, standards should be developed through entities who have experience creating specific guidelines and policies for spaceflight safety regulations so that the global community can safely function and integrate and interoperate. Agencies such as the Commercial Spaceflight Federation (CSF), the International Association for the Advancement of Space Safety (IAASS), and ASTM

International, formerly known as the American Society for Testing and Materials, could be good entities to begin this endeavor. Using NASA Private Astronaut standards NASA 3001 for training and certification for private crews and passengers could serve as a baseline reference for other spacefaring nations and private entities to begin their safe journey to space. Safety programs could then be expanded upon while developing better policies and procedures and adopting lessons learned to enhance their proprietary space safety requirements that serve value and purpose to improve safety, preserve life, property, and safeguard security measures.

Conclusions of the Significant Findings

1. A standardized global Space Safety Risk-Based Management System, which all nations could choose to adopt, should be developed to preserve life ultimately.
2. Spacecraft design and certification should improve lifesaving standards to include escape craft in case of emergencies.
3. As part of the spacecraft design and certification process, whenever feasible, all spacecraft should be segmented to allow containment of events such as fires, depressurization due to meteorite or debris collisions, or toxic spills.
4. Environmental impacts should be prioritized, particularly regarding the mitigation of debris and planetary protection standards.
5. There is a need to develop a clearinghouse to standardize certifications, requirements, and ethical standards for space travel and colonization between governments and private entities.
6. A clearinghouse should prioritize protecting life and move toward establishing international standards related to all aspects of safety to include but are not limited to the following: space law, policy, and procedures, operations, interagency relations,

licensing, monitoring, enforcement, interdiction, training, testing/evaluation, and certification. Other issues that need to be included are detection of space accidents, space rescues, insurance and bond requirements, space traffic management, security to avoid hostile utilization of space, standardized testing, and intellectual property protection.

    a. More research is needed on developing a clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities.

7. Space Traffic Management (STM) is important and needs to be better managed and/or coordinated globally and regulated within a standardized global policy and possibly a single entity.
8. Having global standardization safety guidelines as a reference is necessary to ensure consensus and confidence for acceptable risks within the global space industry would serve a beneficial purpose. The global community could adopt a set of safety standards as a minimum set of safety requirements.
9. Working towards integration and interoperability amongst other spacefaring nations and sharing best business practices is beneficial.
10. There is no need to investigate the requirement for a single entity for global space safety due to various international trust, sovereignty, and other factors being accomplished. Particularly in the United States, the Commercial Spaceflight Federation (CSF) is the leading voice for the commercial spaceflight industry.
11. Regarding global safety guidelines, there should be standardized interoperability and compatibility of docking mechanisms, flight safety protocols, accountability to all

states, more data regarding the effects of space travel on human beings, and transparency that ultimately prioritizes the preservation of life.

12. There is a need to investigate the requirement for infrastructure to develop a universal Emergency Space Response Management System (ESRMS), which is necessary to protect life and property. This entity will render aid in the rescue of life and property when a distressed spacecraft occurs.
    a. It was identified that the infrastructure to develop a universal Emergency Space Response Management System (ESRMS) is developed through international collaboration and investment, that the influence of individual governments over decision-making related to the project (e.g., number of votes) should be proportional to each government's investment in the project.
13. Spacecraft certification should require including having repair capabilities onboard, with defined written emergency procedures that would indicate the proper course of action and include redundant systems to mitigate the loss of life or property due to a mechanical or system failure, and effectively disabling the vehicle in space.
14. Space crew certification should require using only experienced, trained, and certified pilots and crews to respond to normal and non-normal procedures.
15. As the space infrastructure network is developed, it would be beneficial to have space hubs or space stations where repairs could be performed, and commercial entities should be responsible for their repairs.
16. A standardized safety-centered maintenance program should be developed with well-defined practices and procedures that should require all tangible maintenance actions,

related parts, and the supply chain to be globally interoperable and integrated and follow one set of minimum standards.

17. There need to be better spacecraft design certification standards and protection mechanisms to prevent MMOD so that nothing penetrates the ship's hull. Additionally, there need to be better radiation protection safeguards in place during the spacecraft design certification process.
18. Advanced early-warning detection and avoidance technologies with maneuvering systems capabilities should be developed and integrated on spacecraft so that the spacecraft has advanced notice of all space debris and can avoid collision early on.
19. Defined PPE and HAZMAT standardization requirements need to be further researched for both crew and commercial passengers for various types of spaceflight duration, i.e., what type of PPE and or HAZMAT should be required on the spacecraft for a certain number of passengers for a certain duration?
20. Before space travel, there should be a universal minimum standard for screening, selection, training, and certification for all commercialized humans.
21. There should be different screening, selection, training, and certification criteria based on the person's function in space, i.e., tourist, flight crew, employee, colonist, etc.
    a. Space entry for all commercialized travelers should be specifically categorized, i.e., tourist, an employee with defined role and responsibility, flight crew, colonist (Lunar or Deep Space, i.e., Mars "longevity trip"), etc.

22. Spacecraft with human passengers should be required to carry an onboard medical officer when a planned space travel duration exceeds a defined time, but that defined time needs to be further delineated via more research.
    a. More research needs to occur regarding whether spacecraft with a certain number of passengers onboard should carry an onboard medical officer and what number of crew and passengers and flight time duration dictate when a medical officer should be placed onboard.
23. The Commercial Spaceflight Federation (CSF), and the International Association for the Advancement of Space Safety (IAASS), would be two entities to help provide universal guidelines for space travel and/or colonization for future guideline development.
24. Universal guidelines for passenger and crew requirements associated with long-endurance spaceflight (greater than thirty days in space) should be developed and accepted globally as a standard.
25. It is desirable to develop an agency or clearinghouse for the standardization of ethical standards for space travel and colonization.
26. It is feasible to define the space flight boundaries as quantified series of three zones instead of a singular line with separate governing rules, regulations, and requirements, which could ease the restrictions on suborbital and low Earth orbital flights.
27. Further investigation is needed to determine whether a single entity for global space safety would be optimal for promoting space travel and colonization advancement.
28. There is a need for a unified global space safety regulation that the global community uses as the universal standard regarding commercial crews, passengers, and vessels.

This list would include but is not limited to the designated maximum allowable space flight times for awake duty cycles for crewmembers and non-crewmembers, sleeping accommodation requirements, spacecraft minimum equipment lists, radiation exposure monitoring standards, onboard medical care requirements, and emergency procedures/protocol for flight crews and ground support crews/staff.

29. Additional data about the effects of physical and psychological stressors on the general population are needed to determine whether and to what extent guidelines for passenger and crew requirements for long-endurance spaceflight should be developed.
30. The Artemis Accords should serve as the vessel that operationalizes the Outer Space Treaty (OST) of 1967 and allows space policy regulation to evolve and mature in today's modern era? This will allow for universal cooperation from all participant nations to agree to work together for the better and peaceful use of space.
31. If life support cannot be maintained and/or space flight cannot continue, there should be an escape craft capable of sustaining all onboard passengers' and their life support requirements to the intended point of destination, with maneuvering capabilities.
32. There is a need to create an International Space Academy to develop and train our next generation to ensure the highest level of success before any off-Earth colonization and/or longevity endurance space travel commences in the Cosmos.
33. The top three things that may lead to an onboard accident in spacecraft resulting in death and or property loss in hierarchical descending order (as per research findings consensus) are as follows:

    1) Mechanical or systems failures

2) Human error

3) Depressurization

Importance of this Research

The importance of this research study is that ultimately it identifies areas that future researchers can use for topics of discussion to investigate international experts' thoughts regarding the need to establish and prioritize a guideline for the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. Additionally, it captures a global consensus on many spaces safety concerns regarding human passengers, interoperability, integration, globalism in space theory for future policy doctrine application. This study can serve as a minimum reference baseline as an initial international study regarding the integration and interoperability for commercialized human space safety programmatic and/or policy standardization at the national and/or international levels.

Recommendations for Further Research

More research needs to occur regarding the global unification of the Artemis Accords and the upcoming Lunar Mission and beyond. Specifically, areas of global partnership regarding policy integration, interoperability, and safety should be explored. What is the feasibility of the unification for the partner nations' possible success and why other nations are not partnering, like China and Russia, and what does that mean? Research could include China's and Russia's partnership for their independent space stations, their mutual future lunar base, and their geopolitically and militarily impacts regarding cosmological allegiances. The global community must work to achieve diplomatic resolutions that enhance the overarching efficacy of space safety from an end-to-end, systematic, and logical approach. Though there may be disagreements

between nations and people, we as a global community must figure out how to agree that nothing comes above the safety of humankind and that it is the responsibility for policymakers to ensure they are giving their best effort to ensure that perpetually occurs as we increase human space travel flights and begin to colonize space and beyond.

Researchers and policymakers/regulators should utilize the data herein to enhance space safety and capitalize on lessons learned from the last 118 years of incidents and accidents in the aerospace industry. Proactive planning and prognostication and international partnerships are critical in the next era of the commercialized human space arena. Space commerce, which also includes technology, is a major industry that space safety needs to encompass. Space defense is also very important as wars and battles have been fought since the beginning of time or words and minimal actions that one person does. It is not a matter of whether it will happen, but when it will happen in space. We, as humans, must take care of ourselves and aid each other perpetually in the Cosmos no matter what the cost so that humans both endure and thrive off-Earth.

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APPENDICES

Appendix A

Drafted Email for Delphi Research Study

Enhancing Safety for Commercialized Human Space Travel and Colonization

Dear Space Community Professional:

I am conducting a global research study designed to examine the potentially harmful impacts of global policy regarding commercial space safety operations, including space travel and colonization.

The purpose of this research is to investigate the need to establish and prioritize a guideline for the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. This research study will consist of global space professionals, considered experts in various fields from the space community. Each round is expected to take 30 to 45 minutes via an online research instrument through Qualtrics. Please see the Delphi Research Study Outline and the Qualtrics Delphi Survey Questions first round of questions regarding; "Enhancing Safety for Commercialized Human Space Travel and Colonization" (attached for your review).

If you are willing to participate in this research study, please respond to this email to actively participate in all possible rounds of the Delphi study. Additionally, if you know of another space professional colleague in the space community whom you believe would be willing to participate in this study, please forward this email to that individual.

Your willingness to participate and support this research study is greatly appreciated, and I sincerely request your participation.

Oklahoma State University, Office of University Research Compliance, has approved this research study (IRB 21-251).

If you have questions or concerns, please do not hesitate to contact me.

Very respectfully,

Joshua Larson, Doctoral Candidate
Oklahoma State University
361-455-8309
Joshua.larson@okstate.edu

Appendix B

Qualtrics Delphi Survey Questions

Enhancing Safety for Commercialized Human Space Travel and Colonization: Round 1

1. From your perspective, what are the priorities for the development of guidelines for space travel and or colonization as expressed by public (government) and private entities? Please list three to five priorities.

2. What is the feasibility of the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities? In your response, please describe what would be needed to develop such an agency or clearinghouse.

3. What are practical solutions to the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for space travel and colonization between governments and private entities? Please describe at least two practical solutions.

4. Does having a growing plethora of independently functioning worldwide national space agencies and private commercial space entities, with various undefined governing laws, policies, and procedures, pose a problem for future space exploration and colonization? Please explain why or why not. Please also describe any alternatives you envision.

5. Is there a need to investigate the requirement for a single global space safety integration and overarching interoperability entity that is the sole source that controls Earth's commercial entrance and exits through the Karman line while utilizing a universal Space Traffic Management (STM) system; which is governed and regulated by one policy and single controlling agency? Please explain why or why not in your response.

6. What are the needs in developing one global/universal commercial space transportation guideline and governing policy with well-defined, established emergency procedures and protocols on Earth, during spaceflight, and at every possible destination in the Cosmos to ensure the highest efficacy of safeguards are always in place to attempt to preserve and protect life and property?

7. Is there a need to investigate the requirement for the need for an infrastructure to develop a universal Emergency Space Response Management System (ESRMS)? In your response, please reflect on the need to develop a single global agency to act as a safeguard/lifeguard type of asset to aid in the rescue and recovery of life and property. Please explain your view. If you believe that a central infrastructure is needed, what

entity should be responsible? Additionally, what sort of construct could be used to develop a central emergency response system?

8. Is there a need to explore the feasibility of establishing and prioritizing a guideline for developing an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities? Suppose the need for an international entity to serve as a clearinghouse function is determined. In that case, some possible issues that might need to be addressed might be space law, policy, and procedures, operations, interagency relations, licensing, monitoring, enforcement, interdiction, training, testing/evaluation, and certification. What additional issues or topics for inclusions (if any) would you like to add to this list?

9. The vastness of space presents many problems that cause existential threats to humans and spacecraft. Please explain your views regarding the following challenges that may potentially emerge regarding the use of commercial vessels and other spacecraft.
    a. How do commercialized vessels manage inflight and off-Earth mechanical failures?
    b. How do commercialized vessels manage inflight and off-Earth uncontrolled fires?
    c. How do commercialized vessels manage inflight and off-Earth collisions with micrometeoroid and orbital debris (MMOD), leading to a major loss of cabin pressurization?
    d. How do commercialized vessels manage inflight and off-Earth collision with a visiting vehicle?
    e. How do commercialized vessels manage inflight and off-Earth toxic spills that endanger the people onboard or off-Earth?

10. What safety equipment should be required on all spacecraft for inflight/spaceflight operations, and what governing guidelines doctrine and agency should have the oversight to ensure that there is a universal minimum standard level of safety equipment on board?

11. Should there be a universal minimum standard for screening, selection, training, and certification for all commercialized humans before space travel? What are your thoughts about this, and as future commercial travelers begin to travel in the Cosmos, do you have any recommendations?

12. Should there be different screening, selection, training, and certification criteria based on the person's function in space, i.e., tourist, flight crew, employee, colonist, etc.? If so, what such criteria should be developed? Additionally, is there a need for a universal policy to develop a set of standards to create the criteria for these to be equally chosen from around the globe?

13. Should space entry for all commercialized travelers be specifically categorized, i.e., tourist, an employee with defined role and responsibility, flight crew, colonist (Lunar or Deep Space, i.e., Mars "longevity trip"), etc.?

14. Should all spacecraft greater than X number of passengers onboard be required to carry an onboard medical officer? If so, what should that numerical X number be?

15. Is there a need to investigate better long-endurance (greater than one day in space) passenger and crew requirements, crew rest and seating accommodations, and amenities onboard commercialized spacecraft?

16. What are the top three things that may lead to an onboard accident spacecraft resulting in death and or property loss?

17. What are the top three things that will lead to an off-Earth, i.e., on another planetary body accident (not including a spacecraft accident) resulting in death and or loss of property?

Appendix C

Delphi Research Study Initial Outreach Draft

The following letter and title were used to solicit participation in the present study. It was tailored to each candidate specifically to reference their expertise and reasons for requesting their participation.

Enhancing Safety for Commercialized Human Space Travel and Colonization

Dear Space Community Professional:

Soon NASA will begin its Artemis Moon missions and, subsequently, its mission to Mars. In parallel, individuals like Elon Musk of SpaceX, Jeff Bezos of Blue Origin, and Richard Branson of Virgin Galactic have their eyes set to commercialize the Cosmos with humans for the space tourism industry. They plan to send our first humans on spacecraft bound for space travel and colonization to the Moon, Mars, and beyond.

The problem explored in this study was the lack of global standardization guidelines as the world begins commercializing human space operations, including space travel and colonization into the Cosmos. The safety issue posed with the future of commercial human space transportation is due to the independent functioning of national space agencies and private commercial space entities, despite the presence of international entities such as the United Nations Office for Outer Space Affairs (UNOOSA) and The Committee on the Peaceful Uses of Outer Space (COPUOS) (UNOOSA, 2021).

I will be conducting a Delphi research study through the active participation of the global community of space professionals, Aka "research group." As a result, this research group's findings will help understand prioritizing issues relevant to establishing guidelines to help identify future safety regulations which enhance global commercialized human space operations, including space travel and colonization. I am reaching out to you to seek your active participation as you are considered an expert in your field within the space community and are considered a space professional.

The purpose of this Delphi study is to investigate the need to establish and prioritize a guideline for the development of an agency or clearinghouse for the standardization of certifications, requirements, and ethical standards for commercialized space travel and colonization between global governments and private entities. The information obtained by this research may also help facilitate further discussion and possibly implement future changes within the global commercial and government space transportation industries. As a result of this study's findings, industry decision-makers may become more knowledgeable of safety concerns regarding human and spacecraft certification and qualification approval before any human or spacecraft is allowed into space by commercialized methods.

As part of this study, the participants' information is confidential and anonymous, where I (the researcher) will know the participant's real identity, but that information will not be disclosed. All names and employment/job positions of the participants who actively participated in the research study will never be revealed at any time, before, during, or after the study, including if the study is published. No member of the study will know any of the other participants who are also actively participating in the research at any time, before, during, or after the study. Through informed consent of the participant, their information will be kept confidential, but anything publicized will be kept anonymous. All information will be reported in aggregate; as an example, I may make a statement in a publication to such terms as the "research population," and I will not use terms such as the government or a private entity." I will refer to "the findings of the research group," as that or as possible as "the consensus of the research group," as a collective group so that no individual's specific input would possibly reveal one's identity.

By method of a Delphi study, this research aims to reach a consensus through the space professionals' expertise and active participation to understand better how future policies can be developed for guidelines regarding standardization of certifications, requirements, and ethical standards between governments and private entities to enhance the overarching safety of commercialized human space operations, travel, exploration, and colonization of the Cosmos.

This research aims to qualify and quantify the global community of space professionals' expertise regarding enhancing the future of safety in commercialized human space travel and colonization. It provides thoughtful insight from space professionals' regarding establishing better policies that foster ethical safer operations regarding humans in space. As a final product of this dissertation, the researcher aims to publish the findings' entirety and gain a peer review. Through a peer review and dissemination through the space professional and space policy industry, the dissertation aims to strengthen the industry through diplomacy. The data herein will foster dialogue that will build partnership capacities globally, allow for deep thought, expand the discussion, and hopefully lead to new enhanced, safer international legislation and policy that will better allow future space travel and colonization to endure and thrive.

Through a series of Delphi rounds, the objectives aim to:

- Capture the global space professional community's consensus, which may lead towards developing a possible single global agency or clearinghouse guideline to standardize certifications, requirements, and ethical standards for space travel and colonization between governments and private entities.
- Better understand endurance requirements for onboard commercial spacecraft life support systems under one governing global policy doctrine.
- Investigate the space community's consensus, potentially leading to enhanced, more regulated commercial spacecraft safety certification standards and routine maintenance inspection requirements under one governing global policy doctrine that allows for better overarching integration and interoperability.

A Delphi research approach will be utilized to identify and prioritize decision-making issues through consensus among study participants. In the Delphi method, study participants, often experts in the field related to the topic of interest, are asked to identify the most critical issues. In the first round of the Delphi method, participants are asked to provide their inputs about the most

critical issues related to the topic of interest, using a qualitative approach. The Delphi method's first phase is referred to as "brainstorming." In the subsequent phase, within the Delphi method, the goal is to develop consensus among experts to narrow down the list through a selection process. The Delphi method's final phase involves ranking the factors based on the paired-down list. The ranking phase may involve multiple rounds until a consensus is reached. Researchers have recommended that at least 50% of experts agree for consensus to be met.

Four possible rounds of the Delphi method will be used in this study. The rounds are proposed to meet the two to three phases of the Delphi methods. Round 1 will be used for brainstorming, Round 2 for "narrowing down," and Round 3 (and Round 4, if necessary) will be used for ranking. These rounds are further described below. In Round 1, open-ended brainstorming on the topic to develop a list of statements will be developed using open-ended survey responses. In Round 2, a list of statements collected in Round 1 will be presented to all participants. If a consensus of more than 70% is met through a Likert-scale ranking, the panel's statements will be endorsed, and a presentation of the findings will be developed. If consensus is not met, Round 3 includes further refinement in which the list of the reduced statements developed in Round 2 will be presented to participants. If a consensus of more than 70% is met through a Likert-scale ranking, the panel's statements will be endorsed, and a presentation of the findings will be developed. This means that the fourth round will be canceled. Round 4 is the final round and includes presenting the final list of statements to the panel based on panel endorsement feedback. Just as in previous rounds, if a consensus of more than 70% is met through a Likert-scale ranking in Round 4, the panel's statements will be endorsed, and a presentation of the findings will be developed.

Appendix D

Informed Consent/Participant Information Form

INFORMED CONSENT/PARTICIPANT INFORMATION FORM

Delphi Research Study
Enhancing Safety for Commercialized Human Space Travel and Colonization

This study is being conducted by: Joshua A. Larson, Doctoral Candidate, The School of Education Foundations, Leadership and Aviation, Oklahoma State University

Under the direction of Mallory K. Casebolt, Ed.D., The School of Education Foundations, Leadership and Aviation, Oklahoma State University

Preferred Language of Study: English

Purpose:

This study is intended to explore the perceptions and opinions of global space professionals that are considered experts in various fields from the space community and investigate the potentially harmful impacts of global policy regarding safe commercialized human space operations, including space travel and colonization.

Procedures:

This study will seek active volunteers to answer a series of questions via a Delphi study with a minimum of two rounds and no more than four, depending on the research group's findings and how quickly the group narrows down the consensus. By method of a Delphi study, this research aims to reach a consensus through the space professionals' expertise and active participation to understand better how future policies can be developed for guidelines regarding standardization of certifications, requirements, and ethical standards between governments and private entities to enhance the overarching safety of commercialized human space operations, travel, exploration, and colonization of the Cosmos. Most of this study's questions are primarily qualitative/open-ended, which will require a descriptive narrative through personal comments. Additionally, a quantitative Likert scale is associated with the numerical measurement as a mixed-method approach as the study progresses. Each round is expected to take 30 to 45 minutes of participation via an online research instrument through Qualtrics. Though this study is voluntary, your active participation is essential due to a Delphi study's nature. It is essential if able to make every attempt to complete all rounds of the Delphi study and not prematurely terminate your active participation, as your input is extremely valuable from start through finish.

Risks of Participation:

There are no known risks, including emotional, psychological, legal, and physical pain, associated with this more significant than those ordinarily encountered in daily life.

Benefits:

This research aims to qualify and quantify the global community of space professional's expertise regarding enhancing the future of safety in commercialized human space travel and colonization. It provides thoughtful insight from space professionals' regarding establishing better policies that foster ethical safer operations regarding humans in space. As a final product of this dissertation, the researcher aims to publish the findings' entirety and gain a peer review. Through a peer review and dissemination through the space professional and space policy industry, the dissertation aims to strengthen the industry through diplomacy. The data herein may foster dialogue that may build partnership capacities globally, and allow for deep thought, expanded discussion, and hopefully lead to new enhanced, safer international legislation and policy that will better allow future space travel and colonization to endure and thrive.

Confidentiality:

All information about you and your institution will be kept confidential and will not be released unless subpoenaed by a court of law. Identification numbers rather than names will indicate all record forms. The records of this study, written and electronic, will be kept private. Any written results will discuss group findings and will not include information that will identify individuals or institutions. Research records will be stored securely, and only the researcher responsible for research oversight will have access to the records. As part of this study, the participants' information is confidential and anonymous, where the researcher will know the participant's real identity, but that information will not be disclosed. All information regarding the study will be destroyed or deleted at the end of the study. All names and employment/job positions of the participants who actively participated in the research study will never be revealed at any time, before, during, or after the study, including if the study is published. No member of the study will know any of the other participants who are also actively participating in the research at any time, before, during, or after the study. Through informed consent of the participant, their information will be kept confidential, but anything publicized will be kept anonymous. All information will be reported in aggregate; as an example, the researcher may make a statement in a publication to such terms as the "research population," and the researcher will not use terms such as the government or a private entity." The researcher will refer to "the findings of the research group," as that or as possible as "the consensus of the research group," as a collective group so that no individual's specific input would possibly reveal one's identity. The research team works to ensure confidentiality to the degree permitted by technology. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online. However, your participation in this online survey involves risks similar to a person's everyday use of the internet. If you have concerns, you should consult the survey provider privacy policy at [https://www.qualtrics.com/privacy-statement/].

Compensation:

No compensation will be offered to you as a participant. Your participation is strictly voluntary.

Contacts:

The researcher of the study personally thanks you for your participation, feedback, and support of this research. You may contact the researcher at the following email address or phone number, should you desire to discuss your participation in the study: Josh Larson at 361-455-8309 or Joshua.Larson@okstate.edu. If you have questions about your rights as a research volunteer, you may contact the IRB office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377, or at irb@okstate.edu.

Participant Rights:

Your participation in this research study is strictly voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time without penalty.

By replying with a copy and paste of the following quote, in an email, back to the researcher, with the following phrase, [**I agree to participate in this complete Delphi study],** will indicate that you freely and voluntarily agree to initially participate in this study and acknowledge that you are at least 18 years of age. It is recommended that you print a copy of this consent page for your records. The researcher will provide further details of the upcoming Delphi study with a hyperlink via Qualtrics for your participation in a future date shortly.

Statement of Consent
I have read the above information. I have had the opportunity to ask questions and have my questions answered. I consent to participate in the study.

I consent to be contacted for follow-up in this study or future similar studies, and I consent to participate in this Delphi study actively.

If you agree to the terms of this consent form and are willing to participate in the upcoming Delphi study, please email the researcher the following phrase: **I agree to participate in this complete Delphi study.**

Appendix E

IRB Form

Oklahoma State University Institutional Review Board

Date:	06/01/2021
Application Number:	IRB-21-251
Proposal Title:	ENHANCING SAFETY FOR COMMERCIALIZED HUMAN SPACE TRAVEL AND COLONIZATION
Principal Investigator:	Josh Larson
Co-Investigator(s):	
Faculty Adviser:	Mallory Casebolt
Project Coordinator:	
Research Assistant(s):	
Processed as:	Exempt
Exempt Category:	

Status Recommended by Reviewer(s): Approved

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in 45CFR46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,
Oklahoma State University IRB

VITA

Joshua Adam Larson

Candidate for the Degree of

Doctor of Education

Dissertation: ENHANCING SAFETY FOR COMMERCILIZED HUMAN SPACE TRAVEL AND COLONIZATION

Major Field: Applied Educational Studies, Aviation & Aerospace

Biographical:

Education:

Completed the requirements for the Doctor of Education in Applied Educational Studies, Aviation & Aerospace Option at Oklahoma State University, Stillwater, Oklahoma, in December 2021.

Completed the requirements for the Master of Science in Aerospace and Aviation Management, and Systems Safety, at Embry-Riddle Aeronautical University, Worldwide Campus, in October, 2011.

Completed the requirements for the Bachelor of Science in Professional Aeronautics Embry-Riddle Aeronautical University, Worldwide Campus, August, 2000.

Completed the requirements for the Associates of Science in Professional Aeronautics Embry-Riddle Aeronautical University, Worldwide Campus, August, 2000.

Membership affiliation includes Federal Bureau of Investigation (FBI) Citizens Academy Alumni, FBI InfraGard, American Association of Airport Executives (AAAE), U.S. Naval Aviation Tailhook Association, Air Line Pilots Association, International (ALPA)/United Airlines member, National Association of Underwater Instructors (NAUI) Certified Diver, United States Parachute Association (USPA).