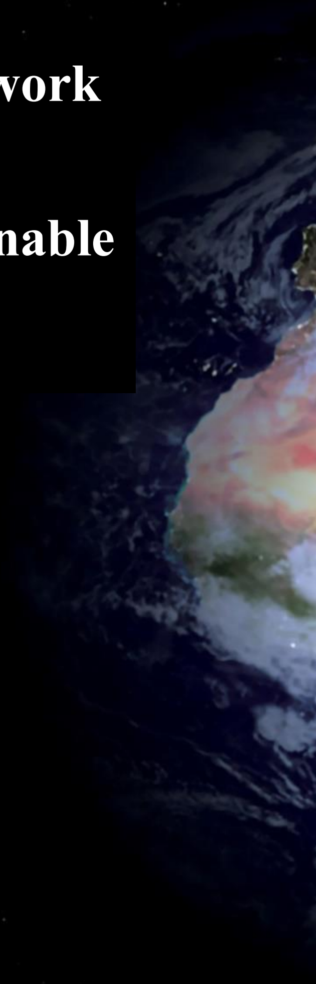
Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities



GLOBAL EXPERT GROUP ON SUSTAINABLE LUNAR ACTIVITIES

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Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities

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Forword

The near future will see a multitude of lunar missions through the efforts of both space agencies and commercial stakeholders. The current lack of coordination mechanisms for lunar activities presents a serious challenge to future missions and could lead to dangerous conflicts, especially in light of the increased global interest in specific areas like the lunar south pole. The need to preserve the peaceful uses of space, together with the desire to begin a new era of sustainable space exploration, urges the development of a common level playing field for upcoming lunar activities.

A number of issues must be addressed to ensure sustainable lunar exploration and settlement in and around the Moon, including, for example, mitigating the creation of debris in lunar orbit, defining standards to enable interoperability, and regulating access to natural resources.

In 2019, the Moon Village Association (MVA) created an international platform to address these critical issues with the goal of de-risking future lunar missions and increasing global cooperation for lunar exploration and settlement. The MVA decided to promote the development of a neutral forum for multi- stakeholder discussions on lunar exploration: the *Global Expert Group on Sustainable Lunar Activities* (GEGSLA), with the goal of de-risking future lunar missions and increasing global cooperation for lunar exploration and settlement.

The primary goal of GEGSLA meetings is to stimulate informal discussions to prepare documents to be brought to the attention of UNCOPUOS for further discussion and deliberation. The Group started its work with the kick-off meeting on February 25, 2021, creating the basis for increasing global coordination for a new era of sustainable space exploration.

To achieve its goals, the Group had the following goals:

- Leverage contributions from major stakeholders of the space community, including space agencies, private companies, academia, and international organizations;
- Involve the public by promoting outreach efforts regarding the activities of the Group through the involvement of local actors at the global level;
- Serve as a platform to exchange information and views within the space community on key issues for the peaceful and sustainable conduct of lunar activities;
- Support complementary activities, within UNCOPUOS or other international forums, for the development of an international framework regulating space resource utilization.

The Group operates by consensus, and it is composed of members and observers, who act in their individual capacity. They are stakeholders in lunar activities, including representatives from space agencies/government, industry, international organizations, academia and civil society. The Group is chaired by Dr. Dumitru-Dorin Prunariu (Romania) and its members include 37 experts from the following countries: Australia, Austria, Brazil, Canada, China, Cyprus, Egypt, France, Germany, India, Israel, Kenya, Luxembourg, Mexico, Netherlands, Nigeria, Romania, Russian Federation, Saudi Arabia, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland and United States of America. The Group also includes about 195 observers from more than 40 countries.

More information can be found at:

https://moonvillageassociation.org/gegsla/about/

Table of Contents

Preamble

The Moon and its relationship to Earth are unique. Created by an impact event approximately 4.5 billion years ago, the Moon has shaped the evolution of terrestrial and marine ecosystems, contributing to the habitability of Earth. Every human culture has expressed the influence of the Moon through its cosmology, spirituality, science, and creative and social life. For these reasons, the exploration and use of the Moon can truly be the province of all humankind.

Now, the Moon, through activities on or around it, is poised to play a new role in facilitating human exploration and use of the solar system and enhancing the long-term sustainability of outer space activities. These activities have the potential to contribute to the future benefit of humankind through the development of new technologies, access to rare resources, and deepening human understanding of the solar system and our place within it.

The promise of the Apollo missions waned when humans left the Moon in 1972 and did not return. In this new phase of human engagement with the Moon, there are multiple stakeholders, emerging technologies, and new goals – including the intent to stay. It is essential that these activities proceed prudently and ethically to reaffirm the confidence of the people of Earth. However, even building on experience gained from over 60 years of space activities, standards and legal norms are needed to guide these activities.

The Global Expert Group on Sustainable Lunar Activities (GEGSLA) was established to promote and support the development of lunar activities in a safe and sustainable manner. Its vision is to enable globally inclusive participation in this next stage of human endeavors in space. For this purpose, the GEGSLA has engaged widely with lunar stakeholders from industry, government, and academia to develop the Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities.

The Recommended Framework and Key Elements is designed as a guide for well-balanced lunar projects and offers recommendations for how to implement safe and sustainable lunar activities through norm- setting, coordination, and management. It builds on principles established in international space law, relevant UN outer space treaties and soft law documents (e.g. the UN COPUOS Guidelines for the Long Term Sustainability of Outer Space Activities (2019)), and other distinctive international or multilateral agreements (e.g. the Artemis Accords), national legislation and regulations, and guidance documents (e.g. the Building Blocks for the Development of an International Framework on Space Resource Activities (2019), the MVA Best Practices on Sustainable Lunar Activities (2019), and the Vancouver Recommendations on Space Mining (2020)).

Documents such as the UN Long Term Sustainability Guidelines have developed higher-order principles to guide humanity's engagement with outer space, including the Moon and other celestial bodies. The GEGSLA recognized that the next steps forward might require more detailed elaboration. The GEGSLA seeks to extend existing principles into a framework that can effectively facilitate dialogue and cooperation among multiple lunar stakeholders. The participation of the space industry was vital in verifying sustainable practices and crafting practical recommendations that act as incentives rather than barriers.

The Recommended Framework and Key Elements can act both as a guide for designing lunar activities and as a benchmark against which to gauge the success of those activities in achieving sustainability. The Recommended Framework is aimed at providing transparency, accountability, and certainty for all stakeholders, present and future.

The Recommended Framework and Key Elements are not a proscriptive set of principles to regulate all potential types of lunar activity. Instead, the Recommended Framework and Key Elements is a living document which focuses on lunar activities that are likely to occur in the near and medium terms, within a vision of the long-term expansion of human activities in lunar orbit and on the lunar surface for the benefit of all peoples irrespective of the degree of their economic or scientific development.

In eleven chapters, the Recommended Framework and Key Elements cover coordination and management; information sharing; safe operations and lunar environmental protection; compatibility and interoperability; lunar governance; benefits for humanity; sustaining the lunar economy; and human Interactions. Moreover, two additional documents advance the work done by the main GEGSLA outcome: the *Technical and Operational Practices and Case Studies on Peaceful and Sustainable Lunar Activities* and *A List of Future Issues of Sustainable Lunar Activities* which are not covered by the Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities and recommended it for further discussions at a later stage. While not object of consensus within the GEGSLA plenary, as indicated in the Chair's Explanatory Note on Annexes, these two documents constitute a critical complementary to the overall work.

There is no doubt that exploring and using the Moon in the present era will present unforeseen challenges, testing the limits of human ingenuity and cooperation. It is the hope of the GEGSLA that the Recommended Framework and Key Elements will provide the next steps forward in ensuring the peaceful and sustainable foundation of lunar activities.

Principles

Chapter 1: Objective

The Recommended Framework and Key Elements seek to support the creation of an enabling environment for peaceful, safe, and sustainable activities on the Moon and in its orbit, which is in the interests of, and benefits, all humankind, and all countries, irrespective of their degree of economic or scientific development. The Recommended Framework and Key Elements are designed to:

- Provide certainty and predictability through technology-neutral recommendations to all public and private actors intending to conduct lunar activities under the principles of international space law, enshrined in the Outer Space Treaty, including the freedom of use and exploration of space.
- Promote a constructive, multilateral exchange of views on such activities, including their legal, technical, industrial, social, and economic aspects under UNCOPUOS;
- Facilitate international cooperation and coordination in such activities.

To achieve this objective, the Recommended Framework and Key Elements:

- Identify and define the relationship of lunar activities with existing international space law, including the provisions of the United Nations treaties on outer space, as well as the related United Nations principles and guideline resolutions related to outer space activities;
- Propose recommendations for the consideration of States and international organizations for the possible application to development of domestic policies and regulations, as well as the

possible formulation of an international framework, on such activities;

- Identify necessary, practical, and effective principles, mechanisms, and/or technical standards that contribute to the reduction of the risk of harmful interface with lunar activities and promote long- term sustainability;
- Promote the development of sustainable practices by lunar stakeholders to create, fund, incentivize, and facilitate near-term activities on the Moon and in its orbit.

Chapter 2: Definition of Key Terms

For the purpose of this Recommended Framework, the following terms are defined as:

2.1 *Lunar activity* is any scientific, commercial, and human activity which takes place on the lunar surface, subsurface or orbit, as well as any associated ancillary activities.

2.2 *Commercial activity* is any activity with an exchange to earn a profit, which includes but is not limited to resource extraction and transactions such as selling, bartering, donating, leasing, licensing, etc.

2.3 *Data* refers to information about the lunar environment and lunar activities, such as measurements, results and statistics collected for reference, analysis or decision-making. The data can be digital, visual, quantitative or qualitative, in raw or processed form.

2.4 *Environmental harm* is an adverse effect, both present and future, on the lunar environment that is not trivial or negligible in nature, extent or context that hinders the use of the Moon for scientific and/or commercial purposes or for safe human habitation. Serious environmental harm is actual or potentially adverse effect(s) that are irreversible, of high impact or widespread, or causes actual or potentially adverse effect(s) to the environment of an area of high conservation value, scientific interest, or otherwise is of special significance.

2.5 *Harmful interferenc*e refers to the result of any activity with a significant adverse effect on the lunar activity of other actors, which prevents them from carrying out their legitimate lunar activities or gaining access to an area.

2.6 *Lunar cultural heritage* is any place with human material culture on the Moon or that is associated with intangible practices, representations, expressions, knowledge, or skills that has historical, social, aesthetic, spiritual or scientific significance for present and future generations. Lunar *natural heritage* is any place, geological or landscape formation that has historical, social, aesthetic, spiritual or scientific significance for present and future generations.

2.7 *Interoperability* refers to the development of common standards of design, manufacture, and construction and/or operations to enable software and hardware components to be interchanged or operate in conjunction to facilitate international cooperation, recycling and repurposing.

2.8 The *lunar environment* consists of but is not limited to the lunar surface and subsurface, including mountains and craters, rocks and boulders, regolith, dust, minerals, gasses, water, ice, boundary exosphere, and surrounding lunar orbits.

2.9 The *lunar surface* is understood as the layer of regolith comprising unconsolidated rocks, pebbles, and dust. The lunar subsurface consists of primordial bedrock and lava tubes or caves.

2.10 *Environmental Sustainability* is the ability to preserve the outer space environment for future generations and to oversee the conduct of space activities on and around the Moon indefinitely into the future in a way that realizes the objectives of equitable access to and benefits from the exploration and use of outer space for peaceful purposes.

2.11 Lunar *in situ resources* are mineral or volatile resources on or below the lunar surface which have applications for scientific, commercial, construction or residential utilization.

2.12 *Safe operations* are those activities that, under proper authorization and supervision, are carried out in a way that avoids harm to the lunar environment and human life or other activities on the Moon while safeguarding free and equal access.

2.13 A *safety zone* is a publicly notified area with clear geographic and time-delineated parameters established around the site of a given lunar activity in order to ensure safety and avoid potentially harmful interference among lunar activities.

2.14 A *lunar settlemen*t is a residential area or habitat designed for temporary or permanent human habitation with its associated facilities and the resources required for the maintenance of life.

2.15 *Lunar stakeholders* include governmental and non-governmental entities and international organizations participating directly or indirectly in the exploration and use of the Moon or in any other way contributing to the sustainability of lunar activities.

Chapter 3: International Legal Norms for Lunar Activities

This Chapter identifies existing norms that support the adoption of sustainable practices in all lunar activities and proposes new norms needed for the near future. Such norms should reflect operational experience, i.e., practical, achieve a balance between incentive and prescription, and be technology neutral. Since all actors, whether governmental or non-governmental, should have an equal interest in achieving sustainable use of the Moon, these norms apply to all or are encouraged to be followed by all according to the legal effect of specific norms.

Norms are established by international law, national legislation, or policy, but also by the common acceptance that certain behavior is desirable or good practice. While built on precedence, norms can also be aspirational and responsive to changing public perceptions of ethical behavior. The role of norms in sustainable lunar activity is to provide agreed-upon tenets that guide actions consistent with sustainable practices.

A legal norm is a binding rule that determines the rights and duties of an actor, as enshrined in national and international law. Breaking a legal norm may result in sanctions; however, the norm remains intact even if violated.

A behavioral norm is a standard of behavior, not necessarily enshrined in law but commonly accepted as appropriate. Behavioral norms are shared beliefs between actors which may cover social and moral expectations.

3.1. Summary of existing norms relevant to lunar activities

3.1.1. International legal norms

3.1.1.1. A number of widely recognized international legal norms related to lunar activities have been codified in existing international treaties, including the Outer Space Treaty 1967, the Rescue Agreement 1968, the Liability Convention 1972, and the Registration Convention 1976. These are widely recognized international law norms and, as such, pertain to lunar activities.

3.1.1.2. The Moon Agreement 1979, although with a limited number of States Parties, contains a number of elements that are relevant to the development of legal norms for lunar activities.

3.1.1.3. Some international instruments can be related to the lunar activities, including, but not limited to, the Constitution and the Radio Regulations of the International Telecommunication Union (ITU).

3.1.2. Current guidelines and principles

3.1.2.1. In addition to international treaties, there are a number of guidelines, principles, and proposed normative frameworks drafted by international governmental and non-governmental organizations and States, and that contain relevant provisions pertaining to lunar activities.

3.1.2.2. The Guidelines for the Long-Term Sustainability of Space Activities 2019 (A/74/20, para 163 and Annex II)

3.1.2.3. Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space 2007 (A/62/20, Annex and General Assembly Resolution 62/217 of December 22, 2007)

3.1.2.4. Safety Framework for Nuclear Power Source Applications in Outer Space 2009 (A/AC.105/934, 2009)

3.1.2.5. The Artemis Accords (2019)

3.1.2.6. The Hague International Space Resources Governance Working Group Building Blocks for the Development of An International Framework (2019)

3.1.2.7. The Vancouver Recommendations on Space Mining (2020)

3.1.2.8. The MVA Best Practices for Sustainable Lunar Activities (2020)

3.1.3. Behavioral Norms from Operational Experience

Extensive operational experience in space activities has been developed in Earth orbit and limited operational experience in lunar activities through the historical activities of States. This operational experience has created behavioral norms which might influence and inform sustainable lunar practices, including (but not limited to) practices in space debris mitigation, radio frequency coordination, and notification and registration.

3.1.4. National Legislation

Some States have adopted national laws, regulations and policies related to space activities, including lunar activities. Such legislation, as state practice, may contribute to the interpretation and development of international law in this field.

3.2. Limitations

Limitations in existing norms arise because many situations have not yet been tested in real circumstances. For example, there has rarely been more than one active lunar surface mission or multiple human missions at the same time. Some of the gaps will be identified and addressed in the technical annexes to this report.

3.3. Proposed norms needed for the near future

3.3.1. Jurisdiction and Control

3.3.1.1. The appropriate States shall retain jurisdiction and control over their personnel and their vehicles, equipment, facilities, stations, and installations on the Moon. Ownership shall not be affected by their presence on the Moon.

3.3.1.2. Lunar stakeholders shall not carry out activities or conduct themselves in ways which would be contrary to the applicable laws, including their national legislation or international laws.

3.3.2. Registration

Lunar stakeholders should register all space objects under the provisions of national registration practices and in accordance with the Registration Convention 1976 and/or General Assembly resolution 1721 B (XVI) of December 20, 1961, taking into account General Assembly resolution 62/101 on registration practices and other requirements under the relevant treaties, principles, regulations, and resolutions.

Lunar stakeholders should register other objects, like facilities, stations, and installations, which might be partially made by lunar resources or any other things which would not be defined as space objects and notify this registry to the international community in an appropriate way.

3.3.3. Interoperability

Lunar stakeholders recognize that the development of interoperable and common lunar infrastructure and standards will contribute to the safety and viability of lunar operations. Lunar stakeholders should pursue reasonable efforts to develop, promote, utilize, and follow interoperability standards.

3.3.4. Mitigation of harm

With regard to the current state of technology, lunar stakeholders shall take appropriate measures to avoid and mitigate harm to the lunar environment and/or to other operators in that environment.

3.3.4.1. Environmental protection: lunar stakeholders should adopt appropriate measures to avoid harmful contamination to the environment of the Moon or adverse changes in the environment of Earth resulting from the introduction of extraterrestrial matter. This shall include consideration of

a) Internationally agreed planetary protection policies.

b) Adverse changes to designated and internationally endorsed lunar natural or cultural heritage sites

c) Adverse changes to designated and internationally endorsed lunar sites of scientific, commercial or another interest.

3.3.4.2 Space debris mitigation: In consideration of the harmful effects of the creation of space debris on or around the surface of the Moon, lunar stakeholders should adopt appropriate measures as far as possible to avoid the creation of lunar orbital debris and lunar surface debris, and to mitigate the impacts of lunar orbital debris, both in lunar and Earth orbit.

3.3.4.3 Harmful interference: In consideration of a) risks to the safety of persons or property and b) risks to other ongoing space activities, including other lunar activities, Lunar stakeholders should adopt appropriate measures to avoid harmful interference with lunar activities carried out by other stakeholders. Should harmful interference be anticipated, stakeholders should seek appropriate consultation.

3.3.5. Non-appropriation

In line with the provisions of the Outer Space Treaty 1967, no lunar stakeholders shall take national appropriation of the Moon and its orbit by claim of sovereignty, by means of use or occupation, or by any other means. The establishment of safety zones around lunar operations and exclusion or buffer zones around sites of cultural and natural heritage significance, or scientific interest, shall not result in such appropriation.

3.3.6. Freedom of access and scientific investigation

Lunar stakeholders are free to access and use all areas of the Moon and have the freedom of scientific investigation on the Moon in accordance with international law.

3.3.7. Radiofrequency

In conducting lunar activities, lunar stakeholders should adopt appropriate measures to avoid, to the extent possible, the adverse impact caused by the use of radio frequency on the achievement of objectives of any other stakeholder, and give special consideration to the requirements of Moon- based astronomical observation.

Use of radio frequency shall be registered in accordance with the Radio Regulations of the ITU.

3.3.8. Sharing of Scientific Data

Lunar stakeholders should share the scientific data obtained from lunar activities, and disseminate the data to the public and the international scientific community in accordance with international law, including those related to intellectual property rights.

3.3.9. Fair use of resources

In their use of a lunar resource, lunar stakeholders should avoid taking actions which would prevent its use by future generations by overexploiting or contaminating the resource.

3.3.10. Peaceful use of the Moon

3.3.10.1. The Moon and other celestial bodies shall be used by all lunar stakeholders exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on the Moon and other celestial bodies shall be forbidden.

3.3.10.2. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies shall also not be prohibited.

Chapter 4: Coordination and Management

Coordination and management mechanisms should be transparent and inclusive among lunar stakeholders and should build upon outreach to the general public in an inclusive, broad, and holistic fashion.

4.1. Agreed-upon principles for coordination and management are a critical enabling factor for safe and sustainable lunar activities.

4.1.1. Principles for the coordination and management of lunar activities should focus on creating an enabling environment for sustainable lunar exploration and utilization through promoting information sharing for the purposes of coordinating safety and reduction of harmful interference.

4.1.2. Principles for the coordination and management of lunar activities should also foster international cooperation.

4.1.3. Principles for the coordination and management of lunar activities will necessarily be implemented at multiple levels with diverse scopes of application. These levels and scopes include multilateral/bilateral, international/ regional / sub-regional, intergovernmental / non-governmental, regulators / industry and private sector.

4.2. Development of principles for the coordination and management of lunar activities should draw on existing mechanisms to the greatest extent possible.

4.2.1. It is important to take into account and build upon those existing regulations and principles governing coordination and management in outer space and that already contribute to lunar sustainability.

4.2.2. In the coordination and management of lunar activities, existing international fora should be utilized to the greatest extent possible. These fora include but are not limited to:

a. UN COPUOS: a unique platform for international cooperation in the peaceful use of space and global space governance and plays a unique role in developing international space law and fostering dialogue among space-faring and emerging space nations.

b. UNOOSA: the Secretariat of the UN COPUOS and "assists any United Nations Member States to establish legal and regulatory frameworks to govern space activities and strengthens the capacity of developing countries to use space science technology and applications for development by helping to integrate space capabilities into national development programmes."

c. The International Space Exploration Coordination Group (ISECG): "a voluntary, non-binding coordination forum of space agencies which exchange information regarding interests, plans and activities in space exploration and work together to strengthen both individual exploration programmes and the collective effort."

d. The Committee on Space Research (COSPAR): a platform for promotion on an international level of scientific research in space, including preparation of scientific and technical standards related to space research.

e. The International Telecommunication Union (ITU): the UN specialized agency for information and communication technologies "which facilitates international connectivity in communications networks, allocating global radio spectrum and satellite orbits, developing the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs to underserved communities worldwide."

f. The Consultative Committee for Space Data Systems (CCSDS): a "multi- national forum for the development of communications and data systems standards for spaceflight."

g. The "International Organization for Standardization" (ISO): a non- governmental international organization that works to "share knowledge and develop voluntary, consensus-based, market relevant International Standards," including many that deal directly with space activities.

h. The Inter-Agency Space Debris Coordination Committee (IADC): "an international governmental forum for the worldwide coordination of activities related to the issues of man-made [sic] 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."

i. The International Atomic Energy Agency (IAEA): an "international organization that seeks to promote the peaceful use of nuclear energy, and to inhibit its use for any military purpose, including nuclear weapons."

4.3. To develop safe, sustainable, and transparent lunar activities, there are several aspects for which coordination and management practices will be essential:

4.3.1. Fostering International Cooperation: Coordination of interactions between governments, science communities, industry, and civil society to support sustainable lunar activities.

4.3.2. Registration Practices: Registration of lunar activities shall be encouraged, in accordance with the Outer Space Treaty (1967), Registration Convention (1976) and/or General Assembly resolution

1721 B (XVI), taking into account General Assembly resolution 62/101 on registration practices and other obligations under the relevant treaties, principles, regulations and resolutions. Such registration should focus on types, locations, and durations of lunar activities. General acceptance and consistent implementation of registration requirements and mechanisms across multiple jurisdictions and levels of coordination can be a confidence-building measure that enables multiple types of lunar activities.

4.3.3. Data-Sharing: Scientific data-sharing should be encouraged on the basis of international cooperation and benefit-sharing principles. Any data-sharing needs to take into account proprietary data and export control needs and limitations.

4.3.4. Interoperability: Interoperability of systems and capabilities can promote safety and the development of shared infrastructure to enable sustainable activities.

Chapter 5: Information Sharing

As a key element of the Outer Space Treaty (1967), the Registration Convention (1976) and the Moon Agreement (1979), information sharing is increasingly treated as a global public good. It plays a fundamental role in developing global space governance and will be at the core of ensuring peaceful and sustainable lunar activities.

5.1. Definition

Lunar information sharing is the exchange of data among stakeholders, carried out either under legal obligations, with the agreement of the relevant stakeholders or on a voluntary basis, throughout the lifecycle of any activity.

5.2. Purpose

Information can be shared for multiple purposes, including:

5.2.1. Transparency: information sharing promotes confidence among lunar stakeholders to verify or ensure the Moon is used exclusively for peaceful purposes and in line with other requirements under international space law.

5.2.2. Coordination: information sharing enhances safety, increases predictability, and reduces the risk of harm and harmful interference.

5.2.3. Cooperation: information sharing fosters dialogues among lunar stakeholders, enables inclusiveness, promotes interoperability, and facilitates exchange among governmental agencies, private entities, and the general public in sustainable lunar activities

5.2.4. Capacity building: information sharing contributes to capacity building in nations and communities, particularly those that have historically been absent from space activities.

5.2.5. Benefit sharing: information sharing can help to ensure that lunar activities are carried out for the benefit and in the interest of all countries. Technical and scientific information, and knowledge derived from lunar activities constitute a benefit and should be shared as widely as possible in accordance with Article XI of the OST.

5.2.6. Safety: information shared helps all stakeholders to better assess their own risks and develop precautionary measures.

5.3. Stakeholders' responsibilities

5.3.1. Stakeholders in lunar information sharing include governmental and non-governmental entities, such as space agencies, lunar project operators, space industries, research and scientific institutions, and the general public.

5.3.2. Stakeholders shall share information in accordance with their legal obligations under international treaties (for example, Articles VIII and XI of the Outer Space Treaty (1967)), and the applicable national legislation relating to outer space or lunar activities.

5.3.3. Stakeholders should factor information sharing into the design and implementation of lunar activities, and consider partial or conditional sharing of information if commercial or other competing considerations require otherwise.

5.3.4. Stakeholders should establish appropriate record-keeping for the information shared with other stakeholders. Publicly available information shared should also be deposited in internationally designated and agreed repositories in a timely manner.

5.3.5. Common standards for data sharing should be developed for the needs of the user.

5.3.6. Stakeholders should provide clear and publicly accessible avenues of contact for enquiries.

5.3.7. Ideally, information sharing should be multi-level and as diverse as possible. It will be most frequently between lunar operators and international or national regulators or authorities to aid in coordination and transparency.

5.3.8. Information should be shared to the extent feasible, subject to legal limitations such as export controls, the protection of intellectual property and other proprietary information.

5.4. Type of information

5.4.1. Lunar operations: including the coordinates of safety or other zones, nature and duration of the operations, changes in the nature of the activity in the course of operation, technical parameters and equipment used, any identified technical vulnerabilities, environmental impact assessments of harm and harmful consequences and mitigation measures proposed to address them.

5.4.2. Scientific: consisting of raw or processed data, results from scientific analysis, or any other information leading to an enhanced understanding of the Moon

5.4.3. Natural hazards: space weather, radiation, asteroid passes or meteorite bombardment, or any other information relevant to the safe operation of plants or personnel.

5.4.4. Lessons learned: anomaly resolution and improved operational practices.

5.4.5. Locational information is recorded and provided in a commonly understood set of GIS coordinates.

Chapter 6: Safe Operations and Lunar Environmental Protection

In conducting lunar activities, there will be a need to consider a balance among the interests of environmental protection, scientific research, heritage management and commercial viability. The following measures shall be encouraged in order, to the extent possible, to avoid causing adverse changes to the lunar environment or cislunar space and avoid harmful interference to other lunar operators and stakeholders

6.1. Safety Zones

6.1.1. Safety zones for lunar activities are an essential technical means for implementing core tenets of international space law, including information sharing, consultation, avoiding harmful interference, fulfilling due regard obligations, and providing certainty to operators. Safety zones would contribute to building trust, facilitating coordination, and sustaining peace and security in outer space.

6.1.2. Establishment of safety zones:

6.1.2.1. Safety zones are purely informational and are to be consistent with the principle of free access under Article I and the principle of non-appropriation under Article II of the Outer Space Treaty (1967).

6.1.2.2. Prior to establishing safety zones, the responsible State for a lunar activity should consult with stakeholders whose current and planned lunar activities would be potentially affected by the establishment of such zones.

6.1.2.3. The responsible State for a lunar activity that intends to establish a safety zone should carry out research on the scope, duration, and nature of the safety zone in accordance with commonly accepted scientific principles and sustainability considerations.

6.1.2.4. The responsible State who decides to establish a safety zone based on the aforementioned research should provide notice to the United Nations Secretary- General.

6.1.2.5. Such notice should include sufficient information regarding the nature of the activity to enable other operators, non-governmental entities and governmental agencies in the vicinity (i) to maintain safety, (ii) to operate with their duty of due regard, and (iii) to avoid potential harmful interference that would require consultation under Article IX of the Outer Space Treaty (1967).

6.1.2.6. In such notice, the responsible State should provide explanations to support the scope, duration, and nature of the safety zone prior to its establishment.

6.1.2.7. If lunar activities change, the associated safety zone notification should be updated in a timely fashion, and the safety zones should be terminated when the relevant activity or activities are concluded.

6.1.3. Effect of safety zones:

6.1.3.1. The purpose of safety zones is to provide notice to others of the location and nature of an operator's activities in order to promote the safety of lunar activities and prevent harmful interference among lunar operations.

6.1.3.2. The establishment and management of safety zones should be guided by principles such as necessity, balance, optimization, and coordination and not result in the appropriation of any areas on the Moon or in its orbit by the responsible State and should not impede other stakeholders' free access to the Moon and its orbit.

6.2. Lunar Heritage

6.2.1. It is acknowledged that access to cultural heritage is a human right according to the UNESCO Universal Declaration on Cultural Diversity (2001) and the UN Universal Declaration of Human Rights (1948) Article 27.

6.2.2. Lunar activities should be conducted, to the greatest extent possible, to avoid causing adverse changes to lunar cultural and natural heritage.

6.2.3. Lunar heritage is a non-renewable resource which includes both tangible and intangible components.

6.2.4. Lunar natural and cultural heritage duly proclaimed either at the national level or designated by the competent international authorities should be managed in accordance with well-established norms, with due regard to the interests of all the pertinent stakeholders.

6.2.5. Management of natural and cultural heritage values is a key part of sustainable lunar activities, which contributes to free access to the Moon as well as the scientific exploration of the Moon.

6.2.6. The management requirements of lunar heritage should be examined on a case-by-case basis, balancing the specific characteristics and value of the heritage and the free access, exploration and use rights of all stakeholders. In this process, the principle of "Do as much as is necessary and as little as possible" (Burra Charter 2013) should be considered.

6.2.7. An assertion of natural or cultural heritage significance shall not lead to a national appropriation of the relevant lunar sites or areas, which is in contravention of the Outer Space Treaty (1967).

6.2.8. Management and mitigation strategies should be applied consistently across all classes of natural and cultural heritage according to the applicable national or international norms.

6.2.9. The safety of human persons takes precedence over the conservation of heritage.

6.2.10. The determination of heritage significance, management, and mitigation strategies for lunar heritages must proceed from an expert assessment of heritage significance based on the national law, bilateral or multilateral agreements or the standards of an appropriate international authority.

6.2.11. When a State has reason to believe that an activity or experiment planned by it or its nationals on the Moon would cause adverse changes to the cultural heritage sites formulated by others' lunar activities, it should undertake appropriate consultations with the relevant States before proceeding with any such activity or experiment, even if these sites are not yet designated as lunar heritage by relevant national law, by international agreements or by an appropriate international authority.

6.3. Debris Mitigation & Environmental Sustainability

6.3.1. Environmental Sustainability is defined as the status and ability to maintain the conduct of space activities on and around the Moon indefinitely into the future in a manner that realizes the objectives of equitable access to and the benefits from the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations.

6.3.2. In order to curtail the generation of space debris on the lunar surface and in lunar orbits, it is recommended that:

6.3.2.1. Space systems constructed for lunar activities should be designed to minimize the release of space debris to the greatest extent possible.

6.3.2.2. Stakeholders should limit the probability of accidental collision in orbit of /to or on the Moon.

6.3.2.3. Lunar infrastructure should be based on interoperability principles.

6.3.2.4. During normal operations within lunar orbits or on the lunar surface, stakeholders should avoid the intentional destruction of space objects and assets and other harmful activities which may generate unreasonable and unnecessary space debris.

6.3.2.5. Stakeholders should minimize the risk of post-mission break-ups, including those resulting from stored energy in their lunar activities.

6.3.3. Stakeholders should adopt appropriate measures, where necessary, and follow due regard and other principles under international law to prevent environmental harm to the Moon and to lunar orbits.

6.3.4. Prior to authorizing and/or conducting lunar activities, States and lunar stakeholders may take the following measures on the basis of up-to-date scientific research in line with any relevant COSPAR requirements:

6.3.4.1. Conduct and present an analysis of the environmental impact to determine any environmental harm of the lunar activities while bearing in mind the purpose of those activities; review and approval of the impact of the activity in a timely manner should balance the needs for long-term sustainability with the purpose of utilization of the Moon.

6.3.4.2. Plan for remediation or mitigation as appropriate, and provide proper notification of those activities; and

6.3.4.3. Request consultations with all interested stakeholders if the lunar activities may cause potentially harmful contamination to the Moon and lunar orbits.

6.3.5. States and international organizations should monitor any harmful impacts to the Moon and lunar orbits resulting from lunar activities for which they are responsible to the greatest extent feasible and practicable.

6.3.6. If a harmful impact resulting from a lunar activity is discovered or is reasonably expected to occur, the responsible States or lunar stakeholders should implement appropriate measures to respond to such harmful impact and consider whether the lunar activity should be adjusted or terminated.

6.4. Sites of Special Scientific Interest

6.4.1 In consultation with the international scientific community, areas of special scientific interest on the lunar surface may be identified as requiring special protective arrangements.

6.4.2 Any such special protective arrangements will be agreed upon in consultation with the scientific community and endorsed by competent bodies of the United Nations.

Chapter 7: Interoperability

7.1. Definitions

7.1.1. Interoperability is a key element of sustainable lunar activities. Interoperability is critical to improving international cooperation and benefit sharing, as outlined in the Outer Space Treaty (1967).

7.1.2. Interoperability enables projects, systems, and services to be used together or interchangeably to achieve enhanced quality or stability in their functions and utilities. Interoperability can be achieved at various levels by various means, and applies to the full range of systems and services employed in lunar activities, including spectrum, communications, navigation, transport, life support, and all other operations.

7.1.3. Interoperability requires coordination, consultation, and information sharing. International standardization initiatives will contribute to interoperability and should be promoted among lunar stakeholders.

7.1.4. Interoperability can be achieved among all types of lunar stakeholders by signing agreements or by adopting common standards.

7.1.5. Any information related to interoperability should be shared as widely as possible, to the extent permitted by the relevant protective requirements about intellectual property and other proprietary information, and user feedback should be incorporated into the design and manufacture of systems and services to achieve further interoperability.

7.2. Function of interoperability

7.2.1. Interoperability enables international cooperation and facilitates the effective participation of all lunar stakeholders.

7.2.2. Interoperability reduces the risk of systems and service failure and increases the safety and stability of lunar activities.

7.2.3. Interoperability assists in aiding persons in the event of accidents, distress, or other emergency situations and in avoiding catastrophic failures of equipment which might endanger persons or harmfully contaminate the lunar environment.

7.2.4. Interoperability supports the optimization of the use of resources by avoiding duplication of infrastructure, reusing materials, and facilitating repair and maintenance, which in turn contributes to reducing harm to the lunar environment.

7.2.5. Interoperability can facilitate optimization and reduce costs for lunar systems development and operation.

7.3. Common standards

7.3.1. Lunar stakeholders should be encouraged to develop and implement common standards of design, manufacture, construction, and operation and to adopt standard data formats, technical references, and procedures in order to achieve interoperability. In doing so, existing international standards should be considered and, if necessary, adapted for lunar activities.

7.3.2. Common interoperability standards should be technically neutral and should not become a barrier to equal participation in lunar activities.

7.3.3. Common interoperability standards should strive to achieve a balance between adhering to general practices and fostering innovations.

7.3.4. Common interoperability standards should start with the systems and services related to the materials and resources that are used by all lunar stakeholders (e.g., water, oxygen, regolith, spectrum, power).

7.3.5. Effective realization of interoperability will depend upon a culture of willingness, readiness, and capacity at all organizational levels during the entire lifecycle of lunar activity.

7.3.6. Common interoperability standards will change as technology develops.

7.4. Participation

7.4.1. Interoperability may lower the cost of entry into the lunar economy and encourages broader participation by non-spacefaring nations and private entities.

7.4.2. Common interoperability standards should not be used to exclude newcomers, particularly emerging space nations, or to enable collusion or anti-competitive behavior.

7.4.3. Lunar stakeholders should promote awareness and capacity building to enable emerging space nations to adopt common interoperability standards.

Chapter 8: Lunar Governance

8.1. Definitions

8.1.1. Lunar governance broadly encompasses all decision-making and management related to the full range of lunar activities, which, through multi-stakeholder engagement and dynamic interactive processes, supports sustainable exploration and use of the Moon.

8.1.2. Lunar governance addresses shared challenges and expectations related to the use and exploration of the Moon in order to ensure peace and security thereon, maintain sustainability and benefit all humankind.

8.2. Lunar governance adaptive framework

Lunar governance will be guided by a wide range of hard and soft law instruments and requires a complex and adaptive framework. It seeks to:

8.2.1. Respect general principles and norms such as those enshrined in international space law and soft law instruments, including but not limited to peaceful uses, due regard, non- interference, mutual understanding, non-discrimination, equal access, freedom of exploration, non-appropriation, information sharing and transparency, and international cooperation;

8.2.2. Ensure predictability, accountability, coherence, and synergy in a manner that fosters cooperation, including fair access and market competition among multi-stakeholders in lunar activities; and

8.2.3. Align governmental, intergovernmental, and non-governmental actors through an adaptive process, including public-private partnerships, private funding initiatives, and the application of new technologies.

8.3. Operationalization of the framework

Lunar stakeholders should strive to operationalize this multilaterally agreed-upon framework with a focus on the protection and management of the lunar environment and sustainable lunar activities. This process should include the meaningful involvement of stakeholders from developing countries.

8.4. Global space governance

Lunar governance should be considered within, and contribute to, global space governance, including the Space 2030 Agenda and the Guidelines for the Long-Term Sustainability of Space Activities, and as a pioneering project for deep-space governance.

Chapter 9: Benefits for Humanity

The common interest of all humankind in the exploration and use of outer space, including the Moon and other celestial bodies, is universally recognized. According to international law, lunar activities should be carried out for the benefit of all people, both present and future, irrespective of the degree of their economic or scientific development. In addition to promoting international cooperation, sharing the benefits of lunar exploration and use contributes to sustainability for present and future lunar activities, including the exploration and use of lunar resources.

9.1. Key principles of benefit sharing

9.1.1. Sharing the benefits of lunar exploration and use should be based on the principles enshrined in the Outer Space Treaty (1967) and informed by the Moon Agreement (1979), as well as relevant UN documents such as the 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 (1996) and the UN Declaration on the Responsibilities of the Present Generation Towards Future Generations (1997). Sharing the benefits of lunar activities should ensure the use of the Moon and other celestial bodies is exclusively for peaceful purposes.

9.1.2. Lunar stakeholders are encouraged to share the benefits of their lunar activities without discrimination of any kind, on the basis of equality and equal opportunities, and in accordance with applicable laws.

9.1.3. The exploration and use of the Moon shall be aimed at increasing the general prosperity and well-being of humankind. Benefits should be derived from sustainable lunar practices and contribute to sustainable development on the Moon and Earth.

9.1.4. Lunar benefit sharing can be a catalyst for information and benefit sharing on Earth. Benefit sharing is a two-way process, as recipients of benefits are able to develop a greater capacity to contribute innovation and support to lunar activities.

9.2. The benefits of lunar exploration and use for humanity

9.2.1. Lunar benefits may derive not only from activity on the Moon itself but from the efforts made on Earth to develop technologies and systems for lunar exploration and use. The benefits may be scientific, technological, social, or inspirational. These include, but are not limited to, the following examples:

9.2.2. Scientific benefits.

9.2.2.1. Lunar exploration and use will increase human knowledge of the Moon itself, the Earth-Moon system, the Solar System and the Universe. This knowledge has both intrinsic and practical value.

9.2.2.2. The lunar surface provides a platform for astronomical observations; in particular, the far side of the Moon provides unparalleled opportunities for radio astronomy.

9.2.2.3. Permanently shadowed regions at the lunar poles constitute unique areas that may preserve important records of the delivery of volatiles and organic materials to the inner Solar System, including the Earth.

9.2.3. Technological benefits.

9.2.3.1. Exploration and use of the Moon increase the diversity of human technologies and may vault humanity into a new phase of innovation.

9.2.3.2. Technological solutions created by science and industry on the Moon can be used for the benefit of people on Earth.

9.2.4. Social benefits.

9.2.4.1. Sustainable lunar activities can be the source of new models for cooperation and governance to promote greater peace and prosperity on Earth.

9.2.4.2. The lunar economy and its sustainable development will create a new economic sphere and promote cooperation between the space sector and non-space sectors.

9.2.4.3. The scientific and technological advances achieved by lunar activities will further promote education, training, and capacity building in the field of space science and technology.

9.2.5. Inspirational benefits.

9.2.5.1. The Moon has provided inspiration for social goods throughout the deep history of human existence in the form of music, art, literature and science.

9.2.5.2. Exploration of the Moon may help inspire more young people to take up scientific and technical education, leading to wider societal benefits beyond the space programme itself.

9.2.5.3. The exploration and use of the Moon will enhance and make accessible new sources of inspiration deriving from the closer engagement with the lunar landscape and environment.

9.2.6. Sustainability benefits.

9.2.6.1. Technologies, governance structures and science developed on the Moon can be used to help achieve the Sustainable Development Goals.

9.2.6.2. Studies of the ages of lunar craters will help refine our understanding of the impact threat to Earth from comets and asteroids. Space technology and infrastructure developed with the aid of lunar resources may also aid the interception of asteroids and comets, which might otherwise impact the Earth in the future.

9.2.6.3. Technologies developed through lunar activities can be used to sustainably use resources on other celestial bodies such as planets, moons and asteroids.

9.2.6.4. The utilization of lunar resources may ultimately help reduce environmental pressures due to mining activities on Earth.

9.2.7. Further exploration of the solar system.

9.2.7.1. The infrastructure established on the Moon and in its orbit can be utilized as a base or transfer point for deep space exploration to other celestial bodies. This reduces the costs and environmental impacts of deep space missions.

9.2.7.2. The Moon can be used to develop environmental, social and governance protocols which might be adapted for other celestial bodies.

9.3. Mechanisms for sharing the benefits of lunar exploration and use with humanity

9.3.1. Mechanisms for sharing may be different according to whether the benefit is scientific, technological, social, inspirational, sustainable or exploratory.

9.3.2. There is no one-size-fits-all solution for sharing the benefits of lunar activities. Lunar stakeholders are encouraged to consult to agree on the exact nature of the benefit shared and how to share such benefit. Diversity, inclusiveness and transparency are key elements to consider when developing such mechanisms.

9.3.3. Benefit sharing can occur across multiple levels and adopt different forms.

9.3.4. Scientific data and results, technical standards and skills, etc., should be translated into different languages to facilitate their wide dissemination and to benefit the greatest and most diverse groups of people.

9.3.5. An international framework should set out the rules for sharing benefits and facilitate their distribution, taking into account current international space law treaties and instruments.

9.3.6. Lunar stakeholders are encouraged to identify which benefits to share and factor sharing of such benefits into the early stages of project planning while acknowledging that not all benefits will be immediately available, and many may arise in the process of lunar activities.

9.3.7. Lunar stakeholders are encouraged to have regard to the desirability of making a portion of samples of lunar materials available to the international community for scientific investigation and to share scientific research results through channels of scientific exchanges, and in this regard, the provisions of the Outer Space Treaty (1967) and the principle of Open Science should be taken into account.

9.4. Role of developing countries and emerging space nations in benefit sharing

9.4.1. Partnerships, joint ventures and agreements between established and emerging space nations can enable the sharing of scientific and technical benefits. Well-resourced lunar stakeholders are encouraged to contribute to the relevant capacity building of developing countries and emerging space nations by undertaking programmes, creating partnerships and other appropriate means.

9.4.2. Information sharing enables those countries to participate in lunar exploration or to work with partners in order to share benefits without duplication of investment.

9.4.3. Sharing data and results with developing countries and emerging space nations can provide them with an opportunity to develop and contribute their own science to lunar exploration.

9.4.4. Collaboration between scientists from different countries, including developing countries, on experiments and data analysis, is a mechanism for inclusion and capacity building.

9.4.5. Space nations with lunar projects should be encouraged to invite astronauts from emerging space nations and provide training to them by mutual agreement.

9.4.6. Benefit sharing can take the form of allowing access to infrastructure, such as launch pads, processes and resources by agreement to enable participation by stakeholders from developing countries and emerging space nations.

Chapter 10: Sustained Lunar Economy

A lunar economy is an integral part of the space economy, should be oriented towards the global benefit of humanity, and should take into account environmental sustainability on Earth and on the Moon. Achieving a sustainable lunar economy is only possible by allowing equitable access to all stakeholders.

10.1. Drivers for a sustainable lunar economy

Space agencies, space industries, and science and technology institutions have implemented multiple pilot/ad hoc programs and initiatives related to the space economy, which provide an evidence base of operational knowledge and good practices to inform the development of a lunar economy.

10.1.1. A lunar economy should be based on a diverse set of customers that includes, but is not limited to, governmental actors, space-industry actors and customers from outside the space sector.

10.1.2. A sustainable lunar economy will be supported by lunar activities primarily funded by governments and increasingly by private investment enabled by governments and should create new economic opportunities to serve the general public and for the benefit and in the interest of all countries.

10.1.3. The development of long-term ground infrastructure on the lunar surface will be of critical importance to the emergence of a lunar economy. Such infrastructure could be a shared asset between governments as well as the private and public sectors, encouraging international cooperation and public-private partnership models. Examples of potential areas of shared infrastructure include landing pads, ground transport, and interoperable navigation and communication systems.

10.1.4. A sustainable lunar economy enables the long-term exploration and use of the Moon for continued access to the benefits deriving from lunar activities and resources.

10.1.5. A sustainable lunar economy should enable growth both on Earth and on the Moon, aiming at supporting the independence of lunar activities from supply from Earth as well as contributing to sustainable development on Earth.

10.1.6. Government space exploration programs will play a key role in establishing a lunar economy. In addition to allocating portions of national budgets for space activities, governments can also be supportive of the involvement of the private sector in lunar activities.

10.2. Involvement of developing countries in the development of a lunar economy

10.2.1. It is critical to involve developing countries in achieving a sustainable lunar economy. Such involvement might be achieved in various ways, including:

10.2.1.1. These countries could contribute by proposing a vision for the long-term development of a lunar economy;

10.2.1.2. A more direct and short-term approach would directly involve developing countries, based on their different capabilities, in existing and upcoming missions;

10.2.1.3. Sharing scientific and technical information are critical steps to involve developing countries in the lunar economy.

10.2.2. The special needs of developing countries and opportunities provided by their distinct attributes are important for consideration related to the lunar economy.

10.2.3. Providing partnership opportunities to developing countries, including those with emerging space capabilities, is important to further develop their capacity and contribute to the lunar economy.

10.3. Role of terrestrial industry sectors in the development of a lunar economy.

10.3.1. The development of a lunar economy will draw upon experience from both terrestrial sectors as well as other areas of the space economy.

10.3.2. The involvement of non-space industry actors in lunar activities could lower costs and close knowledge gaps. Such involvement might be achieved by:

10.3.2.1. Raising awareness among non-space sectors on the role and value of a lunar economy;

10.3.2.2. Promoting the inclusion of a lunar economy dimension in the general industry policies;

10.3.2.3. Providing platforms and fora to foster exchanges between lunar stakeholders and other industry sectors. In this regard, the specific role played by local governments and other special economic zones and authorities in economic development should be acknowledged.

10.4. Regulatory needs for a sustainable lunar economy.

10.4.1. As the number of lunar activities and stakeholders increase, regulatory measures will be needed for the long-term growth and function of a lunar economy.

10.4.2. The lunar economy, in particular commercial investments, and activities, requires some level of legal certainty and predictability to develop.

In this regard, special consideration should be given to the protection of proprietary information and intellectual property rights without prejudice to the legal obligations under the OST.

10.4.3. Regulatory approaches in support of a sustained lunar economy should be adaptive in nature and achieve a mutually agreed balance between enabling investments while reducing uncertainty.

Chapter 11: Human Interaction

A key part of the sustainable and peaceful use of the Moon is maintaining harmonious relations between lunar stakeholders, including the individuals they comprise. Human interactions on the Moon are governed by international treaties, national legislations and other international norms, among which the principle of international cooperation and protection of human rights are the most important. As a lunar community develops and lunar stakeholders and activities increase, it will be important to prevent emergencies and disasters, disputes, and human rights violations. Achieving this requires appropriate regulation of human interactions.

11.1. Emergency support services

11.1.1. Principles of cooperation and mutual assistance to astronauts and personnel, as well as international obligations to notify, rescue, return and take all possible steps, and render all necessary assistance in space and on celestial bodies to them, are outlined in Article 5 of the Outer Space Treaty (1967) and the Rescue Agreement (1968), and further reinforced in the Moon Agreement (1979). It is noted that the Rescue Agreement focuses mainly on personnel returning to Earth; however, these principles should be applicable, *mutatis mutandis*, to any person on the Moon or in cislunar space.

11.1.2. As a first step, all States conducting lunar activities are encouraged to become a Party to the Rescue Agreement (1968).

11.1.3. Emergency support services for lunar activities can be built upon relevant principles and norms, including the *negotiorum gestio* and/or the Good Samaritan principles that rescuers acting on a voluntary basis in assisting a person in distress cannot be sued for wrongdoing.

11.1.4. To enable interoperability and provide legal certainty about procedures, rules, and responsibilities for managing emergencies and disasters, it is suggested that lunar stakeholders develop codes of conduct, and common standards, leveraging relevant experience with human spaceflight, to achieve rapid responses and clear communications.

11.1.5. The protection of human life on the Moon is paramount and should be prioritized in response to any emergency situation. It will be the joint duty of all lunar stakeholders to cooperate and coordinate to take all necessary steps in order to manage the safety of persons during emergency situations.

11.1.6. All lunar stakeholders should follow the due diligence principle to provide safe working conditions for their space-based persons.

11.1.7. In developing the most suitable mechanisms for emergency and disaster responses, lunar stakeholders should take into account the unique conditions of the lunar environment that are likely to create emergencies and disasters which have no precedent on Earth, and return to Earth may not always be possible for space-based personnel.

11.1.8. Lunar stakeholders should undertake to provide, either singly or in collaboration, material resources and relevant training to afford safety to personnel in the event of an emergency. These may include but are not limited to access to radiation shelters, pressurized pods, supplies of oxygen, food and water, first aid kits, and portable communication kits. These resources may be surface-based or located in orbiting modules. Such training and support can be shared between stakeholders.

11.1.9. To prevent and manage emergency situations on the Moon, lunar stakeholders should use satellite monitoring and detection services and share information with other stakeholders to reduce the risk of emergencies and facilitate better preparation for response and mitigation.

11.1.10. For lunar activities, a dedicated frequency should be established to make emergency requests. Human lunar stakeholders should use this communication channel for emergencies to request help. Lunar operators receiving these requests should respond accordingly.

11.2. Individual rights

11.2.1. Lunar stakeholders are bound by international human rights law, consisting of the UN Universal Declaration of Human Rights, the International Covenant on Civil and Political Rights (1966) and the International Covenant on Economic, Social and Cultural Rights (1966) as per Article III of the Outer Space Treaty (1967), and other relevant human rights international treaties.

11.2.2. National legislation and/or policies should guarantee the protection of individual rights on the Moon for personnel from those nations.

11.2.3. Where relevant, conditions to maintain the physical and mental health and safety of space-based personnel should be guided by the COSPAR and World Health Organization's recommendations.

11.3. Dispute settlement mechanisms

11.3.1. The existence of disputes between lunar stakeholders shall not be allowed to compromise the safety of space-based actors.

11.3.2. The purpose of dispute resolution is to maintain harmonious relations in lunar activities and ensure the exclusively peaceful use of the Moon. Disputes may be settled on the Moon and from

Earth, using existing mechanisms adaptable to the unique lunar situations as well as any future mechanisms established by lunar stakeholders.

11.3.3. As stakeholders and sponsors of lunar activities, States are responsible for resolving disputes between them peacefully, preferably through amicable methods such as negotiation, mediation, arbitration, and judicial settlement.

11.3.4. States are recommended to include acceptance of dispute settlement mechanisms in their cooperative agreements.

Chair's Explanatory Note on Annexes

In addition to participating at plenary discussions, the members of GEGSLA also formed four sub- groups. Under the instruction of the Chair, subgroups worked intensively through regular meetings to advance topics which are developed in the plenary. The outcome of the sub-group deliberations was compiled in a separate document titled *Technical and Operational Practices and Case Studies on Peaceful and Sustainable Lunar Activities*.[1] Furthermore, upon the Chair's suggestion, the observers of GEGSLA through their collective efforts identified *A List of Future Issues of Sustainable Lunar Activities*[2] which are not covered by the Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities, and recommended it for further discussions at a later stage.

The Chair on behalf of the Bureau of GEGSLA thanks the members of the sub-groups and observers for their efforts to enrich the evidence base and to further the perspective of our joint initiative towards peaceful and sustainable lunar activities, and takes the liberty to share the aforementioned two documents with interested lunar stakeholders.

The Chair would like to note that due to time constraint, GEGSLA did not have time to discuss aforementioned two documents, therefore they should be treated as separate and independent from the Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities which was adopted by the GEGSLA plenary in consensus.

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[1] https://moonvillageassociation.org/gegsla-annexes/
[2] https://moonvillageassociation.org/gegsla-annexes/

GEGSLA Members

Members of the Group participated on a personal basis and any views expressed at the meetings or by the Group do not represent the position of organizations to whom members may belong.

Here is the list of Members in alphabetical order:

Ayman Ahmed is the Head of the Space Imaging division at the Egyptian Space Agency- EgSA, He is a member of EgSA board of directors and member of Egyptian National Space Council, a Member of the African space Working Group to Develop African Space Policy and Strategy, a Member of the Industrial Advisory Board, Coventry University. Ayman has a Master's degree in Business Administration and Ph.D. in satellite earth observation systems. He coordinated a number of space projects at national and international levels, received the united nation office of outer space affairs– UNOOSA prize 2021, and has a patent in improving the performance of electronic systems in the space environment.

Nasr Al-Sahhaf has practical experience, academic, scientific research, as well as government and diplomacy. He served as advisor to the Royal Private Affairs and represented KSA at the UNCOPUOS. He established the National Space Geodesy Center in 2009, and, as principal investigator, set out to establish the first of its kind project in the region, COGNET. A network of Continuous Operating Receiver Stations (CORS). Under his supervision a team of engineers and technicians were able to successfully build (in-house) an atomic clock. thus, reviving the Saudi Arabian Laser Ranging Observatory (SALRO). He is currently Chair of the International Moon Day Group.

Ioana Bratu is a lecturer and researcher at Vrije Universiteit Amsterdam, where she is introducing space law as a new area of law part of the educational curricula. She is also a founder of AI & Space Law Society, an internationally unique concept advocating for the sustainable development of space via a newly recognized United Nations SDG 18. Before joining the academic environment, she was an attorney-at-law for more than 10 years part of international law firms and as a founder of her private practice.

Irina Chernykh is an Assistant Professor at the Department of International Law of Law Institute at RUDN University. The main focus of her research is on international space law, especially the sustainability of outer space activities. She is responsible for the Centre of International Space Law named after prof. Gennady Zhukov at the same Department. She teaches various international legal disciplines in the full-time and evening department. She leads the student team for the Manfred Lachs Space Law Moot Court Competition and holds the position of the Executive Secretary of Space Law Research journal. She is a member of the International Institute of Space Law.

Ian Christensen is Director of Private Sector Programs at Secure World Foundation (SWF), a non-profit organization promoting the secure, sustainable and peaceful uses of outer space. He is responsible for leading SWF's engagement activities with the commercial space industry, where his activities focus on policy and governance topics in support of the development of private sector space capabilities. Mr. Christensen was a member of the Hague International Space Resources Governance Working Group, where he chaired the Group's Socioeconomic Panel. Mr. Christensen holds a Master of Arts (M.A.) in international science and technology policy, focusing on space policy from the George Washington University Elliott School for International Affairs.

Timothy Cichan is the Space Exploration Architect at Lockheed Martin, where he leads a multi- disciplinary team of engineers who figure out how to help astronauts and robots visit the Moon, asteroids, and Mars. He previously was the Orion System Architect. Timothy joined Lockheed Martin in 2002, and has worked for both human spaceflight and commercial communication satellite teams, in optimal trajectory design, mission analysis, subsystem development, and systems engineering. He has a Master's and Bachelor's degree in Aerospace Engineering from Penn State.

Renata Corrêa Ribeiro has a Ph.D. in International Relations and works with International Space Cooperation at the Brazilian Space Agency since 2016. She has been a visiting scholar at Indiana University and conducted researches focused on space cooperation in emerging countries, published in important scientific journals. Since 2019, she has been actively engaging in COPUOS as a Brazilian delegate.

Ian Crawford is currently Professor of Planetary Science and Astrobiology at Birkbeck College, University of London. The main focus of his research is in the area of lunar exploration, including the remote sensing of the lunar surface and the laboratory analysis of lunar samples. Ian also has research interests in astrobiology and in the future of space exploration, which he believes will become increasingly important for the future of humanity. A more detailed summary of his interests, and list of publications, can be found at: https://www.bbk.ac.uk/our-staff/profile/8004655/ian-crawford

George Danos, Republic of Cyprus, Cyprus Space Exploration Organisation (CSEO).

Ziv Dubinsky is the founder of Metabolic Robots ltd from Israel, he is an inventor and entrepreneur dedicated to building strong agrifood tech solutions and sustainable space exploration. Ziv was awarded by the Israeli prime minister for innovation on his work on defense systems and food safety solutions, robots, welfare and efficiency AI, for poultry and insect farming. He is also owner of a pottery school.

Marc Fournier is a former engineer in environment in renewable energies that commits to open techs&science since 2008 by creating or co-operating open frameworks to engage citizen in open projects in Robotics, Medicine (Citizen research on cancer with ROCHE witch Epidemium), Science and Space (Space gambit with NASA/ OpenSpace Maker with CNES/ Mars Society/) and R&D projects. Cofounder of the citizen ScienceLab "La Paillasse" in 2011 which he was Secretary, Treasurer and Director until 2019. Lecturer for higher education establishments (Science PO, ESSEC, ENSCI...) Speaker for 50+ groups (BNP, Engie, GRDF, ...) & International conferences, Panelist in policy work group (French ministry of research on open science, Environment).

Mike Gold is the Chief Growth Officer at Redwire and is responsible for all of the company's civil, commercial, and national security business development; marketing/communications; and government relations activities. Prior to joining Redwire, Mr. Gold was NASA's Associate Administrator for Space Policy and Partnerships and also served as Acting Associate Administrator for the Office of International and Interagency Relations, and Senior Advisor to the Administrator for International and Legal

Affairs. During his tenure at NASA, Mr. Gold led the development and implementation of the Artemis Accords, the binding agreements for the Lunar Gateway, the first lunar resource purchase by NASA, and reforming/updating planetary protection policies. Due to this trailblazing policy work, Mr. Gold was awarded NASA's Outstanding Leadership Medal in 2021.

Alice Gorman is an internationally recognised leader in the field of space archaeology and author of the award-winning book Dr Space Junk vs the Universe: Archaeology and the Future. Her research focuses on the archaeology and heritage of space exploration, including space junk, planetary landing sites, off-earth mining, and space habitats. She is an Associate Professor at Flinders University in Adelaide and a heritage consultant with over 25 years' experience working with Indigenous communities in Australia. Gorman is also a member of the Advisory Council of the Space Industry Association of Australia.

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Dumitru-Dorin Prunariu is a member of the Board of the Romanian Space Agency. He is one of the founding members and former President of the Association of Space Explorers (ASE), was also the President of the Romanian Space Agency, the Ambassador of Romania to the Russian Federation, the Chair of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), Co-vice-chair of the COPUOS Working Group on Space2030 Agenda, representative of Romania in the International Relations Committee of the European Space Agency (ESA), Member of the Trustees Board of the International Astronautical Academy (IAA), the Vice-Chairman of the Board of Directors of the Asteroid Foundation. D. Prunariu earned a degree in Aerospace engineering (1976) from the University POLITEHNICA of Bucharest and a Ph.D. in the field of space flight dynamics. In May 1981 Prunariu accomplished an eight-day space flight on board Soyuz-40 spacecraft and Saliut-6 space station. For his accomplishments an asteroid was named with his name, the asteroid "10707 Prunariu".

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GEGSLA Chairmanship

Dumitru-Dorin Prunariu - GEGSLA Chairman
Timothy Cichan - GEGSLA Vice-Chair, Industry.
Alice Gorman - GEGSLA Vice-Chair, Academia.
Rajeswari Pillai Rajagoplan - GEGSLA Vice-Chair, Civil Society.

GEGSLA Secretariat

Giuseppe Reibaldi - MVA President & GEGSLA Executive Secretary

Dr. Reibaldi is a Senior Space Policy Adviser. Apart from being President of the MVA he also acts as the Executive Secretary of the "The Hague Space Resources Governance Working Group" which started under his initiative in 2015. Moreover, he is, since 2013, the Director of Human Spaceflight at the International Academy of Astronautics. For 35 years (1977- 2012) he worked for the European Space Agency covering different functions and fields.

Giuliana Rotola - GEGSLA Implementation Support Officer

Ms. Rotola is a space law and policy researcher. She holds a Law degree from the University of Trento and a Master of Space Studies from the International Space University. Previously, she worked at the European Southern Observatory, as a research fellow with the Legal Priorities Project, the Center for Space Governance, and the Open Lunar Foundation. She serves as Policy and Advocacy Coordinator for the Space Generation Advisory Council.

The Secretariat liaise with the Members and Observers of the Group, maintain a dedicated website and social media, organize meetings, lead discussions, and prepare documents. The Chairman, the Vice-Chairs, or Executive Secretary represent the Group in external events. Each Vice-Chair represents a Stakeholder group.

GLOBAL EXPERT GROUP ON SUSTAINABLE LUNAR ACTIVITIES

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GEGSLA

ANNEX I - Technical Guidelines for Implementation of the Recommended Framework

&

ANNEX II - Future Issues

GLOBAL EXPERT GROUP ON SUSTAINABLE LUNAR ACTIVITIES

GEGSLA Chair's Explanatory Note

In addition to participating plenary discussions, the members of GEGSLA also formed four sub-groups. Under the instruction of the Chair, subgroups worked intensively through regular meetings to advance topics which are developed in the plenary. The outcome of the sub-group deliberations was compiled in a separate document titled *Technical and Operational Practices and Case Studies on Peaceful and Sustainable Lunar Activities*. Furthermore, upon the Chair's suggestion, the observers of GEGSLA through their collective efforts identified *A List of Future Issues of Sustainable Lunar Activities* which are not covered by the Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities, and recommended it for further discussions at a later stage.

The Chair on behalf of the Bureau of GEGSLA thanks the members of the sub-groups and observers for their efforts to rich the evidence base and to further the perspective of our joint initiative towards peaceful and sustainable lunar activities, and takes the liberty to share the aforementioned two documents with interested lunar stakeholders.

The Chair would like to note that due to time constraint, GEGSLA did not have time to discuss aforementioned two documents, therefore they should be treated as separate and independent from the Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities which was adopted by the GEGSLA plenary in consensus.

Introduction

The **Annexes I and II** are organized as follows:

Annex I (Technical Guidelines for Implementation of the Recommended Framework), assigned to Members, with the participation of Observers in working groups, covers technical guidelines around 4 parts: Lunar Information Sharing, Safe Operations and Lunar Environmental Protection, Interoperability, and Lunar Governance.

The Lunar Information Sharing part offers templates and protocols for supporting lunar actors in the global development of consistent LIS practices, together with a case study including the potential establishment of safety zones.

The Safe Operations and Lunar Environmental Protection part covers 3 sections, on Safety Zones, Heritage Protection, and Debris Mitigation and Environmental Sustainability.

The Safety Zone section recommends the establishment and public notice of Safety Zones when conducting lunar activity. While defining precise criteria for Safety Zones notice procedures, objectives, information, and consultation mechanisms, it is emphasized that Safety Zones are purely informational, have no inherent legal effect, and are subject to the principle of free access under international law. Furthermore, they should be updated if activities change and, being temporary in nature, should be terminated when activity is concluded.

The Heritage Protection section is briefly introduced then further developed in a reference document that can be found on the MVA webpage. Lunar Heritage sites fall under two categories, cultural and natural: a lunar cultural heritage site is any place with human material culture on the Moon or that is associated with intangible practices, representations, expressions, knowledge, or skills, that has historic, social, aesthetic, spiritual, or scientific significance for present and future generations. A lunar natural heritage site is any place, geological or landscape formation that has historic, social, aesthetic, spiritual, or scientific significance for present and future generations.

The Debris Mitigation and Environmental Sustainability section is developed then further enriched by technical recommendations developed in a reference document that can be found on the MVA webpage. Debris Mitigation covers both human-made and naturally created debris. Environmental Sustainability includes the ability to maintain the conduct of space activities on and around the Moon indefinitely into the future. Its practice is defined in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes. This is conducted in order to meet the needs of the present generations while preserving the outer space environment for future generations.

The Interoperability part refers to the development of common standards of design, manufacture and construction and/or operations to enable software and hardware components to be interchanged or operated in conjunction, to facilitate international cooperation, recycling and repurposing. It covers a around a dozen technical categories that are Avionics and computer components, Communication and navigation, Rendezvous and docking systems, Outboard robotics, including lunar equipment, Training of mission crews, Harmonization of training methods in terms of safety, Space Debris Disposal, Mechanical, Pneumatic-Hydraulic, Electric, Power Supply Systems, Safety Support Means of Crewed Missions, and Deployment Systems.

The Lunar Governance part defines governance as systematic and comprehensive management and decision making on issues related to the full range of lunar activities, consistent with the principles enumerated in the Outer Space Treaty and other relevant aspects of international law. Through multi-stakeholder engagement and dynamic interactive processes, lunar governance will enable the sustainable exploration and use of the Moon. Governance is the sum of all the ways through which members of the global society manage shared problems. It is a mean to promote cooperation between members and a process capable of producing effective results in the management of global issues. By expanding the definition of governance from Earth affairs to Moon activities, lunar governance is concerned with management of shared problems related to the use and exploration of the Moon and should be developed to ensure peace and security in outer space, to maintain the sustainability of lunar activities, and to benefit all humankind. After reviewing stakeholders and essential elements of responsible lunar governance, instruments for developing it and processes to implement it are being defined.

Annex II (Future Issues), assigned to Observers, contains a summary listing of matters pertaining to the peaceful, safe, and sustainable development of lunar activities, which, whilst not being assessed in the technical guidelines in the Recommended Framework Document main body and Annex I, nevertheless would require some international agreement, but not in the timeframe envisioned under the Recommended Framework document. These matters will therefore remain to be resolved in a later time frame. The contents of this Annex are not intended to overlap with matters considered in Annex I, and are deliberately limited to only a brief description and possible implications, carrying no implied priority order.

Finally, several directing principles have been guiding this work all the way:

a) This is a living document. It will evolve over time and will probably be revisited yearly.
b) This work is conducted in a collaborative and inter-disciplinary manner. It should be accessible and digestible by all, avoid using jargon, and it will be edited where necessary.
c) All participants have tried to anticipate many situations that will happen in coming decades of lunar activities, while putting forward mechanisms to mitigate what could possibly go wrong or become unsustainable.
d) Participants are also mindful of the fact that, until a clearer picture of lunar activities emerge, premature regulatory efforts may backfire, either by proving irrelevant, missing out on important cases, or stifling innovation.
e) At the same time, regulatory certainty is required in order for investors, major operators, and venture businesses, to be able to focus with more predictability on sets of solutions.

It is the intention of all participants for this work to contribute to support the development of lunar business, legal, and technical architectures, while enabling proper pathways for safe, peaceful, and sustainable governance of lunar activities, for the benefit of all humankind.

Table of Contents

- Safety Support Means of Crewed Missions
- Deployment Systems

PART D: Lunar Governance

n) Defining Lunar Governance
o) Responsible Lunar Governance
p) Stakeholders in Lunar Governance
q) A common approach to responsible lunar governance
r) Essential elements of responsible lunar governance
s) Instruments for developing responsible lunar governance
t) Implementation of Responsible Lunar Governance

ANNEX II - Future Issues

Introduction

Benefits for Humanity

Sustained Lunar Economy

. Concept of ‘priority Zones’

. International Framework of Governance

Human Interaction

Other

Conclusion

ANNEX I

Technical Guidelines for Implementation of the Recommended Framework

PART A: Lunar Information Sharing

Table of Contents

Introduction

Few contests that information sharing will play a critical role for the safety and sustainability of lunar activities. In this document, Lunar Information Sharing (LIS) is defined as the exchange of data about lunar activities among all stakeholders involved, carried out either under legal obligation, with the agreement of the involved parties or on a voluntary basis, as well as the wider dissemination of lunar data for the benefit of humankind. To the greatest extent practicable, information shared should be accurate, up to date and adequate for its purpose.

This document is divided into four sections. Section 1 gives a general overview about LIS by discussing foundational aspects such as its goals, object, actors, time and process. Section 2 offers templates and protocols for supporting lunar actors in the global development of consistent LIS practices. To complement this analysis, Section 3 presents a case study based upon an hypothetical scenario of private lunar operations, with special consideration to the potential establishment of safety zones as well as the limitations posed by intellectual property rights or national security concerns. Finally, Section 4 concludes the document by considering the way forward for the development of databases and institutions for hosting and reviewing information shared.

Section 1 - LIS Essentials

This section provides an overview of the essential components for effective and adaptive LIS.

1.1. Working definition

For the purposes of this document, Lunar Information Sharing (LIS) is defined as the exchange of data about lunar activities among all stakeholders involved, carried out either under legal obligation, with the agreement of the involved parties or on a voluntary basis, as well as the wider dissemination of lunar data for the benefit of humankind. To the greatest extent practicable, information shared should be accurate, up to date and adequate for its purpose.

1.2. Rationale

In our discussions we have identified the following main drivers for LIS (in no particular order):

u) Transparency, to promote confidence-building and preserve peaceful purposes.
v) Safety, to enable due regard and prevent potentially harmful interference.
w) Coordination & cooperation, to support interoperability and enhance sustainability.

1.3. Legal basis

We recognized the applicability of the following legal sources to Lunar Information Sharing:

- The Outer Space Treaty, and in particular its Article XI;
- The Registration Convention.

We also recognized the importance of the following UN resolutions:

- UNGA Resolution 1721 (XVI) B (International Cooperation in the Peaceful Uses of Outer Space)
- UNGA Resolution 61/101 (Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects)

1.4. Relevant Stakeholders and associated responsibilities

Sharing information about lunar activities is inherently a multi-stakeholder process. Pursuant to relevant norms of international space law, UNOOSA should be prepared to receive, organize and disseminate information received from States immediately and effectively. It is recommended that the following stakeholders might be involved as main focus: States, Operators, and Civil Society.

- *States*

Based upon applicable norms of international space law, States might be required to share information about their space objects and/or space activities with UNOOSA, other States, the general public and the scientific community.

- *Operators*

Based upon applicable norms of national space law and regulations, operators may be required to share information about their space objects and/or space activities with their licensing State.

- *Civil society*

On a voluntary basis, civil society organizations might support information sharing by developing and managing complementary databases for hosting additional information as either provided by operators or other reliable sources within the space community.

1.5. Issues, Hurdles and Obstacles

Needless to say, information sharing is not a completely uncontroversial endeavor. From our assessments we have identified the following issues, hurdles and obstacles.

- *Political Issues*

Political issues within the global arena might negatively affect information sharing among States. However, given that lunar activities are not about security and intelligence operations, States could be persuaded to see that there are in fact positive benefits from information sharing. Knowing what others are engaged in and removing suspicions could prove to be beneficial in the long run.

- *Social Hurdles*

Lunar activities as flagship projects of many spacefaring nations also come with significant social, cultural and political connotations, which might further complicate their calculation on whether and how to share information. Reiterating that space is part of the global commons and that states and other stakeholders all stand to benefit from information sharing could slowly open up states to engage in openness and transparency measures.

- *Intellectual Property & National Security Obstacles*

Intellectual property rights and national security concerns can significantly hamper the process of information sharing. Therefore, it is essential to prevent the abuse of these clauses as an *a-priori* obstacle to information sharing. More on these topics will be discussed in Section 3.

1.6. Key principles of Lunar Information Sharing

From the above analysis we can derive the following key principles for LIS:

- *LIS is a (critical) means to an end*

With information sharing we can achieve fundamental goals of international space law.

- *One size does not fit all*

Different purposes require different content and processes.

- *LIS is a multistakeholder effort*

Public and private actors need to be involved at different governance levels.

- *LIS is a benefit, not a burden*

Without information sharing we cannot protect activities from interference and conflicts.

- *Effective LIS requires follow up*

We need institutions to share, consult & conciliate on a stable and continuous basis.

- *The whole is more than the sum of its parts*

Centralized information on lunar activities could open new markets and opportunities.

Section 2 - Operational guidelines for LIS

This section provides suggested guidelines for the practical benefit of lunar operators. Subsection 2.1 presents suggested content and processes for achieving the various purposes of lunar information sharing. Subsection 2.2 discusses proposed templates and protocols to support pioneering operators in the global development of common practices for lunar information sharing.

2.1. Suggested content and processes

This subsection presents suggested content and processes for achieving the various purposes of lunar information sharing.

- *LIS for Transparency*

  Minimum content:

  - Nature of the activity (scientific or commercial; human or robotic; exploration or use)
  - Envisaged landing area and duration (start – end)
  - Space objects and/or humans involved (with description, e.g. rover, crew, tourist)
  - Contact information for consultation requests

  Envisaged processes:

  - Notification to the UN Secretary General under Article XI OST;
  - Public announcement:
  - Further information sharing via relevant international fora;

- *LIS for Safety*

  Minimum content (potentially under NDA):

  - Fundamental mission parameters, such as:
  - Nominal area of operations (including exact lunar coordinates);
  - Nominal evolution of operations (including envisaged changes in locations).
  - Safety impact assessment, such as:
    - Harmful consequences of operations (e.g. dust creation, radio-interference);
    - Vulnerabilities of operations (e.g. exposure to dust, sensitivity to vibrations);
    - Mitigation measures (e.g. safety/coordination zones).

  Envisaged process:

  - Article XI OST, *ad hoc* transmission upon motivated request from interested States.

- *LIS for Coordination & Cooperation*

  Minimum content:

  - Scientific discoveries (e.g. lunar surface composition, conditions of environment);
  - Technical parameters for systems' interoperability;
  - Lessons learnt from lunar operations for developing standards & guidelines.

  Envisaged process:

  - Public dissemination through media, contribution to lunar database.

Section 2.2. Proposed Templates & Protocols

To complement the previous suggestions on content and processes, this sub-section presents proposed templates & protocols to support pioneering operators in the global development of consistent practices for lunar information sharing.

- *Templates*

The development and use of templates for lunar information sharing might play a critical role in facilitating and streamlining the global development of best practices. To this end, this Annex would like to recall the pioneering work conducted in this area by individual GEGSLA Members within the context of the Article XI Project for the uniform application of an innovative Template for Sharing Information under Article XI OST.

- *Protocols*

Currently, the global landscape for information sharing is significantly fragmented. Each actor values information sharing in a different way and consequently adopts different approaches in undertaking it. This lack of minimum harmonization prevents the optimal use of information and might represent a critical risk to the immediate safety and long-term sustainability of lunar activities. To mitigate such a risk, this subsection provides a step-by-step process that lunar operators may wish to consider for the consistent development of global best practices in the area of information sharing.

a) Phase 1: Preliminary Assessment

First of all, all operators involved in lunar activities should appoint a Chief Information Officer (CIO) to create and manage relevant internal processes as well as coordinate with external stakeholders and partners.

Following, operators should engage in knowledge gathering, surveying the current landscape for information sharing as provided either in public sources or ad hoc consultations with experts and other operators. The discovered knowledge should then be used to conduct a preliminary SWOT analysis on the strengths, weaknesses, opportunities and threats of LIS for the given operator.

a) Phase 2: Documentation

After completing the SWOT analysis, operators should conduct an information audit to identify the types of data concretely produced by the organization and subsequently develop an internal repository. These data should be then categorized based upon their content, internal strategic relevance and external usefulness. As part of this process, operators might want to follow the well-known FAIR model, according to which data should be Findable, Accessible, Interoperable and Reusable.

a) Phase 3: Strategy

Combining the results of the SWOT analysis with those of the internal information categorization, operators could develop a strategy to govern their LIS engagements in accordance with their legitimate interests and in compliance with applicable legal obligations. This strategy should lead to the development of guidelines for the internal collection and external dissemination of information through the establishment of disclosure levels and related procedures. These guidelines should be tailored to the specific purpose of information sharing (among the three identified in the previous section) as well as to the relevant target audience. The strategy should also foresee the development of post-release evaluation mechanisms for continuous improvement, as well as the inclusion of a public point of contact for any question, request for consultation or opportunity for cooperation.

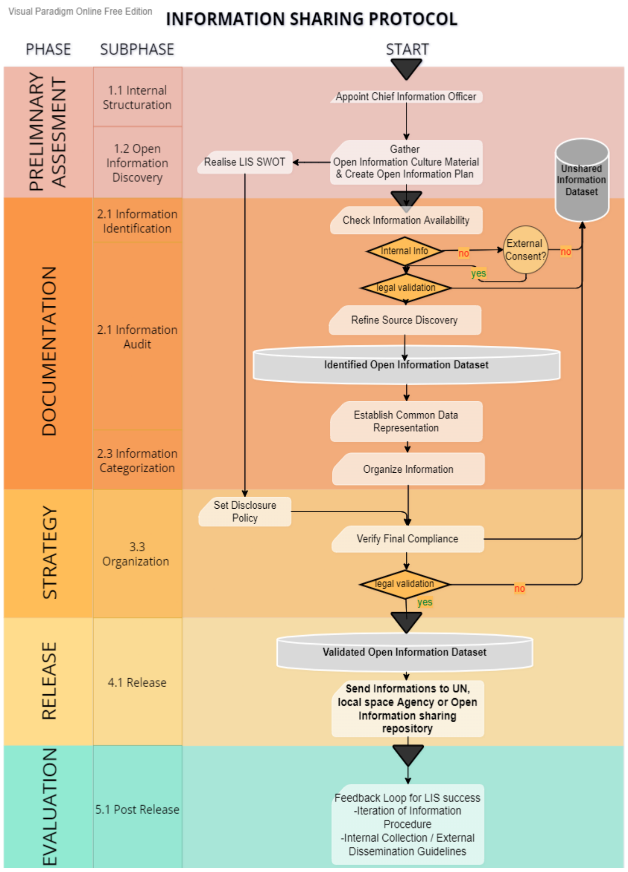
a) Phase 4: Release

In accordance with their dissemination guidelines, operators should release information based upon relevant disclosure levels and procedures, included but not limited to regulated disclosure of validation information as part of the exploration, mapping, and licensing processes. These processes may be required to quantify economically extractable reserves out of assumed resources, making that information available to relevant stakeholders.

a) Phase 5: Evaluation

Finally, operators should build a feedback loop for evaluating the success of their LIS engagements in accordance with the goals and procedures laid down in their strategy. This should include dedicated mechanisms for the concrete modification of the strategy itself, as well as of the internal collection and external dissemination guidelines.

The flowchart below summarises the above-described phases in a visual manner.



Finally, the table below provides four strategic goals for the development of an Open Information Culture that might facilitate the implementation of the above protocol on LIS. Each strategic goal is designed to be specific, attainable, targeted and measurable. The table further defines strategic objectives as clear descriptions of the main actions that must be taken to achieve each goal. They are designed to be the "bridges" that take operators from where they are today to where they need to be with respect to LIS.

Strategic Goal	Description	Strategic Objectives
Goal #1: Institute Uniform Information Sharing Policy and Governance	Enable the transformation of culture necessary for information sharing: policies, governance models, standards, personnel formation, and compliance mechanisms.	a) Develop a policy framework to increase information sharing across the Structure and with external partners and customers. b) Establish governance mechanisms to instill common practices for information classification, clearance processing, and policy and standards compliance. c) Reduce risks to civil liberty and privacy infractions from greater information sharing. d) Ensure policy implementation through institutionalized training programs and standards for information sharing policies and procedures. e) Resolve information sharing disputes.

Goal #2: Advance Universal Information Discovery and Retrieval	Advance information search, discovery, retrieval, dissemination, and pervasive connectivity through common metadata tagging.	a) Define common metadata tagging standards for information to achieve discovery, search, and retrieval objectives. b) Establish "universal discovery" processes, procedures, standards, and tools to support information transparency. c) Develop retrieval protocols to information repositories based on analytical focus, mission needs, and identity attributes. d) Integrate Open information networks at each possible level.
Goal #3: Establish a Common Trust Environment	Put in place uniform information identity attributes, management, information security standards, information access rules, auditing, and access control to promote common trust.	a) Define a uniform information structure and uniform attributes to enable information management, develop uniform standards and guidance for information management, and support decentralised, stakeholder-specific implementation. b) Establish information management standards for authentication, authorization, auditing, and cross-domain services. c) Develop information security policies to support logical and physical data protection efforts. d) Create a common classification guide for the Space Community. e) Establish a risk management approach that supports the common trust and information environment while still protecting sensitive information from disclosure.
Goal #4: Enhance Collaboration Across the Community	Develop the tools and incentives necessary at the institutional, leadership, and workforce levels to collaborate and share knowledge and expertise and information.	a) Develop information sharing communication programs to create awareness of a "responsibility to provide" culture. b) Create award and assessment programs to transform the culture from a "need-to-know" to a "responsibility to provide" mindset. c) Serve as an integration point for establishing a virtual collaboration environment to facilitate collaboration and information sharing among Community (e.g., analysts and collectors). d) Enable the Community stakeholders and partners to connect on a time-imperative basis to fulfil their mission requirements.

Section 3 - A case study

This section contains a case study intended to illustrate how States should share information in a manner that satisfies their legal obligations to register space objects and share information regarding space activity under the Outer Space Treaty and other instruments of space law.

3.1. The Scenario: Lunar Water Works SA

Lunar Water Works SA (LWW), a company incorporated in State A, is planning to undertake multiple lunar missions (i) to prospect for water ice on the south pole of the moon, (ii) to harvest the ice, and (iii) to process the ice into usable water, oxygen, and hydrogen. To power the operation, LWW will also operate the LWW Solar Energy Farm located at a Peak of Eternal Light on the rim of the Shackleton Crater.[1] The entirety of LWW's operations (including prospecting, harvesting, processing, and the solar farm) would take place within a square area measuring one (1) km by one (1) km.

3.2. How to Share Information About Safety Zones?

There are two primary methods of sharing information through the United Nations: the Registration Convention Register and the Article XI OST Index. It is recommended that all State Parties to the Outer Space Treaty always share information through submissions to the Article XI Index due to its better suitability to lunar missions. As a complement to that, all State Parties to the Registration Convention should also ensure that their space objects are duly registered as required under the Convention

Safety zones are intended to ensure the safety of operations and crews ~~astronauts~~ while also helping to avoid harmful interference by providing information about the location and nature of activities on the Moon. The dimensions of a safety zone are determined unilaterally by the responsible State upon consideration of the location and nature of the protected activity.

Safety zones can be viewed as "buffer zones" around the site where operations will take place. If this perspective is adopted, State A would share the dimensions of this "Zone of Operation" in which an actor will be conducting operations on the surface of the moon. Further, the submitting State should also provide the dimensions of one or more types of safety zones.

For this case study, three areas will be described (including two types of safety zones):

a) The Zone of Operation (ZoO)
The general area in which activities will be conducted.

b) The General Safety Zone (GSZ)
The area surrounding the ZoO in which other actors should operate in light of (1) their duty to exercise due regard and (2) the potential need of undertaking appropriate international consultations prior to entering or operating within the GSZ.

c) The Launching and Landing Safety Zone (LLSZ)
The area surrounding the ZoO within which other actors should launch or land a space vehicle in light of (1) their duty to exercise due care and (2) the potential need of undertaking appropriate international consultations prior to launching or landing within the LLSZ.

In determining the dimensions of the GSZ and the LLSZ, State A would take into account the particular nature of LWW's operations including (i) LWW's plan to prospect for and harvest ice throughout the ZoO and (ii) the operation of solar panels that can be harmed if covered by dust created by the launching or landing of a space vehicle.

The following paragraph provides a minimalistic example of the type of information that should be submitted to the Article XI Index regarding LLW's mining operation. Note that this information includes not only coordinates and land measurements, but also describes (i) the particular nature of the protected activity and (ii) the reasons underlying the dimensions of the zones.

- *Zone of Operation (ZoO)*

The ZoO will occupy a square area measuring 1 km by 1 km.

- *The General Safety Zone (GSZ)*

The General Safety Zone extends two (2) kilometers beyond the borders of LWW's operations. The outer borders of the GSZ form a square measuring 5 km x 5 km.

- *The Launching and Landing Safety Zone (LLSZ)*

A Launching and Landing Safety Zone (LLSZ) extends four (4) kilometers beyond the borders of LWW's operations. The outer borders of the GSZ form a square measuring 9 km x 9 km. This LLSZ is necessary to prevent potential harmful interference with the operation of LWW Solar Energy Farm due to the settling of dust on the panel faces or the accumulation of dust on the mechanical gears that allow the panels to be properly oriented.

Although different from the types of safety zones discussed above, State A might also conceivably use the Article XI Index to share information that would have the effect of protecting LWW's Solar Energy Farm from the risk of sunlight being blocked by new installations (such as a row of parked SpaceX Starships). To protect against such interference by providing notice, State A might consider providing the following information for inclusion in the Article XI Index:

The operation of the LWW Solar Energy Farm could be adversely affected by the construction of new installations which (whether individually or collectively) harmfully interfere with the efficient operation of the Farm's solar panels.

Although the Registration Convention only requires the registration of an object that has already been "launched" into space[5], Article XI of the OST allows for the sharing of information at any time. For maximum transparency, we recommend that information regarding space activities should be notified to the UNSG *prior to* the commencement of the activity. Such prospective submissions may help prevent potentially harmful interference between the forthcoming activity and other ongoing or future lunar activities. As the activity commences and evolves, State A should make supplemental submissions in order to add to and update the information in the original submission.

3.3. Potential Limitations due to Intellectual Property & National Security Concerns

LWW plans to use mining equipment of a certain type that will provide it with a significant competitive advantage. This mining equipment happens to be particularly vulnerable to lunar dust which harms the rotary action of the equipment. LWW should not be required to share such information in order to maintain its competitive advantage.

Having said that, even if LWW is not required to disclose information regarding resource location and the nature of its mining equipment, it may be in LWW's benefit to do so. For example, by explaining that its equipment is vulnerable to lunar dust, other operators will be placed on notice and will be obliged under international law to conduct their operations in the vicinity in a manner that pays due regard to the legitimate interest of LWW to protect its mining operations from potentially harmful interference caused by the creation of lunar dust.

Article XI OST provides that States "inform the Secretary-General of the nature, conduct, locations and results of [space] activities" only to the extent that sharing such information is "feasible and practicable." If State A prohibits the disclosure of sensitive technologies to foreign persons under its export-control laws and regulations (including disclosure by the State), the sharing of controlled data would not be "feasible" on the grounds that it would violate national legislation. Even if not in violation of a domestic law, the sharing of sensitive technologies might be neither feasible nor practicable due to national security concerns. For either reason, State A would be excused from sharing said technology with the Secretary-General.

As is true with controlled technology, Article XI does not require States (and by extension, their private operators) to share proprietary business information or intellectual property if disclosure is not "feasible and practicable." In other words, operators are excused from sharing information that would cause significant harm to a significant and legitimate business interest. Underpinning this concept is the need (and the right) of operators to maintain its financial viability and competitive advantages. For example, LWW would not be required to disclose proprietary information that would rob LWW of a key competitive advantage, such as knowledge of the precise location of rich ice resources, unless that would be required by legal obligations under either national or international law. Another protected type of information might be a description of proprietary confidential technology (whether or not the technology is protected by a patent or other intellectual property law) that LWW will use in its mining operations. The question here is (1) whether the information at issue is proprietary and confidential and (2) whether disclosure would cause significant harm to the operator's business interests.

Section 4 - Way Forward for the Development of LIS Datasets and Institutions

Information is only as powerful as are the means available for putting it into fruition. This is the reason why in SG1 we decided to complement our work on practical tools and case studies for lunar information sharing with actionable proposals on the development of datasets and institutions to respectively host and manage lunar information sharing.

4.1. Datasets

The importance of dedicated datasets for lunar information sharing stems from the many benefits produced by information when meaningfully organized. If properly arranged, raw data, information and knowledge on lunar activities might become a powerful tool of coordination and cooperation.

In accordance with Articles I and III OST, information sharing can be a powerful way to share the benefits of lunar activities with all humankind through international cooperation. To serve these purposes, we suggest the complementary use of governmental and non-governmental datasets, and to organize both of them around the key principles of openness and transparency.

- *Governmental Datasets*

Governmental datasets would be those developed and managed by either a national government or the UN Office for Outer Space Affairs (UNOOSA). These datasets would be fed with information officially collected by States (e.g. through their licensing processes) and then hosted in their national registries or internationally shared through diplomatic channels under Article XI OST, the Registration Convention or Resolution 1721(XVI) B. Among these channels, we recognize the potential of the "Index on Submissions by States under Article XI OST" to serve as the primary platform for hosting information about activities in the exploration and use of the Moon.

At present, concretely useful information required under Article XI OST (such as nature, location and duration of a given activity) are not *prima facie* visible in the Index. Further, the Index hosts all notifications and submissions ever sent by States under Article XI OST since 1967, which makes it difficult to use it for lunar coordination purposes. To address these issues and enhance the practical relevance of the Index, we suggest to create a sub-section dedicated to lunar activities and arrange it with a more *user-friendly* interface displaying information on actual *missions* rather than State's notifications or *submissions*, as exemplified in the figure below.

1 Example of Lunar Index interface

Mission	**State(s)**	**Operator(s)**	**Status**	**Nature**	**Location**	**Duration**	**Additional information**
Artemis 1	USA	NASA	Planned (March 2022)	Technology demonstration	Circumlunar orbit	25 Earth days	[hyperlink to submission]

- *Non-Governmental Datasets*

By definition, non-governmental datasets would be all those set up by non-governmental entities. These platforms would be fed with information on lunar activities either discovered by their managers or submitted by external contributors. Non-governmental databases would allow all interested entities to participate in lunar information sharing and could ensure the inclusion of other types of information that would not be normally hosted in formal databases (like detailed technical parameters or constantly updated data). To serve these purposes, we recommend the development of a global, neutral and interactive platform publicly and freely available for consultation as well as open to contributions from all stakeholders based on open-source licensing. Any non-governmental entity interested in setting up such a dataset is welcome to contact SG1 to explore opportunities for cooperation and synergies.

- *Coordination Mechanisms*

The practical usefulness of lunar information will critically depend on the ability to align data provided by different sources in a consistent manner. Thus, in addition to setting up various datasets for hosting lunar information, we consider it is important to ensure institutional coordination among them with a view to improving the quality and utility of the lunar information stored therein.

According to Article XI OST, Member States have an obligation to share information about their lunar activities (as a category of "activities in outer space") with the UNSG, the public and the international scientific community, which logically calls upon these three receivers to coordinate among themselves to better use of the shared information. Either voluntarily or preferably through an institution, regular and interactive engagement between different lunar datasets should be promoted as a critical means for lunar sustainability.

4.2. Institutions

For the above reasons, we consider the development of templates and protocols for lunar information sharing, followed by the organization of shared information in dedicated lunar databases, to be critical but also preliminary steps. As more and more actors engage in the exploration and use of the Moon, the likelihood of potential overlaps across lunar activities - for good or for worse - will grow substantially. Whether these overlaps will end up in conflict depends on the availability of recognized, effective structures and procedures to peacefully address them. In the lack of international lunar governance, the institutionalized opportunity for consulting about lunar activities is at least as important as the information shared about them.

a) *Institutional suggestions for "appropriate international consultations"*

Under Article IX OST, a State with reasons to believe that its space activities might harmfully interfere with those of other States shall undertake "appropriate international consultations". This broad expression has been chosen by the OST drafters to allow for the development of diversified solutions which can be tailored to specific space activities. The establishment of dedicated bodies for reviewing lunar information would provide an effective tool to conduct the "appropriate international consultations" required by the OST.

The question then becomes: *which institution?* In principle, the variety of entities operating within the space community offers many potentially good answers to this question. For example, a dedicated lunar consulting institution could take the form of an inter-agencies consultation body, following the example of the "International Space Exploration Coordination Group" (ISECG). Such an entity could also be developed as an expert-based multi-stakeholder platform, similar to what has happened with GEGSLA. Finally, it could be set up as a dedicated working group within UNCOPUOS, like the Legal Subcommittee has done in 2021 for space resources. While all these solutions have their merits and demerits, the truth is that none of the existing examples would prove to be an optimal solution. An inter-agency group would leave out private operators, while vice versa industry groups would do the same with space agencies. Significantly, both would lack tools to incorporate civil society's feedback and give consideration to interests from the general public. A multi-stakeholder platform like GEGSLA would lack the political mandate to take any decision, whereas a UNCOPUOS working group would have difficulties to act in a timely manner.

One way to develop an optimal solution would be setting up *all these entities* to each coordinate a specific segment of the lunar community. This polycentric approach would have the merit of bringing the development of potential solutions closer to their intended beneficiaries. At the same time, entrusting multiple entities with the same consultative function poses a serious risk of divergence. This risk could be neutralized by a formal distribution of competences among these entities coupled with the development of a shared forum for mutual exchanges of views among their representatives. However, while these mechanisms would contribute to minimum alignment, they would also add further layers of complexity impacting efficient and effective functioning.

b) *Summary of potential options for LIS Institutions*

a) Interagency Lunar Coordination Committee

Rationale: build upon the successful experience of the IADC, IDCC and ISECG
Pros: technically focused, legitimacy as expert body established by States
Cons: unfit to discuss legal and policy issues; excludes industry and private actors
Solution: expand membership to fill expertise and stakeholder's gaps

b) Lunar Coordination Forum

Rationale: spinoff combining GEGSLA, Registration Project, Moon Dialogues
Pros: inclusive and effective multistakeholder platform
Cons: lack of political mandate; unfit to consult/conciliate at high level
Solution: reconnect with decision-makers through appropriate institutional procedures

c) Lunar Coordination Mechanisms within COPUOS

Rationale: capitalize COPUOS' potential as the only Committee of UN General Assembly dealing with peaceful use of outer space and its universal representativeness
Pros: multilateral diplomatic body merging legal & technical expertise
Cons: unfit to respond in a timely manner; excludes private actors
Solution: hold single agenda item discussions at the Committee in preparation to the future establishment of a working group leveraging intersessional work and stakeholders' contributions.

d) Polycentric Governance

Rationale: one entity cannot deal with all the problems
Pros: polycentric approach with each institution playing its strengths
Cons: fragmented approach, risk of divergent solutions
Solution: develop formal allocation of competences and links among bodies.

Section 5 - Conclusion

The ideas expressed in this document are meant to provide constructive suggestions that could be rapidly implemented in relatively uncontroversial ways. They build upon existing international space law and are driven by the goal of supporting its faithful implementation in the context of lunar activities. We hope our considerations could trigger a global conversation on the consistent development of best practices for sharing information about lunar activities. With as many as 106 lunar missions planned for the present decade, we urge the international community to conduct said conversations in good faith and to approach them with a practical, not ideological, mindset.

PART B: Safe Operations and Lunar Environmental Protection

Table of Content

Section 1: Safety Zones

Executive Summary

This memorandum recommends the establishment and public notice of Safety Zones when conducting lunar activity. The following bullet points provide a brief summary of the recommendations:

a) When conducting lunar activity, the authorizing State should provide notice to the UN Secretary-General, to be publicly disseminated, of a Safety Zone surrounding the site of such activity with the primary goals of (i) ensuring safety, (ii) avoiding harmful interference, (iii) protecting the legitimate interests and rights of other States.

b) Notice of a Safety Zone should provide clear geographic dimensions determined in accordance with the principles of necessity, equilibrium, optimization, and coordination.

c) Notice of a Safety Zone should include sufficient information regarding the nature of the activity to enable other operators in the vicinity (i) to maintain safety, (ii) to operate in compliance with their duty of due regard, and (iii) to conduct appropriate consultation under Article IX of the Outer Space Treaty to avoid harmful interference.

d) Safety Zones are purely informational, have no inherent legal effect, and are subject to the principle of free access under international law.

e) Safety Zones should be updated if activities change and, being temporary in nature, should be terminated when activity is concluded.

a. Introduction

Beginning in 2022, a steady procession of missions to the surface of the Moon will commence, undertaken by multiple space agencies as well as private operators. These missions, which will include both crewed and robotic missions, will involve a variety of activities including, among other things, scientific exploration, the establishment of human habitats, solar energy farming, and resource extraction and processing. Considering multiple missions being undertaken in similar locations (such as the polar regions), there is a risk of harmful interference and potential legal and political disputes among operators. In order to avoid or solve such issues, the establishment of so-called “safety zones”[1] have been proposed in various fora.

b. Purpose of Safety Zones

The purpose of safety zones is to provide notice to others of the location and nature of an operator’s activities in order to:

- promote the safety of lunar activities;
- avoid harmful interference among lunar operations; and
- prevent legal and political disputes among concerned parties.

[1] The international community could consider whether a term other than “safety zone” would be more appropriate. One alternative would be “notification and coordination zone”.

c. Definitions

- Safety Zone: an area with clear geographic parameters publicly noticed surrounding the site of lunar activities established in order to ensure safety, avoid harmful interference among lunar activities, and prevent disputes arising from legitimate rights and interests.[2]
- Authorizing State: the State which authorizes and supervises lunar activity and establishes the related Safety Zone.

d. Objective of International Framework of Safety Zones

Any international framework regarding Safety Zones should have the following as its objectives:

- The recognition and protection of legitimate rights, interests of all relevant parties;
- The resolution of existing or potential disputes; and
- The fair and efficient use of lunar resources for the benefit of all humankind.

e. Rationale for the Establishment of International Framework of Safety Zones

Four principles should be considered to formulate the international framework or mechanisms of safety zones, which are: necessity, equilibrium, optimization and coordination.

- The principle of necessity means that the Authorizing State should provide explanations in support of the scope, duration, and nature of this zone, prior to its establishment.
- The principle of equilibrium is to balance between the right to be free from harmful interference and the freedom to access, explore, and use of all areas, no matter whether the actors concerned are the first comer, late comer, parties in a cooperative lunar project, or any other party.
- The principle of optimization is a furtherance of the principle of equilibrium. Equilibrium does not necessarily mean egalitarianism, but is guided by the rationale of efficiency, aiming at leveraging the full use of any Safety Zones in favor of all the stakeholders, as well as all humankind.
- The principle of coordination should be the core value of an international framework regarding safety zones. The principle of coordination should provide guidance as to the formulation of certain mechanisms under the international framework regarding, for instance, information sharing, notification, consultation, and other tools and processes of coordination.

Moreover, any international framework regarding Safety Zones should comply in all aspects with international space law, including but not limited to the non-appropriation principle under Article II of the Outer Space Treaty.

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[2] NASA's Artemis Accords require signatories: *". . . to provide notification of their activities and commit to coordinating with any relevant actor to avoid harmful interference. The area wherein this notification and coordination will be implemented to avoid harmful interference is referred to as a 'safety zone'".*

f. The Legal Effect of Safety Zones

Safety Zones are purely informational and have no inherent legal effect. Safety Zones and their establishment and operation are not tools for national or private appropriation of such zones. They are not exclusion zones and do not, in and of themselves, grant the operator jurisdiction and control of the area, nor entail automatic responsibility for harm caused within the area under *lex lata*. All parties are free to travel and operate within a Safety Zone with the understanding that they should comply with their legal obligations, such as the duties (i) to operate with due regard and (ii) to consult with potentially affected parties if there is a possibility of causing harmful interference with activities of the affected parties. The publication of safety zones is conducive to assisting all parties to fulfill these duties.

g. The Establishment and Notification of Safety Zones

The Authorizing State should determine the dimensions of a safety zone after consulting and coordinating with those States whose lunar activities or other legitimate interests would be affected by the establishment of such a Safety Zone.

The dimensions of a safety zone should be determined in light of:

- the safety of all existing and known future parties operating on the Moon that may be affected by the planned zone;
- the potential of harmful interference with other existing and planned operations;
- the operational necessity of the safety zone;t
- he interests of other existing and known future parties with the goal of reaching an equilibrium that balances relevant interests, economic efficiency, and optimization of lunar activities.[3]

When providing notice of Safety Zones, the following information should be submitted:

- the precise location of related equipment and activities within the safety zone;[4]
- the dimensions of the safety zone;
- a description of the nature of the lunar activity in sufficient detail to alert others about potential interference or safety issues;
- the identity of the operator in control of the related equipment and activities;
- the extent of a human presence within the safety zone;
- the duration of the activity and presence of equipment; and
- the rationale for the dimensions of the safety zone.

Notice of Safety Zones should be submitted to the Secretary-General as soon as practicable and in no event later than the first delivery of related equipment or humans to the area. Information contained in a notification should be updated immediately upon (and when possible, in advance of) any changes to the information. When the activity has ended, the notification should be updated to reflect such termination.[5] (Non-governmental entities which are carrying on or plan to conduct

[3] Among the more important concepts to balance is the right to be free from harmful interference with the right to free access.

[4] All locations should be stated in accordance with the appropriate Geographic Information System.

[5] If equipment is left *in situ* following the termination of the activity, the updated notice should indicate this.

lunar activities with a legitimate need to establish a safety zone should provide the necessary information to the State authorizing such activity, to be submitted in turn to the Secretary-General by this State.)

All notices of Safety Zones should be broadly publicized and made publicly available and easily accessible at no cost. The precise process and method employed by the Secretary-General to publicize Safety Zone notifications is yet to be determined. One possibility would be to include the information on one of the two public registries maintained by the UN (which includes the index maintained pursuant to the Registration Convention and the index maintained pursuant to Article XI of the Outer Space Treaty). The Responsible State would provide information regarding the Safety Zone for inclusion in these registries by diplomatic note before registering the related space objects and activity.

h. Coordination and Consultation After the Establishment of a Safety Zone

Following the establishment and the notification of a Safety Zone, if potentially harmful interference with the activity of the Authorizing State may result from another operator's plans to land, enter, transit, or conduct activity within the Safety Zone, consultations must be requested. Even in the absence of potential harm, prior notice and coordination with the Authorizing State should be strongly encouraged.

Appendix A: Section 11 of the Artemis Accords

SECTION 11 – DECONFLICTION OF SPACE ACTIVITIES

1. *The Signatories acknowledge and reaffirm their commitment to the Outer Space Treaty, including those provisions relating to due regard and harmful interference.*
2. *The Signatories affirm that the exploration and use of outer space should be conducted with due consideration to the United Nations Guidelines for the Long-term Sustainability of Outer Space Activities adopted by the COPUOS in 2019, with appropriate changes to reflect the nature of operations beyond low-Earth orbit.*
3. *Consistent with Article IX of the Outer Space Treaty, a Signatory authorizing an activity under these Accords commits to respect the principle of due regard. A Signatory to these Accords with reason to believe that it may suffer, or has suffered, harmful interference, may request consultations with a Signatory or any other Party to the Outer Space Treaty authorizing the activity.*
4. *The Signatories commit to seek to refrain from any intentional actions that may create harmful interference with each other's use of outer space in their activities under these Accords.*
5. *The Signatories commit to provide each other with necessary information regarding the location and nature of space-based activities under these Accords if a Signatory has reason to believe that the other Signatories' activities may result in harmful interference with or pose a safety hazard to its space-based activities.*
6. *The Signatories intend to use their experience under the Accords to contribute to multilateral efforts to further develop international practices, criteria, and rules applicable to the definition and determination of safety zones and harmful interference.*
7. *In order to implement their obligations under the Outer Space Treaty, the Signatories intend to provide notification of their activities and commit to coordinating with any relevant actor to avoid harmful interference. The area wherein this notification and coordination will be implemented to avoid harmful interference is referred to as a 'safety zone'. A safety zone should be the area in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference. The Signatories intend to observe the following principles related to safety zones:*

    (a) The size and scope of the safety zone, as well as the notice and coordination, should reflect the nature of the operations being conducted and the environment that such operations are conducted in;

    (b) The size and scope of the safety zone should be determined in a reasonable manner leveraging commonly accepted scientific and engineering principles;

    (c) The nature and existence of safety zones is expected to change over time reflecting the status of the relevant operation. If the nature of an operation changes, the operating Signatory should alter the size and scope of the corresponding safety zone as appropriate. Safety zones will ultimately be temporary, ending when the relevant operation ceases; and

(d) The Signatories should promptly notify each other as well as the Secretary-General of the United Nations of the establishment, alteration, or end of any safety zone, consistent with Article XI of the Outer Space Treaty.

- *The Signatory maintaining a safety zone commits, upon request, to provide any Signatory with the basis for the area in accordance with the national rules and regulations applicable to each Signatory.*
- *The Signatory establishing, maintaining, or ending a safety zone should do so in a manner that protects public and private personnel, equipment, and operations from harmful interference. The Signatories should, as appropriate, make relevant information regarding such safety zones, including the extent and general nature of operations taking place within them, available to the public as soon as practicable and feasible, while taking into account appropriate protections for proprietary and export-controlled information.*
- *The Signatories commit to respect reasonable safety zones to avoid harmful interference with operations under these Accords, including by providing prior notification to and coordinating with each other before conducting operations in a safety zone established pursuant to these Accords.*
- *The Signatories commit to use safety zones, which will be expected to change, evolve, or end based on the status of the specific activity, in a manner that encourages scientific discovery and technology demonstration, as well as the safe and efficient extraction and utilization of space resources in support of sustainable space exploration and other operations. The Signatories commit to respect the principle of free access to all areas of celestial bodies and all other provisions of the Outer Space Treaty in their use of safety zones. The Signatories further commit to adjust their usage of safety zones over time based on mutual experiences and consultations with each other and the international community.*

Appendix B: Hague Working Group Building Blocks on Safety Zones

11.3. Taking into account the principle of non-appropriation under Article II OST, the international framework should permit States and international organizations responsible for space resource activities to establish a safety zone, or other area- based safety measure, around an area identified for a space resource activity as necessary to assure safety and to avoid any harmful interference with that space resource activity. Such safety measures shall not impede the free access, in accordance with international law, to any area of outer space by personnel, vehicles and equipment of another operator. In accordance with the area-based safety measure, a State or international organization may restrict access for a limited period of time, provided that timely public notice has been given setting out the reasons for such restriction.

11.4. The international framework should provide that appropriate international consultations are undertaken in case of possible overlap of safety zones or conflicts involving the freedom of access recognized by international law.

Section 2: Lunar Heritage

a) Definitions

A *lunar cultural heritage site* is any place with human material culture on the Moon or that is associated with intangible practices, representations, expressions, knowledge, or skills, that has historic, social, aesthetic, spiritual, or scientific significance for present and future generations.
A l*unar natural heritage site* is any place, geological or landscape formation that has historic, social, aesthetic, spiritual, or scientific significance for present and future generations.

Lunar cultural heritage sites may be located on the surface, subsurface, or in orbit. The extent of a lunar surface cultural heritage site may include all physical objects, marks, or traces in the regolith that are associated with robotic and human activities carried out in that location or using the equipment placed at that location (e.g., rover tracks, sample pits, rocket plumes, chemical alterations). It also may include the views and landscapes experienced by crewed missions or robotic cameras, which correspond to images disseminated on Earth. A site could be defined as all traces left by the activities of one distinct mission.

A *lunar cultural landscape* is the combined work of cultural and natural processes. Cultural landscapes are 'illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic, and cultural forces, both external and internal' (Operational Guidelines 2019: 20).

As defined by the Operational Guidelines to the World Heritage Convention (2019:83), cultural landscapes fall into three types:

- Intentionally designed
- Organically evolved, which can be relict (activities have discontinued in the landscape) or continuing
- Associative, which may have powerful religious, artistic, or cultural associations of the natural element rather than material cultural evidence, which may be insignificant or even absent.

A cultural landscape may have elements of all three. All current lunar sites could be defined as organically evolved cultural landscapes. The near face of the Moon is an associative cultural landscape. Craters, maria, geological features, and albedo combine to create the landscape observed by human, ancestral human, and non-human observers. The process of naming also creates associative landscapes on the Moon. This is enhanced when features can be seen by people on Earth with the naked eye or with telescopes. For example, Shackleton crater has cultural associations. Impacts to the visible face of the Moon through lunar activities have the potential to alter the values of this landscape.

A *lunar heritage precinct* contains more than one cultural heritage site and may be associated with natural heritage values. Examples include Surveyor 3 and Apollo 12.

Cultural heritage includes tangible and intangible components.

Section 3: Debris Mitigation and Environmental Sustainability

a) Introduction

In 2015, under the General Assembly Resolution A/RES/70/1 “Transforming our world: the 2030 Agenda for Sustainable Development” the 17 Sustainable Development Goals (SDGs) and 169 targets were adopted to stimulate action till 2030 in areas of critical importance for humanity and the planet. One of the most important directions in that regard is a necessity “to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations.” In the XXI century, environmental problems and concerns appear even more important. At the same time, they “are often addressed only after their effects are seen, such that damage is minimized rather than reversed or prevented.[6]” To protect and to save the Earth’s environment, it is required to ensure environmental sustainability “acting in a way that ensures future generations have the natural resources available to live an equal, if not better, way of life as current generations”[7] as well as “stabilizing the currently disruptive relationship between Earth’s two most complex systems: human culture and the living world.”[8] However, environmental sustainability issues nowadays extend beyond the Earth.

According to the US Department of Defence's global Space Surveillance Network (SSN) more than 15,000 pieces of space debris larger than 10 cm have been tracked. It is also estimated that there are around 200,000 pieces sized between 1 and 10 cm 0.4 and 4 inches, and millions of pieces smaller than 1 cm. Based on the realization that humanity uses the results and benefits of space activities, space debris prevention and mitigation is considered to be one of the targets in ensuring environmental sustainability in a broader sense, taking into account the exploration of the Moon and its orbits in the near-term perspective.

However, as the lunar environment differs from the Earth’s environment, States and lunar stakeholders should use appropriate methods and approaches tailored to ensure lunar sustainability. The lunar environment is characterized by a lack of a significant atmosphere, which means that there is no protection from solar radiation or micro-meteorites. Also, the Moon does not have a magnetic field and its surface is directly affected by the solar wind and galactic cosmic rays. In addition, the lunar surface is covered by fine dust that can be unintentionally moved by rocket plumes. Lunar dust is harmful to both astronauts and robots. Orbits around the Moon will increasingly be sought-after as lunar stakeholders deploy assets in orbit or enter orbit on their way to the surface. All these conditions will be challenging to humans and spaceflight operations. The gravity of the Moon is 6 times weaker than the gravity of the Earth. The surface of the Moon is seismically active; moonquakes come in strengths up to 5.5 on the Richter scale.

Bearing in mind that it has been a common understanding that the current space debris environment has already posed a risk to spacecraft in Earth orbit, the following guidelines are aimed at curtailing the generation of potentially harmful space debris in the near term and limiting their generation

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[6] Early warning on emerging issues URL: https://www.unep.org/explore-topics/environment-under-review/what-we-do/early-warning-emerging-issues

[7] United Nations Environment Programme. "Sustainability." URL: https://www.unep.org/about-un-environment/sustainability

[8] Evans M. What Is Environmental Sustainability? Definition & Examples of Environmental Sustainability URL: https://www.thebalancesmb.com/what-is-sustainability-3157876#citation-1 (Updated on July 07, 2020).

over the longer term during lunar activities on and around the Moon, its orbits, [as well as for missions traveling to and returning from the Moon][9] and ensuring the environmental sustainability of the Moon and its orbits.

b) Definitions

- Debris for the purposes of the lunar orbit and lunar surface environment is defined as:
  - o Human-made objects including fragments and elements thereof, that are non-functional, or
  - o Naturally occurring lunar rock and regolith that are unintentionally moved by spacecraft or human activity that pose substantial risk of harm to others. [10]
- Debris Mitigation is defined as: the enactment of practices and policies that prevent the proliferation of human-made debris including fragments and elements thereof in lunar orbit or on the lunar surface; or the prevention of naturally occurring lunar rock or regolith from being moved and striking astronauts or structures, facilities, equipment, vehicles, or spacecraft on the lunar surface.
- Environmental Sustainability is defined as: the ability to maintain the conduct of space activities on and around the Moon indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations.[11] [12]
- Launching State is defined as: a State which launches or procures the launching of a space object, or a State from whose territory or facility a space object is launched.[13]
- Harmful interference in the lunar environment is defined as: undertaking an activity which prevents other actors from carrying out their legitimate lunar activities or gaining access to an area; contaminates or depletes a resource being utilized by another actor or presents risks to the safety of lunar activities.
- Harmful Contamination of a lunar environment or lunar orbits is defined as the deliberate or unintentional changing of that environment through the introduction of extra-environmental materials or otherwise, so as to cause harmful interference with other actors carrying out legitimate lunar activities such as science, exploration, or commerce; or to damage sites of scientific or cultural importance.
- Safety Zone: an area with clear geographic parameters publicly noticed surrounding lunar activities established in order to ensure safety, avoid harmful interference among lunar activities, protect heritage sites, and prevent conflicts arising from legitimate rights and interests.
- Sustainable is defined as capable of being continued after an activity has occurred in the environment.
- In the definition of environmental sustainability can be integrated the notion of depletion or degradation of natural resources, that is relevant to in-situ resources utilization. This

[9] From the UN COPUOS Debris Mitigation Guidelines 2007

[10] Adapted from the definition in the "IADC Space Debris Mitigation Guidelines" in March 2020;

[11] Guidelines for the Long-term Sustainability of Outer Space Activities 2019

[12] UN Doc. A/74/20. Annex II. Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space. P. 50.

[13] LIAB + REG

allows for long-term environmental quality for future generations to be able to live an equal, if not better, way of life as current generations.

- Lunar sustainability is defined as responsible interaction with the lunar environment (including lunar orbits) to avoid the degradation of lunar resources; allow for long-term environmental presence and utilization of the Moon; and maintain the conduct of lunar activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of the Moon for peaceful purposes, [in order to meet the needs of the present generations while preserving the Moon for future generations].

c) Background

The intent behind debris mitigation in lunar orbits and the lunar surface is to ensure these environments can be accessed and utilized by current and future generations of public and private lunar stakeholders. Debris mitigation in this context is the practice of:

a) Preventing break-ups in lunar orbits
b) Passivating of space crafts that have reached the end of their mission to eliminate stored energy on a spacecraft
c) Preventing the unintentional break up of assets on the lunar surface
d) [Preventing human-made objects (whether or not they can be contacted, including the final stages of launch vehicles) from hitting the lunar surface without coordination].

e) International norms

In the context of promoting debris mitigation and ensuring environmental sustainability on the lunar surface and around the Moon a number of international legal norms and recommendations exist in the following documents:

1. The Outer Space Treaty 1967
2. The Registration Convention 1975
3. The Moon Agreement 1979, however it is recognized that so far only 18 signatories have ratified the Agreement.
4. The Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water of 5 August 1963
5. The Guidelines for the Long-Term Sustainability of Space Activities 2019 (A/74/20, para 163 and Annex II)
6. Safety Framework for Nuclear Power Source Applications in Outer Space 2009 (A/AC.105/934, 2009)
7. The Constitution, Convention, and the Radio Regulations of the International Telecommunication Union (ITU)
8. The Artemis Accords 2020
9. The Hague International Space Resources Governance Working Group Building Blocks for the Development of an International Framework 2019
10. Documents of COSPAR (recommendations, requirements) relating to the protection of the Moon, its surface, and orbits

International instruments relating to space debris:

11. Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space 2007 (A/62/20, Annex and General Assembly Resolution 62/217 of 22 December 2007)
12. IADC Space Debris Mitigation Guidelines
13. International Telecommunications Union (ITU): Recommendation ITU-R S.1003.2
14. European Code of Conduct for Space Debris Mitigation
15. ISO Standards
16. A Compendium of Space Debris Mitigation Standards adopted by States and international organizations also exists and is being updated on a regular basis by the UN COPUOS.

f) Debris Mitigation: Recommendations and Technical Guidelines

- *Pre-launch Phase*
- Space systems constructed for lunar activities should be designed to avoid the release of nontrivial debris during normal operations [within lunar orbits or on the lunar surface]. If this is not feasible, the effect of any release of debris in lunar orbits or on the lunar surface should be minimized to the greatest extent practicable.
- Design and planning for spacecraft operations that will transit or operate in lunar orbit planning should include consideration for coordination, consultation, and information sharing.

- *Operational Phase*

  a) In the interest of transparency and the prevention of break-ups during operational phases:
     a) Lunar stakeholders that operate assets in lunar orbits or on the lunar surface should be encouraged to voluntarily register the position of their assets with the launching State in which they originate.
     b) Launching States should be encouraged to publicly share position information of assets in lunar orbits as well as on or below the lunar surface.[14]

  a) Recognizing that an increased risk of collision could pose a threat to space operations in lunar orbits or the lunar surface, the intentional destruction of non-functional space objects, assets, or other harmful activities that generate long-lived debris in lunar orbits or on the lunar surface should be avoided. When intentional break-ups are necessary, they should be conducted bearing in mind physical characteristics of the low Moon orbits which are usually not a circular orbit, because it is unstable.

[14] This could be modeled after the Registration Convention (1976). As stated by UNOOSA, "States and international intergovernmental organizations that agree to abide by the Convention are required to establish their own national registries and provide information on their space objects to the Secretary-General for inclusion in the United Nations Register. Responsibility for maintenance of the Register was delegated by the Secretary-General to the United Nations Office for Outer Space Affairs. As required under the treaty, UNOOSA publicly disseminates the information provided as United Nations documents, which are available through its website and through the United Nations Official Document System." This system could be replicated but on a voluntary basis for the Moon, with information submitted by launching states.

b) In order to limit the risk to other spacecraft from accidental break-ups and debris interference, all assets are advised to avoid touching down on the lunar surface within at least a 2-kilometer radius of other assets already on the lunar surface. Spacecraft should avoid touching down within a larger radius if they are likely to create harmful interference with other assets beyond a 2-km radius.[15] A 2-kilometer radius is a safety requirement to prevent landing spacecraft from inducing dust interference on surface assets in the area. With the lunar horizon approximately 1.8-km away from a given asset on the surface, this safety radius avoids dust interference from landing spacecraft. To this end, the specific measures and solutions are to be confirmed among the relevant stakeholders by coordination.

c) Certain safety zones should be established in the places of the common interest of lunar stakeholders [such as the Lunar South pole].

- *Post-Operational Phase*

a) In order to limit the risk to other spacecraft from accidental break-ups, all on-board sources of stored energy should be depleted or made safe when they are no longer required for mission operations or post-mission disposal in lunar orbits or the lunar surface.[16]

b) Non-functional space objects and assets that have reached the end of their operation in lunar orbits should take measures to avoid collision with assets on or below the lunar surface.

c) All missions on deorbiting of space objects should be conducted in a controlled manner, for doing it is recommended to establish a specialized deorbit zone.

d) If a space object is planned to be deorbited to the lunar surface, States and lunar stakeholders are recommended to consider using a dedicated debris disposal zone(s) if possible. Such an impact zone would support the establishment of lunar recycling service activities due to the higher concentration of debris material in the same place. The zone is recommended to be close to the region with lunar activities to allow a recycling process (like the raw materials) without jeopardizing lunar sustainability and lunar activities.

e) To ensure the sustainability of the Moon, States are recommended to hold a national registry of space debris and to promote the creation of the universal registry for space debris, which can be based on the UNOOSA platform.

f) In data exchange on space debris, it is recommended to use various forms of databases such as: involving sensors, servers, network, data AI/ML, blockchain or DLT integration, etc.

g) Environmental Sustainability: Recommendations and Technical Guidelines

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[15] See: The implication of dust for Resource Contention and Lunar Policy. May 7, 2020. https://swfound.org/media/206980/moon-dialogs-research-salon-2-_-may-7-phil-metzger.pdf

[16] Recommendations 3, 4, and 5 are written in alignment with guidelines from the "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space" in 2007.

a) Principles of Environmental Sustainability

Recognizing that the Moon, as a natural satellite of the Earth, has an important role to play in the exploration of outer space and bearing in mind the benefits that may be derived from the utilization of the natural resources of the Moon, States and lunar stakeholders should abide by the following principles of environmental and lunar sustainability:

- To prevent environmental harm to the Moon including its orbits, States and lunar stakeholders should follow the precautionary principle, which requires acting carefully and with foresight while conducting activities on or below the lunar surface or in lunar orbits to avoid negative consequences for the lunar environment. This principle should be followed in a manner that is based on scientific evidence.
- In order to prevent risks to environmental sustainability of the Moon, including the potential threat of organic and biological contamination of permanently shadowed regions (PSRs), States and lunar stakeholders should comply with due diligence obligations, including the observation of the principle of prevention[17] and the principle of good faith[18], as well as the Planetary Protection Policy adopted by the COSPAR.
- States should pursue studies of the Moon and conduct exploration of it in a manner that avoids its harmful contamination and, where necessary, shall adopt [appropriate] measures for this purpose.
- In order to prevent risks from future lunar activities, States should request that lunar stakeholders use voluntary environmental assessment tools before the start of such activities. [To promote the universal environmental assessment (hereinafter EA), it is suggested to create the "Space Environmental Commission" under UNOOSA's umbrella, which will be open for all States and lunar stakeholders and will be based on open tools and information sharing. Functions of such a body could include approval and overseeing mining projects, or charging fees to private companies, which would benefit the international community].
    1) Environmental Assessment and the strong consolidation of risk prevention should be considered due diligence.
    2) To maintain consistency, EA considers impact of every phase of the future lunar activity/mission (design, test, launch, operation, decommission, etc.) on the Moon and relevant space environment and includes an environmental

[17] A 'principle of general international law' is that no state has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.

[18] Supplements due diligence obligations and deploys a constitutional quality in international law, persuading states to take measures and realise a regulatory aim.

risk assessment,[19] an environmental impact assessment report,[20] and environmental impact assessment.[21]

3) It is recommended to apply different forms of Environmental Impact Assessment, which can be used by States and future lunar stakeholders (see Annex 1 "Moon environmental assessment strategy" and Annex 2 "Environmental Impact Assessment**.** Notice for Operators").

- If a lunar activity or experiment planned by a State or its lunar stakeholders on or below the lunar surface or in lunar orbits could cause potentially harmful contamination, it is recommended to States to arrange for remediation or mitigation as appropriate and provide proper notification of those activities.
- If a lunar activity or experiment planned by a State or its lunar stakeholders on or below the lunar surface or in lunar orbits could cause potentially harmful contamination, a [launching] State shall undertake [appropriate] international consultations before proceeding with any such activity or experiment.
- If a State or its lunar stakeholders have reason to believe that a lunar activity or experiment planned by another State or its lunar stakeholders on the lunar surface or in lunar orbits may cause potentially harmful contamination, a [launching] State, or its lunar stakeholders [through nationally and internationally recognized mechanisms] may request consultation concerning the activity or experiment.
- States shall conduct authorization and continuing supervision under the activities of its lunar stakeholders to avoid any harmful contamination of the Moon and its orbits. [To ensure monitoring of any harmful impacts to the Moon and lunar orbits resulting from lunar activities, it is suggested to create a universal mechanism of monitoring on the base of the UN OOSA].
- If a harmful impact resulting from a lunar activity occurs, or is reasonably expected to occur, the State(s) and/or lunar stakeholder(s) should implement measures to address the harm by adjusting or terminating the activity.

b) Lunar Planetary Protection

Recognizing that lunar planetary protection is an essential element of the environmental sustainability of the Moon, States and lunar stakeholders should be committed to transparency relative to the following lunar planetary protection requirements and mitigation methods [considering Principle 21 of the Declaration of the United Nations Conference on the Human Environment of 16 June 1972, and Principle 2 of the 1992 Rio Declaration on Environment and Development]:

1. In exploring and using the Moon and lunar orbits, States and their lunar stakeholders should take measures to prevent the disruption of the existing balance

[19] Identifies potential environmental hazards caused by a business and determines its likelihood or probability to negatively affect various aspects of the environment such as living organisms, natural habitats, and ecosystems

[20] A document which is completed when it is decided that the project doesn't require an environmental impact statement

[21] It is used to identify the environmental and social impacts of a proposed project prior to decision-making in order to predict environmental impacts at an early stage in project planning and design

of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise.[22]

2. Any space experiment conducted on or below the surface of the Moon or in lunar orbits should be evaluated to assess any substantive potential harm, in order to protect the Moon and outer space from biological, chemical and radiation contamination that represent serious environmental threats.
3. Possible sources of contamination of the Moon include but are not limited to, the release of chemical markers, radioactivity resulting from nuclear power sources, generation of gasses in connection with soft landings, introduction of terrestrial microorganisms, lunar dust dissemination, other non-nuclear explosions, and the inadvertent transport of living or other matter from the Earth to the Moon.[23]
4. In order to avoid adverse changes in the Moon's environment caused by introducing extraterrestrial matter from the Earth, and to protect its biological integrity for scientific study, States and their lunar stakeholders should classify any lunar activities as low or high risk. In doing so, it is recommended to take into account but not be limited to the Categories II (a) and II (b) of Planetary Protection Policy adopted by the COSPAR as relevant.[24]
5. States Parties should inform the UN Secretary-General of the measures being adopted by them and shall to the maximum extent feasible, notify the UN Secretary-General in advance of all placements of radioactive materials on the Moon and of the purposes of such placements.[25]
6. In order to prevent risks and protect the environmental sustainability of the Moon, States can leverage safety zones which include both notification and coordination obligations.
7. Activities by States and their lunar stakeholders in lunar orbits or on or below the lunar surface should be conducted in a manner that does not harm sites or artifacts that have cultural or scientific significance may jointly establish safety zones for the areas on the lunar surface or lunar orbits which have significant scientific or cultural significance. If such harm is anticipated or occurs, States and/or their lunar stakeholders should report to the scientific community and to the UN Secretary-General.[26]
8. Lunar stakeholders should choose and use efficient mining methods to not waste lunar resources, such as lunar water ice resources.

c) Future Ideas on Waste management

a) States are encouraged to draft joint environmental protection frameworks for lunar activities as well as develop common protocols on waste recycling on the Moon. All lunar

[22] The Moon Agreement 1979. Art. 7, para. 1.

[23] COCOSL. Article IX of the OST, para. 4.

[24] COSPAR's Planetary Protection Policy. URL: https://cosparhq.cnes.fr/assets/uploads/2019/12/PPPolicyDecember-2017.pdf; https://cosparhq.cnes.fr/assets/uploads/2021/01/Research_Outreach_PPP_2020.pdf

[25] The Moon Agreement 1979. Art. 7, para. 2.

[26] The Moon Agreement 1979. Art. 7, para. 3.

stakeholders, public and private, should be held responsible for their actions in accordance with principles of international space law, including the principle of international responsibility of States for national activities.[27]

b) Waste recycling includes but is not limited to the processing of biological, chemical, and other materials as well as space debris.

c) ISRU waste needs to be placed in such a way that it does not contaminate or damage unexplored lunar resources or other lunar assets.

d) ISRU should not make lunar dust harmful to others, whether it is in the process of digging, transporting or manufacturing.

e) Waste recycling is recommended to include in environment impact studies.

f) Environmental impact mitigation measures should be implemented and strongly amortized inside economically sustainable value chains by lunar stakeholders.

[Caveat: paragraph 3.6.3 is for initial working suggestions only. Guidelines 3.6.3.2 to 3.6.3.6 are already encompassed in the prior section on debris. Furthermore, as a matter of methodology, to begin prescribing guidelines on ISRU years before pilot plants are designed would be premature. Developing such guidelines before the methods are designed could lead to guidelines that are irrelevant or unnecessarily constraining. At the same time, regulatory clarity (or lack thereof) is an important criteria to develop sustainable business models.]

[27] The Outer Space Treaty 1967. Art. VI.

PART C: Interoperability

Table of Content

Definition

Interoperability refers to the development of common standards of design, manufacture and construction and/or operations to enable software and hardware components to be interchanged or operated in conjunction, to facilitate international cooperation, recycling and repurposing.

1. Avionics and computer components.

1.1. Description

Avionics is a conjunction of the words aviation and electronics. It is used to describe the electronic equipment found in modern aircraft.

1.2. Historical / Heritage Systems

The history of avionics is the history of the use of electronics in aviation. Both military and civil aviation requirements contributed to the development.
The term "avionics" was not used until the 1970s. For many years, aircraft had electrical devices, but true solid-state electronic devices were only introduced in large numbers in the 1960s.
The development of aircraft reliability and use for civilian purposes in the 1920s led to increased instrumentation and set in motion the need to conquer blind flight—flight without the ground is visible.
In the 1930s, the first all radio-controlled blind-landing was accomplished. At the same time, radio navigation using ground-based beacons expanded

a) Exploration Systems Project (ESP)

ESP is building a core avionics and software system for the Descent and Transfer Elements of the Human Landing System to land humans on the Moon.

21. The Customer Avionics Interface Development and Analysis (CAIDA) - May 3, 2018.

This supports the testing of the Launch Control System (LCS), NASA's command and control system for the Space Launch System (SLS), Orion Multi-Purpose Crew Vehicle (MPCV), and ground support equipment. The objective of the semester-long internship was to support the day-to-day operations of CAIDA and help prepare for the verification and validation of CAIDA software.
https://ntrs.nasa.gov/api/citations/20180002666/downloads/20180002666.pdf

a) Space Shuttle Program Primary Avionics Software System (PASS) Success Legacy

1. This reviews the avionics software system on board the space shuttle, with particular emphasis on the quality and reliability. The Primary Avionics Software System (PASS) provides automatic and fly-by-wire control of critical shuttle systems which executes in redundant computers. The charts given show the number of space shuttle flights vs time, PASS's development history, and other charts that point to the reliability of the system's development. The reliability of the system is also compared to predicted reliability.

1.3. Analysis and Lunar Perspective

Lunar Surface Systems Software Architecture Study: Interoperability

This report is part of an overarching Lunar Surface Systems (LSS) Software Architecture Trade Study that identifies candidate architectures for the key software that will be used for each LSS Element (e.g., spacesuit, vehicle, robot, habitat). Lunar Surface Systems Software Architecture Study: Interoperability

2. Communication and navigation

2.1. Description

Communication links are the lifelines to spacecraft, they provide the command, telemetry, and science data transfers as well as navigation support. Navigation may be considered the art of directing the movement of a vehicle from one place to another. In today's context, it can be formally defined as the determination of a strategy for estimating the position of a vehicle along the flight path, given outputs from specified sensors.

2.2. Historical / Heritage Systems

a) Near Earth Network (NEN)

The NEN is composed of more than 14 ground stations, comprising more than 25 antennas, worldwide. These upload and download information to and from spacecraft while they are within direct line of sight of the antenna, crossing from horizon line to horizon line.

b) The Deep Space Network (DSN)

The DSN is composed of ground-based antennas and ground stations around the world. The DSN's antennas are huge – as much as 230 feet (70 meters) in diameter – and are placed at three key locations every 120 degrees around the globe, Madrid, Spain; Canberra, Australia; and Goldstone, California.

c) Space Network (SN)

This currently transmits most human spaceflight data, including astronaut communications with Mission Control and even data about the spacecraft's health and telemetry. Data from science and technology experiments also come down to Earth through the SN.

d) THE LORAN SYSTEM

The LORAN (Long-Range-Navigation) is a position fixing aid. It operates on a single frequency of 100 Khz and has a long range (greater than 1200 km). The latest version of this system called LORAN-C is very widespread, having many chains throughout the continental USA, much of Europe and the Middle East.

e) CHAYKA

Chayka is a Russian terrestrial radio navigation system, similar to Loran-C. It operates on similar frequencies around 100 kHz and uses the same techniques of comparing both the envelope and the signal phase to accurately determine location.

f) Lunar Exploration Ground System (LEGS)

The mission of the 18-meter class Lunar Exploration Ground System (LEGS) is to provide direct-to earth communication and navigation services for missions operating in the cisLunar and Earth-Sun Lagrangian regimes. There will be three sites spaced equally around the Earth. The Ground sites will utilize CCSDS Modulation and coding schemes for forward and return data.

2.3. Existing conventions or standards

Space Communications and Navigation (SCaN)

SCaN has developed a set of Standard Services which are inherent to the current functional capabilities of the SCaN networks without modification. There are little-to-no modifications/dependencies on the development of new functions within any of the SCaN networks for standard services

Space Communications and Navigation (SCaN) Mission Operations and Communications Services (MOCS)

2.4. Analysis and Lunar Perspective

Two of NASA's space communications networks will potentially play a key role in making exploration of these distant destinations possible. Current robotic missions on the Moon, such as the Lunar Reconnaissance Orbiter, commonly use the NEN to transmit data to and from Earth. With its global network of ground-based tracking stations, the NEN can support missions from low-Earth orbit to lunar orbit and beyond.

LunaNet will provide users with four services: networking; positioning, navigation and timing; detection and information; and science. With LunaNet in place, users will experience an operational environment similar to that experienced by internet users on Earth. LunaNet is intended to be entirely interoperable and will be created by NASA, other government agencies, academic institutions, and the commercial aerospace industry.

2.5. GEGSLA Guidelines on communication and navigation

Interoperability at the Moon is of absolute importance.

In September 2021, the LunaNet team published draft interoperability specifications as a starting point for technical discussions among industry and government experts from around the world.

The goal is a set of standards that can enable an open, evolving, cooperative lunar communications and navigation architecture. Draft LunaNet Interoperability Specification

This can stand as a foundational framework to be built upon but should not be limited to entities in a single country.

3. Rendezvous and docking systems

Androgyneous Berthing Mechanisms

3.1. Description

Androgyneous docking systems allow for the interoperability of spacecraft, spacesuits and surface vehicles without relying on binary docking mechanisms (such as active/passive port mechanisms). These shall allow for crew and material transfers. Assuming multinational and multiagency operations on both the lunar surface and in orbit, a joint standard is regarded as critical to allow a physical exchange of crew members or goods as well as for contingency situations.

3.2. Historical / Heritage Systems

Apollo-Soyuz Docking: Utilized by RKK Energia as part of the Androgynous Peripheral Attach System (Андрогинно-периферийный агрегат стыковки) in 1975 for enabling the docking between the Apollo. Despite differences between the American and Soviet versions of the docking mechanism, they were still mechanically compatible.

- APAS-89 variant, APAS-95 variant for the MIR station, etc
- The Chinese space station is based on the Russian APAS-89/APAS-95 system with a mass of 310 kg for the androgynous variant.
- ISS berthing standard (IDSS, since 2016)

3.3. Existing conventions or standards

International Docking System Standard (IDSS, currently in rev E, available at: https://www.internationaldockingstandard.com/download/IDSS_IDD_Revision_E_TAGGED.pdf)

3.4. Analysis and Lunar Perspective

The existing IDSS is a mechanism that seems transferrable for lunar orbit docking mechanisms, dating back to 2010; however, the Interface Definition Document (IDD) does not address off-nominal procedures of workflows for operations. It also does not apply to dust-loaded surfaced under (reduced) gravity conditions.

The docking mechanism was developed under the authority of the International Space Station Multilateral Coordination Board. It is also planned to be implemented for the Lunar Gateway initiative.

3.5. GEGSLA Guideline on rendezvous and docking systems

The IDSS-IDD is a commendable template for an androgynous docking mechanism, however, it would have to be expanded for lunar surface conditions, in particular for docking vehicles for crew transfers both in lunar orbit and on the lunar surface. Dust mitigation techniques are a recommended field of study.

Specifically, to be excluded are docking mechanisms for suit-ports, as they have a significant impact on the spacesuit design and as such difficult to coordinate amongst agencies and industrial partners.

4. Outboard robotics, including lunar equipment

4.1. Description

Space-based robotics have been traditionally used by spaceships and orbit tasks.

Looking forward to moon activity and mining explorations robotics may find a new use and purpose for development. Not much has been done to develop robots that will be used in earth activities including moon activities or Mars activities. Any development of such robotic technology will rise from the demand of commercial or government groups and therefore will be used in specific tasks and closed loops.

4.2. Historical / Heritage Systems

Introduction

Space-based robotics have traditionally been tasked with robotic on-orbit servicing functions, but despite several decades of development since the 1980s, this has yet to come to pass. A new application of space manipulators has emerged—active debris removal. Much of the technological development in space robotics over this period is directly applicable to this new task and indeed, given that the more challenging aspects of on-orbit servicing are not required (namely, servicing tasks), the prospect of active debris removal can be met. All the kinematic, dynamic and control issues are identical—this includes the requirement for grappling the target and passivating it. In future Moon village robotics latching mechanisms, Servicing tasks will typically involve the deployment of power tools for bolt manipulation and the use of specialized tools for more challenging tasks such as cutting, taping and resealing.

We first consider a brief schematic of recent on-orbit space manipulators employed by the International Space Station (ISS) and thence proceed to describe the rise and fall of robotic on-orbit servicing missions. We then provide a comprehensive review of the growing space debris crisis and proposed solutions and last the topic of robotics in mining and other moon village activities.

Space manipulator robotics has played a significant role on the ISS, which has installed on it three manipulator systems: the Canadian Mobile Servicing System (MSS), the Japanese Experiment Module Remote Manipulator System (JEMRMS), and the European Robotic Arm (ERA). The MSS includes the 17 m long 7 degree-of-freedom Space Station Remote Manipulator System (SSRMS) with its relocatable base, which is comparable to the 11 m long 7 degree-of-freedom ERA with its relocatable base in contrast to the 10 m long 6 degree-of-freedom JEMRMS fixed to the JEM. Both SSRMS and ERA are symmetric about their elbows, with latching end effectors at the end of each three degree-of-freedom wrist enabling hand-over-hand relocatability. Both were designed for assembly and servicing, while JEMRMS was designed for experiment payload manipulation from a fixed location.]

4.3. Existing conventions or standards

OOS appears to have reached an impasse—much of the robotics technology has been developed, but there has been little in the way of commercial development. However, active debris removal has emerged as another application of the same technology which could potentially provide the final leverage to OOS as a space infrastructure capability. OOS itself also acts as a debris mitigation strategy—refuelling and servicing spacecraft at end-of-life will reduce the rate of creation of space junk.

Defunct parts may be replaced and/or upgraded, although this requires supply from Earth- though supply from lunar in situ resources remains an intriguing future possibility.

4.4. Analysis and Lunar Perspective

When considering the future needs in mining and science expeditions to the moon robotics will take a large part in maintaining and sustaining lunar activities space agriculture biowaste treatment and solar panel cleaning etc.

4.5. Recommended guidelines on outboard robotics, including lunar equipment

It recommended to develop guidelines on outboard robotics, including lunar equipment. These guidelines should include common parts and common software versions for the exchange of damaged robots without the need for long-duration waiting for both from the Earth.

5. Training of mission crews, harmonization of training methods in terms of safety.

5.1. Description

Both interoperability, as well as contingency situation scenario, may require collaboration between lunar crews. To reduce the risk of allowing external crews to interact with one's own astronauts, both the communication cultures and awareness of operational aspects and engineering designs may be essential. Hence, already during training, a harmonization of how to interact with other crews, e. g. during analogue training activities may offer a cost-efficient pathway.

5.2. Historical / Heritage Systems

a) PANGEA/CAVE missions of the European Space Agency: these are established ISS-related training analogue missions allowing for inter-cultural training between astronauts. This could be considered a best-practice example of cross-training between agencies. However, the operational modalities, organizational insularity when it comes to inter-organizational collaboration and scale of activities are not yet compatibly with what might be required for extended lunar operations.

b) Similarly, NASA-led activities like the BASALT or the previous D-RATS missions allowed for limited international participation.

c) There is considerable experience in intercultural training in various grassroots activities with non-professional organizations like the Mars Society or comparable settings like Antarctic research stations like CONCORDIA, VOSTOK, McMURDO etc hosting international crews – although traditionally not formally involved in designing lunar exploration architectures, there is a considerable amount of experience and institutional knowledge to refer to.

5.3. Existing conventions or standards

Polar station crews undergo standardized training for decades to familiarize them with both the environment and basic understanding of polar operations. These are done in observance of established standards like the International Convention on Standards of Training, Certification and Watchkeeping, 1978 (STCW), supplemented by the Part C of the (Int. Maritime Organisation) IMO Guidelines focuses on Operational Procedures, Crewing and Emergency Equipment. Another example would be the guidelines published by the ISO technical committee on arctic operations (ISO/TC 67/SC 8, oil and gas sector).

5.4. Analysis and Lunar Perspective

Polar operations bear several similarities to lunar operations. Although there is a broad variety of crew purposes and tasks, engineering infrastructures etc in arctic activities, there is still a consensus on how to conduct training and minimum certifications for polar operations.

We suggest that these training regimes may serve as an inspiration for harmonizing astronaut crew training principles for safety.

5.5. Recommended guidelines on training of mission crews, harmonization of training methods in terms of safety.

Guidelines are recommended as follows, considering both the need for cross-agency and intercultural training, complemented by the need for at least establishing a basic understanding of foreign engineering principles to enable mutual support in contingency situations. This training should commence during the training on Earth. Similarities in (ant)arctic operations as a model for lunar activities and hence would suggest the adaptation of those established standards to planetary surface activities.

6. Space Debris Disposal

6.1. Description

Inevitably, anthropogenic space debris will be part of the lunar ecosystem, both in the orbit and on the surface. Contrary to spaceflight operations eg in Low Earth Orbit where the emergence of space debris is a recognized challenge for the safe conduct of spaceflight operations, lunar surface operations may have additional characteristics pertinent to the Moon, such as mining operations, establishing permanent large-scale human/robotic outposts, extensive landing/launching operations potentially leading to a debris production beyond what is observed in LEO today.

In order to preserve the pristine lunar environment, minimize the need for transferring materials, reduce the hazards for lunar surface operations and other considerations, the need for space debris disposal is evident.

So far, the international consensus on space debris mitigation on Earth is yet to be established as part of numerous space situational awareness and mitigation efforts. Extrapolating this to the Moon is challenging as long as there is no agreement foreseeable in LEO.

6.2. Historical / Heritage Systems

As early as 1994, the UNOOSA has issued the "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space" (introduced at the 31st STSC session, A/AC.105/571, paras. 63-7), which led to a general endorsement of the guidelines in 2007. A set of mitigation guidelines has been developed by the Inter-Agency Space Debris Coordination Committee (IADC), reflecting the fundamental mitigation elements of a series of existing practices, standards, codes and handbooks developed by a number of national and international organizations.

6.3. Existing conventions or standards

UNOOSA "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space"

6.4. Analysis and Lunar Perspective

Current space debris mitigation conventions are focused on LEO and GEO operations; nevertheless, more recent lunar space debris models project similar behavior and developments in lunar orbit with the increase of human activities. All guidelines currently observed rely on a voluntary observance of mitigation strategies.

As with the example in LEO and GEO, it is yet to be seen if any international mitigation regulations will take their grasp beyond being observed voluntarily. However, there are also economic considerations that may lead to early adoption of those standards: If the risks presented by space debris on lunar orbit or the lunar surface outweigh the economic benefits (e.g. the risk of losing a lunar reconnaissance satellite by space debris), operators may be encouraged to lower their space debris contributions. However, the discrepancy between a single operator's decision to potentially lower his economic expectations for the benefit of everyone calls for a high degree of consensus – exemplified in economic social theories as to the "tragedy of the commons".

6.5. Recommended guidelines on Space Debris Disposal

Guidelines are recommended as follows, considering the risks and projected problems emerging from space debris both on the surface of the Moon as well as the lunar orbit. Given the challenges of agreeing on SSA and space debris mitigation measures on Earth, these models may be extrapolated to lunar operations.

However, in order to facilitate the adoption of future debris mitigation regulations, societal education about those risks can be promoted by space actors including GEGSLA. Similar to the emergence of an ecological movement in our history to preserve natural resources: as it may take decades until the acceptance that the lunar environment is worth protecting, it is recommended to start already now to promote this mindset, which may ultimately evolve into regulatory standards protecting the lunar environment.

7. Mechanical, Pneumatic-Hydraulic, Electric

7.1. Description

This broad topic area covers a range of mechanical and electrical interfaces, including standardized features to facilitate the movement of items, the electrical interface for systems such as voltage and current standards, and the physical interface for transferring electrical power.

7.2. Historical / Heritage Systems

Some example heritage systems in the space domain are the International Space Station (ISS) grapple fixtures. There is a standard without power, the Flight-Releasable Grapple Fixture (FRGF), and a standard with power, the Power Data Grapple Fixture (PDGF). The ISS also has a set of power standards for 120 V DC. 28 V DC is another widely used power standard, but there is not necessarily an internationally accepted standard. It is left to future work to incorporate a 28 V standard into the ISS standards.

On Earth, some mechanical example systems are standardized shipping containers for ocean shipping and forklift attachments features on cargo pallets. There are the household electrical outlet standards, both for voltage and current, and for the mechanical plug. There are also standards for voltage and current for long-distance power transmission.

7.3. Existing conventions or standards

- International Space Power System Interoperability Standards (ISPSIS): https://nasasitebuilder.nasawestprime.com/wp-content/uploads/sites/45/2019/09/power_baseline_final_3-2019.pdf
- International External Robotic Interoperability Standards: https://explorers.larc.nasa.gov/HPMIDEX/pdf_files/17C_Robotics-020918_R1.pdf
- Space Plug-and-Play Architecture Standard: 28V Power Service (AIAA S-133-5-2013): https://arc.aiaa.org/doi/book/10.2514/4.102332

7.4. Analysis and Lunar perspective

It is recommended that the lunar community adopt already-established international standards wherever possible. In addition, the lunar environment such as dust may force a need to develop a lunar-unique standard. Lunar operations will also likely involve more interoperable activity at a smaller scale than a space station, and this scale of activity also needs standards. At this time, there is not a clear need for pneumatic or hydraulic standards given their complexity and lack of use in the space domain.

7.5. Recommended guidelines

Guidelines are recommended as follows: there should be two sizes of grapple fixtures to facilitate the movement of items. The first, larger size is the ISS Flight-Releasable Grapple Fixture (FRGF).

At least a second standard should be developed based on the FRGF but at a smaller size to accommodate the small 100 kg class robotic landers and rovers expecting to operate on the lunar surface. It may be necessary to have a third even smaller standard around the 1 kg class.

The 120 V ISS electrical standard is recommended to be used on the lunar surface, particularly for high power systems and crewed systems. A similar standard, but 28V DC, also needs to be developed and accepted by the international community. Dust-resistant physical interfaces (plugs) need to be developed and accepted by the international community for 28 V and 120 V.

While it is not an immediate need, the community should consider a shipping container standard.

8. Power Supply Systems

8.1. Description

This topic area covers electrical interfaces for providing power, such as voltage and current standards, and the physical interface for transferring electrical power to an element.

8.2. Historical / Heritage Systems

Some example heritage systems in the space domain are the International Space Station (ISS) power standards for 120 V DC. 28 V DC is another widely used power standard, but there is not necessarily an internationally accepted standard. It is left to future work to incorporate a 28 V standard into the ISS standards.

On Earth, there are the household electrical outlet standards, both for voltage and current, and for the mechanical plug. There are also standards for voltage and current for long-distance power transmission.

8.3. Existing conventions or standards

- International Space Power System Interoperability Standards (ISPSIS): https://nasasitebuilder.nasawestprime.com/wp-content/uploads/sites/45/2019/09/power_baseline_final_3-2019.pdf
- Space Plug-and-Play Architecture Standard: 28V Power Service (AIAA S-133-5-2013): https://arc.aiaa.org/doi/book/10.2514/4.102332

8.4. Analysis and Lunar perspective

It is recommended that the lunar community adopt already-established international standards wherever possible. The lunar community should also take advantage of this time to internationally standardize interfaces that don’t currently have a widely accepted standard, such as 28V power. Lower voltage standards could be considered, but it is reasonable for all elements operating on the lunar surface to take 28V DC as input power and convert it from there. It is expected that in the future there will need to be additional standards for things such as high-power transmission, particularly for industrial-scale activity such as in situ propellant product.

8.5. Recommended guidelines on safety support means of crewed missions

Guidelines are recommended as follow, while these recommendations only cover the electrical interface parameters. Mechanical interfaces for electrical power connections are covered by Item 1.2.1 Mechanical, Pneumatic-Hydraulic, Electric.

It is recommended that the 120 V International Space Station (ISS) electrical standard be used on the lunar surface, particularly for high power systems and crewed systems. A similar standard, but 28V DC, also needs to be developed and accepted by the international community.

While it is not an immediate need, the community should consider standards for high power transmission to support industrial-scale activity.

9. Safety Support Means of Crewed Missions

9.1. Description

This topic area covers any process or interface whose purpose is to help protect the safety of humans on the lunar surface.

9.2. Historical / heritage systems

The Outer Space Treaty Article V states that "the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties" and that "States Parties to the Treaty shall immediately inform the other States Parties to the Treaty or the Secretary-General of the United Nations of any phenomena they discover in outer space, including the moon and other celestial bodies, which could constitute a danger to the life or health of astronauts." Standards for providing assistance and rescue in space that are outside the boundaries of a particular program like the International Space Station don't exist. Perhaps the best Earth-analog would be international maritime rescue conventions and guidance.

9.3. Existing conventions or standards

Outer Space Treaty Article V: https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html

International Maritime Rescue Federation collection of International Maritime Organization Documents that are relevant to search and rescue: IMO Documents | International Maritime Rescue Federation

9.4. Analysis and Lunar perspective

Activity on the lunar surface may be the first need for the definition of basic international safety standards. Given the possible complexity of interoperable standards for life support systems and medical care, it may be best to focus initial standards on key items to facilitate meeting the obligations of Article V of the Outer Space treaty. Key items include emergency communication standards, the sharing of safety zone location data for operations, and the sharing of information on hazards. In cases of distress, it is likely best for priority to be placed on getting the crew into an airlock as opposed to trying to interface to Extravehicular Activity (EVA) suits.

9.5. Recommended guidelines on safety support means of crewed missions

Guidelines are recommended as follows: an international communication standard be developed for lunar surface operations, including the definition of emergency frequencies, the broadcasting of safety zone location data, and the format of S.O.S. messages. Furthermore, an international safety database to be developed to log any dangerous phenomenon on the surface of the moon per Article V of the Outer Space Treaty.

10. Deployment Systems

10.1. Description

Costs reductions are possible through the introduction of standards and guidelines for interfaces, interoperability, compatibility, and control principles. This topic area covers interoperability requirements for deployment systems to provide access to the Moon Village technical components being developed.

10.2. Historical / heritage systems

The primary example of space deployment systems is the CubeSat standard for dispensers.

10.3. Existing conventions or standards

- ISO 17770:2017 Space systems — Cube satellites (CubeSats): https://www.iso.org/standard/60496.html

10.4. Analysis and Lunar perspective

There is a wide range of possibilities for the definition of deployment systems for the lunar surface, across a range of sizes and capabilities. It is expected that these systems will need to be defined as the scope and complexity of lunar operations increase. It may be best to start small and build from there. Today, a standard for the deployment of small payloads from lunar landers to the lunar surface similar to the CubeSat dispenser standard may be the most useful given the expected scope of activity in the near term.

10.5. Recommended guidelines on deployment systems

Guidelines are recommended as follows: to develop a standard for the deployment of small payloads from lunar landers to the lunar surface similar to the CubeSat dispenser standards is recommended.

PART D: Lunar Governance

Table of Contents

a) Defining lunar governance

Lunar governance can be defined as systematic and comprehensive management and decision making on issues related to the full range of lunar activities, consistent with the principles enumerated in the Outer Space Treaty and other relevant aspects of international law. Through multi-stakeholder engagement and dynamic interactive processes, lunar governance will enable the sustainable exploration and use of the Moon.

Governance is the sum of all the ways through which members of the global society manage shared problems. It is a mean to promote cooperation between members and a process capable of producing effective results in the management of global issues.

By expanding the definition of governance from Earth affairs to Moon activities, lunar governance is concerned with management of shared problems related to the use and exploration of the Moon and should be developed to ensure peace and security in outer space, to maintain the sustainability of lunar activities, and to benefit all humankind.

b) Responsible lunar governance

Building on the concept of lunar governance, responsible lunar governance will aim to facilitate responsible behaviors among lunar actors. Responsible lunar governance will be consistent with existing international law, including the Charter of the United Nations and the Outer Space Treaty, and will be guided by a wide range of additional hard and soft law instruments as appropriate (see the section on "Instruments for developing responsible lunar governance" below).

c) Stakeholders in lunar governance

Responsible lunar governance emphasizes notions of openness, inclusiveness, and broad participation, using multi-stakeholder engagement to manage and decide on issues related to sustainability of lunar activities. Therefore, in the lunar context, stakeholders include not only traditional space actors but all actors both directly and indirectly involved in lunar activities, including actors along supply chains as well as emerging actors.

To afford multiple stakeholders meaningful participation in Lunar Governance, discussions involving lunar activities should take place at the levels of intergovernmental organizations, academia, non-governmental organizations, industry, and civil society, in addition to traditional fora such as inter- agency fora, inter-governmental organizations, and UNCOPUOS.

Lunar governance is intended to include all participants of space activities. The Outer Space Treaty recognizes the use and exploration of the Moon as the province of (hu)mankind and establishes that they shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development.[28] Therefore, the involvement of developing countries in lunar governance is essential to ensure that their interests and specific needs become

[28] OST Article I

part of the agenda. At the same time, their engagement can be an enabler for increasing compliance with the international framework.

d) A common approach to responsible lunar governance

At the international level, responsible lunar governance is an integral part of global space governance, defined by the United Nations General Assembly as "the institutional framework for the governance of international cooperation in using outer space for peaceful purposes."[29] To promote global space governance, the UN General Assembly adopted *The "Space2030" Agenda: space as a driver of sustainable development* in 2021 as a strategic vision and called upon Member States to implement it. Overarching objective 4 of *The "Space2030" Agenda* is to "build partnerships and strengthen international cooperation in the peaceful uses of outer space and in the global governance of outer space activities." In this regard the activities and outcome of the GEGSLA will contribute not only to the development of lunar governance but also inform the discussion of global space governance at large.

e) Essential elements of responsible lunar governance

Global space governance as a framework includes the United Nations treaties and principles on outer space, the relevant guidelines adopted by the Committee and the resolutions on outer space adopted by the General Assembly, as well as supporting efforts undertaken at the national, regional, and global levels, including by entities of the United Nations system and international space-related entities.[30]

Lunar governance can build upon the aforementioned elements to arrive at a framework that incorporates the concepts of peace, security, cooperation, and mutual understanding in the exploration and use of the Moon and its resources.

Lunar governance seeks to identify synergies, converging interests and expectations, balance current diverging needs and interests as well as the needs and interests of future generations, and is concerned with current and future stakeholder interaction.

Recognizing that responsible behavior can be context-specific, responsible lunar governance will require a complex and adaptive framework facilitating an efficient decision-making process that seeks to:

1) Respect general principles and norms such as those enshrined within international space law and soft law instruments, including but not limited to peaceful uses, due regard, non-interference, mutual understanding, non-discrimination, equality of access, freedom of exploration, non-appropriation, information sharing and transparency, and international cooperation;

[29] A/AC.105/1137

[30] See A/AC.105/1137, paragraph 7

2) Ensure predictability, accountability, fairness, inclusiveness, transparency, coherence and synergy in a manner that fosters healthy competition among stakeholders;

3) Reconcile several variables relevant to lunar activities through an adaptive process, such as, *inter alia*, governmental, intergovernmental, and non-governmental actors interacting through public-private-partnerships, private funding initiatives and new technologies;

4) Operationalize this multilaterally agreed upon framework for the benefit of all humankind with the preservation of the lunar resources and environment and the sustainable lunar exploration and utilization as its key elements.

This should include a consensus-based, effective method of decision-making that ensures collective responsibility and the effective and safe coexistence of all involved lunar stakeholders.

In creating this framework, the full spectrum of lunar activities, as well as the whole life cycle of lunar activities (from R&D to end-of-life) should be considered.

6. Instruments for developing responsible lunar governance

Notwithstanding the potential need for a comprehensive and adaptive multilateral framework to address needs and interests that will be identified as lunar activities evolve, operationalization of responsible lunar governance shall be guided by the existing legal framework, and participants should act in accordance with principles, norms, and rules applicable to the use and exploration of outer space, that arise from instruments such as:

a) The Outer Space Treaty, as the fundamental instrument to rely upon: common interest, freedom of access, use and exploration shall be starting points for responsible lunar governance, which shall continuously seek the maintenance of peace and security, and promote transparency, cooperation and understanding. Though subsequent State practice and agreements will interpret and elaborate some of OST's provisions within the lunar context, its principles and norms shall be references for the development of responsible lunar governance.
b) The Moon Agreement could be considered as the most [The Moon Agreement is a potentially] relevant legal instrument to deal with lunar activities: built upon the intergenerational perspective of sustainability, it provides valuable suggestions for the operationalization of responsible lunar governance in areas including in-space resource utilization (ISRU), environmental protection, and equitable sharing of benefits.
c) The UN Charter: especially with regard to international peace and security, pacific settlement of disputes, friendly relations, equal rights, self-determination, international cooperation, and respect for human rights and fundamental freedoms.
d) The Rescue Agreement, the Liability Convention, the Registration Convention and other relevant international treaties.

Other instruments that provide reference and guidance for the development of responsible lunar governance, as indicative of shared expectations, are:

e) The Long-Term Sustainability Guidelines, *Space 2030 Agenda,* and other soft law instruments.

f) Governance initiatives, such as the Building Blocks for the Development of an International Framework on Space Resource Activities, The Moon Village Best Practices for Sustainable Lunar Activities, and the Effective and Adaptive Governance for a Lunar Ecosystem (EAGLE) Report.

g) The Artemis Accords and other non-legally binding international agreements.

h) International technical and other relevant standards.

7. Institutions for responsible lunar governance

Implementing responsible lunar governance may require institutional innovations. The question remains whether new international institutions are needed to carry out this function, or whether it can be delegated to existing institutions.

In the short term, it may be possible to place the administration of lunar governance with an existing international institution (or institutions), such as the International Space Exploration Coordination Group (ISECG) and/or a reinvigorated International Space Exploration Forum (ISEF), working in collaboration with UNOOSA and COPUOS.

In the longer term, it is possible that a dedicated international institution may be required in order to provide permanent channels of debate between the multiple interested actors, improve decision-making processes and enable better results for the participants. The International Telecommunication Union (ITU) or the International Atomic Energy Agency (IAEA) might serve as possible models.

8. Implementation of Responsible Lunar Governance

National and international mechanisms (national legislation and policy, international treaties, etc.) are one component of the implementation of lunar governance. States also have a role to play in monitoring national activities.[31]

Responsible lunar governance is intended to cast a broader net by including not only state actors but all lunar actors, recognizing that most of these actors will likely participate in lunar governance through their national administrations and agencies. This is intended to foster consistency between the policies adopted by these different actors.

Clearly outlining advantages of participation, as well as the costs of non-compliance, may assist in getting buy-in for participation. Identifying shared interests, goals, and expectations and implementing mechanisms that will guide behaviors and encourage participants to comply will help to achieve better overall results.

[31] Art. VI of the Outer Space Treaty

ANNEX II
Future Issues

A Report from the GEGSLA Observers on Future Issues of the Recommended Framework Document

Table of Contents

a) Introduction

Objectives:

This Annex II, assigned to Observers of GEGSLA, contains a summary listing of matters pertaining to the peaceful, safe, and sustainable development of lunar activities, which, whilst not being assessed in the technical guidelines in the Recommended Framework Document main body and Annex I, nevertheless would require some international agreement, but not in the timeframe envisioned under the Recommended Framework document. These matters will therefore remain to be resolved in a later time frame.

Mindset:

The contents of this Annex II, assembled by Observers of GEGSLA, are not intended to overlap with matters considered in Annex I and are deliberately limited to only a brief description and possible implications, carrying no implied priority order. GEGSLA's deliverables being intended for UNCOPUOS governance with the consensus process as preferred mechanism, the Observers' responsibility is to make sure Annex II gets to the floor of UNCOPUOS for acknowledgement and future resolution of said matters. It is furthermore hardly possible and even less desirable for Observers to offer prematurely a prescriptive path to political and legal resolution at this time, while neither would it be appropriate for Members to forward any prescriptive Annex II language which Members would not have developed and validated themselves in the first place. As Observers acknowledge that GEGSLA is their route to the UNCOPUOS chamber floor, they must therefore work towards the acceptance of Annex II language, so that Observers may achieve their aim of getting these Annex II matters onto the chamber floor in Vienna.

b) Benefits For Humanity

Identify the potential benefits to the inhabitants of the Earth from use of the Moon as a training ground for the longer-term development of economic resources from solar system objects.

Design and operationalize concrete international mechanisms that address the social dimension of sustainability by sharing benefits of lunar activities with the whole society, elaborating Article I, para. 1 OST- including mechanisms to foster the involvement of developing countries in Lunar activities, ensuring inclusiveness, while not threatening the commercial attractiveness of those activities.

Ensure that geographically diverse stakeholders and emerging companies across the spectrum of economic development are granted access to value chains and are included in value generation and sharing processes that were until recently almost exclusively reserved to dominant space actors.

Ensure that people everywhere, gain equitable access to the means of creating value and being able to share it.

For all stakeholders, facilitate a key enabler of that process which is the access to the insights derived from data. Accelerate open source and collaborative creation, extraction, valorization, and equitable sharing of value and, therefore, benefits.

Encourage use of the Moon Village concept in solving Earth global challenges.

c) Sustained Lunar Economy

Supporting the private sector in outer space is excellent public policy. Without the private sector investing resources, talent, creativity, and enthusiasm to sustain human activity in space, not much may happen. But the private sector likewise needs to honor essential public policies, like the Outer Space Treaty and any other treaty/agreement that their host country has signed. In particular, including and not limited to the right set of incentives, private actors may need to commit to sharing and cooperation, rather than exclusion and confrontation, concerning in situ resources. The following is a list of objectives toward economic sustainability.

To the extent not previously covered under Annex I:

1. consider the establishment of an initial testing zone for Lunar industrial activities to limit the potential for environmental damage, and as a result, establish an agreement between the different countries for good uses of these areas.

2. support the introduction of common infrastructure elements on the Moon, including shared landing and take-off sites, and shared roadways, along with the elaboration of mechanisms to foster a responsible use of facilities among the different crews.

3. support the provision of common navigation and communications systems for use on the Moon.

4. ensure that Lunar space tourists receive the same protections under international law that are afforded to governmental astronauts.

Develop mechanisms for sharing in situ resources and the discovery of resources. Develop mechanisms for the resolution of disputes, including commercial disputes, between States and/or their nationals, including consultation, arbitration, and mediation.

In a relevant context of cislunar and lunar economic development, to the extent not already covered at scale by already existing Earth-based services, support the introduction of Lunar banking and currency management arrangements.

Support the development of cislunar and lunar wholesale payment systems and commercial transactions infrastructures and processes, which leverage, at scale, adequate cislunar and lunar data, fintech, and legaltech architectures.

Maintain balance between the requirements of a Machine-to-Machine economy and the needs of human demographics for retail payment and personal finance, with an emphasis on open-source data access, valorization, and sharing.

- **Concept of ‘Priority Zones’**

i. Concept formulation: To the extent not covered under Annex I recommendations, develop mechanisms for the administration and recording of ‘Priority Zones’, with some limited time period validity, for commercial operators to be able to explore for economically accessible and exploitable lunar resources.

ii. Acknowledged friction: A question is to what extent the concept of ‘Priority Zones’ may be construed as conflicting with Treaty principles, which may lead to rejection, particularly if Zones are framed as ‘exclusive’. There seems to be at least two root causes for friction and likely rejection unless these aspects are carefully reconsidered. A first cause for friction is a process allegedly conflicting with the Treaty ban on appropriation. A second cause is the Treaty obligation to guarantee open access to all. That seems to suggest a design and resolution of a 'Priority Zone' mechanism is both dependent on and subsequent to the design and resolution of at least two other mechanisms: one as workaround for the non-appropriation principle that would enable a sustainable economic exploitation by a number of parties ; one that would offer a framework for access and benefit sharing that would in particular preclude two extreme scenarios: one operator free-riding halfway into the SRU cycle on another operator investment, and, one operator offering only crumbs at the SRU cycle end, to another operator also laden with decommissioning costs.

iii. Initial remediation: Data and the recording of operational, legal, and governance processes input and output, is the basis of lunar socio-economic activities. A permanent dynamic record of international activities on the Moon may constitute a basis to identify and track which stakeholders engaged in what activities, how, where, and when. It will take time to establish an assessment of lunar resources as per a rigorous mining methodology that qualifies and quantifies accessibility and exploitability of such economic resources in the early phase, until such time when it is determined to which extent significantly more sizable investments may be justified. It might be useful to design, in lunar exploration early phase, frameworks enabling to first and foremost establish a record, and consider to which extent some non-appropriation principle workarounds and access and benefit sharing mechanisms may then be incrementally developed for operational architectures of 'Inclusive Priority Zones'.

- **International Framework of Governance**

Establish an international framework of governance, including appropriate procedures to govern the exploitation of the natural resources of the Moon as such exploitation is about to become feasible.

The main purposes of the international framework should include:

i. The orderly and safe development of the natural resources of the Moon;
ii. The rational management of those resources;
iii. The expansion of opportunities in the use of those resources;
iv. An equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the moon, should be given special consideration.

Finally, to the extent not previously covered under Annex I-II-III, aim at public and private actors committing themselves to protect the lunar environment, that "magnificent desolation" (Buzz Aldrin), for the use and inspiration of both current and future generations. Aim at developing and implementing any relevant additional international governance frameworks that may be required to that end, including and not limited to incentive systems for behavior better than required.

d) Human Interaction

i. Encourage the provision of safety and security, including rescue and emergency support services, for Lunar occupants.
ii. To the extent not previously covered under Annex I (Safe Operations/Lunar Environmental Protection), establish interference protection and dispute settlement mechanisms, including arbitration and mediation.
iii. To the extent not previously covered under Annex 1, develop mechanisms for the sharing of finite common resources on the Moon (e.g. lunar water, power during Lunar night, oxygen, etc.), in particular in situations endangering the lives of groups of lunar occupants, whereas other groups are in a position to rescue.
iv. Develop mechanisms so achievements of mission critical TRLs (Technology Readiness Levels) are given consideration for life sciences, space medicine, and human resilience, as much as they are given for machine-oriented achievements.
v. Acknowledge issues for consideration in life sciences and space medicine including and not limited to: food production; bio-regenerative life support system design (BLSS); muscles and bones degradation in reduced gravity; cardiac health; SANS (Spaceflight-Associated Neuro-Ocular Syndrome); and radiations.
vi. Plan and regulate for the hypothesis that the Moon and cislunar space may also become a hub for human-operated long duration space travel (LDST) toward the rest of the Solar System, while the following may be noteworthy of consideration: LDST specific medicine ; gynecologic and obstetric aspects of LDST ; risks and benefits associated with taking the combined oral contraceptive pill during LDST ; treatment of LDST-induced antibiotic resistant E.Coli Infections ; role of precision medicine in LDST; use of hibernation for humans in LDST ; and the ethics of conducting genetic modifications to improve survival in LDST. For both short duration Moon operations and LDST, regulate training for mental resilience. Develop systems and procedures for persons with disabilities in SD and LDST.
vii. Consider a system to guarantee Moon and cislunar workers long term healthcare and access to state-of-the-art space medicine, when in space and back on Earth. Include dispositions as part of their contractual relationship with employers such as occupational hazards and profession-induced physiological and mental health issues. Consider creating Moon and LDST-oriented 'Space Labor Regulations'. In order to enable as a first step recommendations from the World Health Organization, provide the WHO with the necessary mandates and capacities to develop international space health standards.
viii. Aim at such a future outer space labor regulatory framework not colliding with fundamental labor standards and other relevant standards related to decent work, that humanity has struggled to recognize and still struggles to implement on Earth.
ix. Promote data-driven law and governance with a human-centered purpose of empowering individuals operating in the Earth-Moon ecosystem. Improve all individuals' inclusiveness in access to justice and legal outcomes in a context dominated by governments and corporations. If law and governance in the Earth-Moon ecosystem are to be optimized through the use of technology, they may be optimized to meet the needs of individuals and of the Moon and cislunar society.
x. Encourage the protection of individual rights. Consider endorsement of the Universal Declaration of Human Rights. Acknowledge the close relation between Human Rights and the future development of international labor standards related to outer space, which is likely to intersect with the mandate of the ILO.

xi. Develop and implement the concept of "The Moon as a Laboratory of Peace"[32]. Aim at leaving behind on Earth the roots of all human warfare, by either keeping cislunar and lunar space unaffected by the consequences of 'geo'-politics, or, at a minimum, establishing and enforcing architectures of pre-emptive deconfliction.

Note: while this section originally applied to the resolution of human disputes more of a personal nature, due to the entanglement between the personal and the economic, there is inevitably some duplication of dispute resolution language with the prior section on economic relations.

e) Other

To the extent not previously covered under previous technical guidelines of Annex 1, establish arrangements to preserve the Lunar far-side for purposes requiring the absence of terrestrial radio emissions (e. g. radio astronomical observations).

Take into serious consideration the risk of harmful interference linked to "microbial diffusion". As human, animal, and plant life develops on the Moon through sustainable communities, either on lunar surface and vicinity, or in underground lava tubes, the Moon's ecological environment will change dramatically. In the presence of radiation in the environment, determine the spread and mutation potential of 'microbial diffusion'. Adapt provisions of planetary protection relevant to both living ecosystems on the Moon and the biosphere and humankind back on Earth, in order to regulate and mitigate potential harmful interferences.

Take into serious consideration the risk of harmful interference linked to "nuclear contamination". Due to the amount of energy needed for long term sustainable lunar communities, solar power alone is unlikely to be sufficient to support industrial, logistics, and human activity. The inevitable use of nuclear power raises waste treatment and contamination risk issues. Determine a most effective way to protect against nuclear contamination. Draw the necessary contingency measures in case of a nuclear power unit failure, in order to regulate and mitigate potential harmful interferences among Moon areas of relevant activities.

Thrive to build trans-disciplinary teams that understand and respond to each other's needs and objectives. Ensure consistency of current and projected legal requirements and governance framework vis-à-vis current and projected scientific and technological readiness levels, as well as realistic trade and investment demand drivers and constraints. Firm up definitions and binding degrees for the linkage between harmful interference and legal requirements. Ensure that legal requirements and governance frameworks do not get quickly outdated due to scientific and technological progress as well as established trade and investment practices.

Acknowledge that processes exist under customary international law for settlements to seek recognition as sovereign states while deferring any specifics on how such a process would work on the Moon or elsewhere.

f) Conclusions

Starting from objectives and a mindset as described in the Introduction, Observers estimated in their assumptions that they would be better off taking a step back and leaving the Appendix 2 items as simply 'issues that will need resolution at a later stage'.

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32 (*) a concept initially coined by space lawyer and Member Prof Mark J. Sundahl.

Observers have formulated a number of issues, together with implications, over various items covering categories such as ‘Benefits for Humanity’, ‘Sustained Lunar Economy’, ‘Human Interaction’, ‘Other’. Their baseline remains a respectful acknowledgement of the Outer Space Treaty and Conventions principles, as pertaining to many such future expected issues of lunar activities governance. Observers executed their methodology refraining from attempts at taking the Annex II language too far: considering that, most of existing space governance and legal frameworks, should they undergo some form of evolution in the coming decades, may only do so once economic traction and diversity of responsible states, combined with the hard-earned operational experience of lunar activities by all stakeholders, reach a critical mass. Observers deem non advisable at this stage to try and fast-track solutioning of any particular issue by one “show-stopper” interpretation of Treaty language, that would solve any particular activities operational friction potentially conflicting with some Treaty principles, by expedient language that implies suppression of such activities as solution. Instead, Observers did acknowledge elements of friction and alleged conflict, analyzing root causes and initial remediation, as in the case of a ‘Priority Zones’ concept. Like a thousand miles journey starting with a single step, it is the Observers’ aim that such issues be validated for bandwidth and resolution at a later stage, through an effective international framework of governance.

Global Expert Group on Sustainable Lunar Activities

The sustainable management of lunar natural and cultural heritage: suggested principles and guidelines.

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11 March 2023

Table of Contents

Table of Figures

Table of Tables

Disclaimer

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Executive summary

This report has been written as an Annex to the Recommended Framework and Key Elements for Peaceful, and Sustainable Lunar Activities produced by the Global Expert Group for Sustainable Lunar Activities (GEGSLA). Preserving natural and cultural heritage values on the Moon is a key part of sustainable activities. This document sets out suggested guidance principles for ensuring that these aspects of the Moon survive for future generations, with the aim of providing a starting point for the development of a mature heritage regime on our celestial neighbour. The principles can be summarised as follows:

- The management of natural and cultural heritage values contributes to sustainable lunar activity.
- The precautionary principle should be applied to all activities which may impact natural and cultural heritage values on the Moon.
- In situ preservation is the preferred management strategy for cultural and natural heritage.
- A Lunar Heritage Register containing natural and cultural heritage sites will aid in maintaining accurate information.
- The planning of lunar activities from the earliest stage should include the identification of natural and cultural heritage places within an activity area or safety zone, assessment of impacts and proposal of mitigation measures if required.
- To the greatest extent possible, the location of activities should be selected to avoid or minimise potential harm to places of natural or cultural heritage value.
- A recommended management option is the preparation of a Lunar Cultural Heritage Management Plan (LCHMP) or a Lunar Environmental Management Plan (LEMP) for activity areas or safety zones.
- Stakeholders in a place of natural or cultural heritage significance should be consulted about values, impacts and mitigation measures.
- No decisions about or changes to a heritage place should be made without advice from an appropriately qualified heritage professional.
- Decisions about the management of a place should derive from an assessment of the significance of the heritage values, rather than development priorities.
- Information about heritage values, curtilages or buffer zones, and management strategies should be shared with all relevant stakeholders both on the Moon and on Earth.

Table 1: Acronyms and abbreviations

Acronym	Meaning
AHC	Australian Heritage Commission
AIAA	American Institute of Aeronautics and Astronautics
ANHC	Australian Natural Heritage Charter
ACIUCN	Australian Committee for the International Union for the Conservation of Nature
BYA	Billion Years Ago
CHMP	Cultural Heritage Management Plan
CMP	Conservation Management Plan
COSPAR	Committee on Space Research
EMP	Environmental Management Plan
GEGSLA	Global Expert Group for Sustainable Lunar Activities
GIS	Geographical Information System
IAU	International Astronomical Union
ICOMOS	International Council on Monuments and Sites
ISCoAH	ICOMOS International Scientific Committee on Aerospace Heritage
IUHPST	International Union for the History and Philosophy of Science and Technology
LCHMP	Lunar Cultural Heritage Management Plan
LCMP	Lunar Conservation Management Plan
LEMP	Lunar Environmental Management Plan
LHR	Lunar Heritage Register
NGO	Non-Governmental Organisation
PCR	Polymerase Chain Reaction
UNESCO	United Nations Educational, Scientific and Cultural Organisation

1.0 Introduction

This technical document covers issues around the management of cultural and natural heritage values on the Moon. By definition, appropriate management contributes to the sustainability of lunar activities, as heritage can be considered a resource for humanity. This is reinforced by Principle 4 of the UN Rio Declaration on Environment and Development (1992), which states that 'In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it'.

The natural environment of the Moon has unique qualities relating to its history and evolution as a celestial body, and to the geological and cosmological processes which have shaped it over time. In addition, the Moon has examples of landscapes and landforms which are rare across the solar system (such as the Permanently Shadowed Regions). As our oldest and most constant neighbour, the fates of Earth and Moon are closely bound together.

Space exploration since the 1950s has left over 100 locations on the Moon where material culture is evidence of humanity's engagement with outer space. Human material on the Moon represents the societies and technologies of the period known as the Space Age, from World War II onwards, when the development of launch technology enabled humans to leave Earth for the first time and eventually reach other celestial bodies.

If humanity becomes a 'multiplanetary species' as some term it, these places and artefacts one day will be equivalent to archaeological traces of the earliest human ancestors, millions of years ago, at places like Olduvai Gorge in Tanzania. There will only ever be one place where humans first set foot on another world. The material remains of the first sixty years of human interactions with the Moon is evidence of the evolution of our future in the cosmos – the beginning of a trajectory whose course we cannot yet know. As a new period of lunar exploration commences, returning a human presence to the Moon more than 50 years after the Apollo missions, it is imperative to take account of the values of these places.

The UN 2030 Agenda for Sustainable Development acknowledges that culture has a role to play in achieving sustainability:

> We acknowledge the natural and cultural diversity of the world and recognize that all cultures and civilizations can contribute to, and are crucial enablers of, sustainable development. (Paragraph 36)

Goal 11.4 of the Sustainable Development Goals is to 'Strengthen efforts to protect and safeguard the world's cultural and natural heritage'. If we understand the 'world' of humans to now encompass the Moon as a physical location in the same way it has always been part of humanity's visual and spiritual world, then these aims equally apply to the Moon.

Just as government and commercial entities must use the Moon's resources so as to leave sufficient for future generations, so too natural and cultural heritage should be considered a resource for the future, according to the UNESCO Declaration on the Responsibility of the Present Generations Towards Future Generations (1997).

Avoiding unnecessary harm to natural and cultural heritage places and values is an integral part of sustainable development. It is important to sustainably manage these values because:

- Access to cultural heritage is a human right according to the UNESCO Universal Declaration on Cultural Diversity (2001) and the UN Universal Declaration of Human Rights (Article 27; 1948).
- Cultural heritage is a non-renewable resource which enriches human existence and contributes to community well-being by creating a sense of place, connectedness and identity;
- Natural heritage, such as geological diversity, contributes to our understanding of the Moon and our place in the solar system;
- Natural and cultural heritage values represent bonds between people on Earth and the Moon that have existed since the emergence of humans as a species;
- Future generations have the right to access the Moon and its natural and cultural heritage resources as freely as present generations.

As well as places on the Moon, the entire Moon as a celestial body can be considered to have natural and cultural value; however, these values are considered beyond the scope of this report. In this document we cover heritage issues in the short to medium term of lunar exploration, with a view to their utility as the basis for evidence-based decision making which builds on heritage practice and scholarship. The report focuses on particular key issues such as assessing significance, mitigation measures, planning and heritage lists, while acknowledging that here are many more areas which will require elucidation in the future.

2.0 Definitions

The aim of this section is to provide clarity and identify sources of ambiguity around terms relating to the natural and cultural heritage of the Moon.

2.1 General

This section defines basic concepts relating to both natural and cultural heritage. Definitions relating specifically to either natural or cultural heritage follow below. The defined term is highlighted in italics.

The Precautionary Principle: The application of the Precautionary Principle to lunar activities has been advocated in numerous documents, eg the Vancouver Recommendations for Space Mining. A widely used definition comes from Principle 15 of the Rio Declaration in Environment and Development (United Nations, 1992):

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Natural and cultural heritage values and their management are combined in the concept of ***place****.* A place can be defined as a meaningful location (Creswell 2004: 132) that is situated at specific geographic co-ordinates or embodied in a material structure (for example, a ship that moves its location or an orbital object).

Messeri (2016) and others (eg Vertesi 2015) have examined the process whereby planetary features are assigned meanings or values. It is a process of 'understanding large conglomerations of rocks and gas as worlds, as places' (Messeri 2016: 190). The place framework is useful, Messeri argues, because 'Even when place is not self-evident, as perhaps with invisible exo-planets, it is nonetheless invoked and created in order to generate scientific knowledge'.

The Moon is a *place*, on the surface of which there are other places defined by the meanings we give them, whether these relate to the geological features or human material culture. The place concept integrates a number of qualities such as intangible associations, material remains, sensory experiences, history, and stability: there is something that anchors these qualities to the co-ordinates. Places are not interchangeable (in contrast to Augé's 2002[1992] concept of *non-place*, where location is irrelevant).

Existence value is 'the value of an object in the natural world apart from any use of it by humans' (Aldred 1994:381). Aldred identifies several components of existence value, of which the following can usefully be applied to the lunar environment:

- Indirect use value: the value derived from knowing a place exists without having to be physically present or derive a direct benefit from it. This can include scientific value.

- Intrinsic value: ‘a willingness-to-pay purely to know that an environmental feature is preserved and undisturbed’ (Aldred 1994:386). The beneficiary of this preservation is the environmental feature itself and the human communities which value it.

2.2 Cultural heritage

A ***lunar cultural heritage site*** is any place with the material remains of human activities on the Moon, or any place that is associated with intangible practices, representations, expressions, knowledge, or skills, and that has historic, social, aesthetic, spiritual or scientific significance for present and future generations.

Lunar cultural heritage sites may be located on the surface, subsurface or in orbit. Lunar cultural heritage sites may be (but are not limited to): crewed or robotic vehicle landing sites and their associated hardware, tracks and traces (including bootprints, rover tracks, sample locations and blast zones); crash landing sites including the crater, ejecta, and rays; and orbiting spacecraft including rocket bodies, satellites and subsatellites, and mission-related debris. The tracks and traces are examples of neoichnology or modern trace fossils (Díaz-Martínez et al 2021, Gorman et al 2022). Orbital objects may over time impact on the lunar surface or possibly leave cislunar space. It is also possible for non-lunar missions to create new lunar sites, as with the 2022 Long March rocket body impact on the far side (Grush 2022).

Due to the slow accumulation of lunar regolith, most current cultural heritage sites are on the surface with limited depth into the regolith. Future activities on the Moon may create sites with greater sublunarian components.

The extent of a lunar surface cultural heritage site may include all physical objects, and marks or traces in the regolith that are associated with robotic and human activities carried out in that location or using the equipment placed at that location. It may also include the views (Burra Charter 2013) and landscapes experienced by crewed missions or recorded by robotic cameras, which are replicated in images disseminated on Earth. Note that the spatial extent of a site may not necessarily correspond the boundary of a site established for management purposes.

The site consists of the material remains, the surface on which they rest, and the environment with which the remains interact. Thus, the site is more than the artefacts present and partakes of the qualities of *place*. National heritage legislation can be applied to the objects belonging to the launching state but not to the site itself. The site, as a place or management unit, lies outside the capacity of existing space treaties and may be best managed by a specific lunar or celestial heritage authority.

Given the comparatively ‘recent’ nature of lunar cultural heritage, a question is at what point a place should be considered as heritage from a management perspective. Some terrestrial heritage legislation imposes an age criterion, where only objects or places over a certain age (100 years is commonly used) are eligible for protection. This leads to logical absurdities: for example, a place can be unprotected one year and covered by the legislation the next, even though its heritage values have remained the same. This is unlikely to be very useful in the lunar context.

One mechanism is that a site can be deemed eligible for consideration as a heritage site when it passes from its systemic context to an archaeological context (ie it has been abandoned or is no longer used; Capelotti 2010; Schiffer 1972). The abandonment of a site may trigger a cultural heritage assessment. This is not always black-and-white, due to the continued use of experimental equipment such as laser retroreflectors at sites which are otherwise abandoned, eg Apollo 11 and the Lunokhod 2 rover. The protection of retroreflectors for continued scientific observation, (and use in creative activities, eg Clar 2021), is an additional benefit of registering a site as lunar heritage.

A surface site could be defined as all traces left by the activities of one distinct mission within the official mission time frame or other time frame considered reasonable. Such a site is considered to have a single component. A ***multicomponent site*** is one location with evidence of successive phases of occupation or activities. An example is Surveyor 3 and Apollo 12. Surveyor 3 was a US robotic probe which successfully soft-landed on the Moon in 1967. In November 1969, Apollo 12 landed 180 m from Surveyor 3, and removed a camera and other materials to return to Earth for analysis. Because of this interaction, they can be considered a multi-component site for management purposes.

However, if an Apollo-related spacecraft, such as the Apollo 11 ascent vehicle (Kindy 2021) or a rocket body, were to subsequently crash onto the surface, this would be considered a separate site to Tranquility Base (even if the impact location was in proximity to the landing site) as they were created by different processes and intentions.

While there may be objects associated with particular lunar missions in Earth orbit or heliocentric orbit, these are considered beyond the management responsibilities of lunar stakeholders at this time. They may, however, be taken into account in the assessment of a site’s cultural significance.

A ***lunar cultural landscape*** is the combined work of cultural and natural processes. Cultural landscapes are:

> illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal. (Operational Guidelines 2021:22)

As defined by the Operational Guidelines for the Implementation of the World Heritage Convention (2021:22-23), cultural landscapes fall into three types:

a) Intentionally designed landscapes;
b) Organically evolved landscapes, which can be relict (activities which have discontinued in the landscape), or continuing;
c) Associative landscapes, which may have ‘powerful religious, artistic or cultural associations of the natural element rather than material cultural evidence, which may be insignificant or even absent’ (Operational Guidelines 2021:23).

A cultural landscape may have elements of all three. All current lunar sites could be defined as organically evolved cultural landscapes, while the Apollo crewed landing sites have some designed elements in the placement of instrument packages (Gorman 2023). Designed landscapes are likely to increase in frequency with the development of industrial, residential and tourist facilities on the Moon.

The entire near face of the Moon is an associative cultural landscape. Geological features and albedo combine to create the landscape observed by humans, ancestral humans, and other sentient terrestrial observers, eg fauna. The process of naming also creates associative landscapes on the Moon. This is enhanced when features can be seen by people on Earth with the naked eye or with telescopes. For example, the highly visible Tycho crater has cultural associations with the astronomer Tycho Brahe (1546-1601) after whom it is named, as well as numerous popular science fiction works, including the 1968 cult film *2001: A Space Odyssey* (see Table 3). Impacts to the visible face of the Moon through lunar activities have the potential to alter the values of this landscape. The far side of the Moon, although not visible from Earth, has its own cultural associations, such as the urban legend of 'space Nazis' and the iconic Pink Floyd album 'The Dark Side of the Moon' (Jonze 2019).

A ***lunar heritage precinct*** is a boundary which contains more than one cultural heritage site and may also encompass natural heritage values. A heritage precinct is defined and managed as a unit. The sites may be related to each other by virtue of chronology, function, geography or proximity – ie places that are close to each other may be best managed by considering them as components of the same cultural landscape. A Lunar Cultural Heritage Management Plan (LCHMP) or other management planning document can then apply to the sites as an assemblage rather than each individual one (see section 5.3).

Space archaeology can be defined as:

> The systematic and scientific study of the non-renewable material remains of human spaceflight history across time and space through the application of modern archaeological method and theory. (Westwood et al 2017:xvii)

The study of space archaeology provides information that can be used in assessing the significance of lunar heritage sites, as well as being an aspect of scientific significance (see section 4.0).

2.3 Natural heritage

A l***unar natural heritage site*** is any place, geological or landscape formation that has historic, social, aesthetic, spiritual or scientific significance for present and future generations. A lunar natural heritage site may include views and landscapes. At the present time, the lunar environment is abiotic.

The Australian Natural Heritage Charter defines ***geodiversity*** as 'the natural range (diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes' (Article 1.4) This includes evidence of past environments as well as a 'range of atmospheric, hydrological and biological processes currently acting on rocks, landforms and soils'. The degree to which geodiversity is retained in a measure of integrity; however, geodiversity is not a static value and can change over time. Bétard and Peulvast (2019) have called the application of geodiversity concepts to other planetary bodies 'exogeodiversity'.

Natural heritage goes beyond categorisations of geological and landscape elements, which have been extensively studied by lunar scientists, to consider the *values* of these elements. These values are different in many respects to the values of terrestrial landscapes. Unlike terrestrial landscapes, the Moon's surface, in the absence of plate tectonics, reflects the events of its history over billions of years (Crawford et al 2021).

Value may be imparted by age (scientific significance), evidence of evolutionary or lunar processes (scientific significance), rarity or typicality (scientific significance), visual appearance (aesthetic significance), feelings of attachment from communities on Earth (social significance), or existence (see Section 2.1). The Australian Natural Heritage Charter includes the capacity to support life as a value (Article 1.3).

Increasingly, heritage scholarship is rejecting the division between cultural and natural by including values traditionally seen as 'cultural', ie having to do with human responses, in assessments of natural heritage value. UNESCO's 1972 Convention concerning the Protection of the World Cultural and Natural Heritage does not apply beyond Earth, but it is noteworthy for covering both cultural and natural heritage and acknowledging they are intertwined in the category of the 'mixed property'.

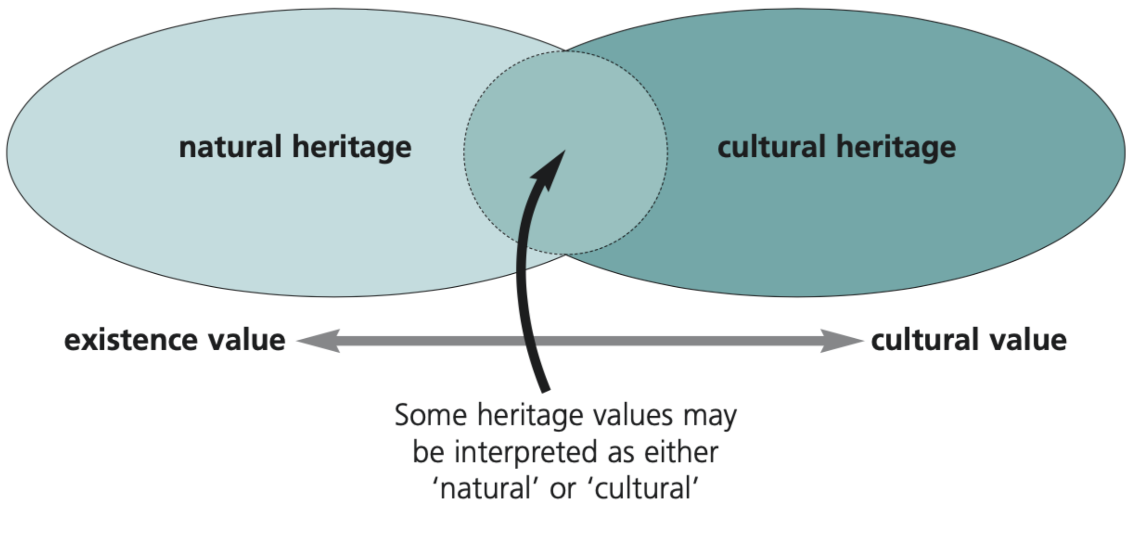

Figure 1: The intersection of natural and cultural heritage (from the Australian Natural Heritage Charter)

A ***lunar landform*** can be defined as:

> relief features developed at the interfaces between the lithosphere and … space on airless planetary bodies. (Hargitai et al 2015:2357)

The genesis of lunar landforms is different from those on Earth; hence the use of terrestrial terminology can be misleading as it implies a similar origin. Hargitai et al (2015: 6365) note that 'the origin of a large part of planetary landforms is not well understood'. Terrestrial landform classification is based on lithology, morphology, structure and inferred origin process(es). However, on other celestial bodies, classification systems are primarily constructed from imaging surface data at a particular resolution (Levy et al. 2008). Our knowledge of the Moon is derived from space-borne and in situ remote sensing data, and models based on this data, combined with regolith samples, and meteorites found on Earth. These sources rarely reveal active processes or recent surface changes (Hargitai et al 2015: 2356). Hence, characterisation of planetary landscapes is currently static and coarse-grained. Forthcoming lunar exploration will be able to observe these processes and ground-truth aspects of the environmental dynamics. There are likely be landform types which are predicted but not yet confirmed.

The Encyclopedia of Planetary Landforms lists several landform types that are distinct to the Moon or characteristic of the Moon (Table 2). As a class, these landforms have scientific or aesthetic value. Individual examples of these landforms may have particular significance.

Landform name	Feature type	Description
Concentric Crater	Nested crater	An impact crater with one or more concentric ridges on the crater wall and/or crater floor with a central depression
Crater Wall Flow-Like Features	Flow	Flow-like topographic or albedo features formed on steep slopes of inner crater walls on airless bodies
Dark Mantle Deposit (Annular)	Deposit	Diffuse, annular, or ring-shaped deposit with very low albedo that mantles or drapes over the lunar surface.
Dark Mantle Deposit (Regional)	Deposit	Diffuse deposit with very low albedo that mantles or drapes over the lunar surface in places.
Light plains	Deposit	Light-coloured highland deposits of plains on the Moon.
Lunar swirl	Albedo feature	Often curvilinear, but sometimes diffuse surface features that are characteristically high albedo, optically immature, and associated with magnetic anomalies
Mare	Volcanic plain; albedo feature	A large dark, smooth plain on the Moon formed when basaltic lava flowed into pre-existing topographic depressions.
Mare Dome	Dome; shield volcano	Low volcanic structures of rounded shape occurring in the lunar mare regions
Mesoscale Positive Relief Landforms	Cone-shaped	Small (less than several km) mounds of circular to elliptic outline with positive conical relief displaying a central depression
Nonmare Dome	Dome	Volcanic edifice on the Moon consisting of non-mare material
Orientale Type Multiring Basin	Impact basin	Large circular impact structure that possesses at least two concentric asymmetric scarps, one of which may be the original crater rim
Red Spot	Albedo feature	Spectral anomalies on the nearside of the Moon characterized by high albedo and strong absorption in the ultraviolet
Tranquillitatis Type Mare Basin	Basin	Irregular, shallow mare basin with relatively thin basalt fill.

Table 2: Unique and characteristic lunar landforms (Source: Encyclopedia of Planetary Landforms)

A ***lunar landscape*** is an assemblage of features, physical or spectral, often considered to have 'scenic' or aesthetic value. Certain landscape types can be typical of geological or chronological processes. Scale, degree, albedo, angle of illumination, colour, and other factors provided by remote sensing data can show very different aspects of the terrain, which often defy easy classification. As with landforms, there are planetary landscape types which have no correlates on Earth. Boundaries between landforms and landscapes may not be easy to delineate.

The characterisation of lunar landscapes, in the absence of biological ecologies and a clear path to economic benefits arising from tourism, show the inadequacies of terrestrial schemes for assessing landscape values. Assessing the values of lunar landscapes will necessarily be a work in progress which will evolve over time as lunar operators acquire and share new information. A new lexicon of planetary environments will need to be developed concurrently with lunar activities.

3.0 Principles for lunar natural and cultural heritage management

This section sets out some basic principles for approaching cultural and natural heritage on the Moon, as included in Chapter 6 of the Key Principles and Documents, with additional principles drawn from heritage practice and scholarship. Chapter 6.2 of the Key Principles is reproduced in the box below.

6.2. Lunar Heritage

6.2.1. It is acknowledged that access to cultural heritage is a human right according to the UNESCO Universal Declaration on Cultural Diversity (2001) and the UN Universal Declaration of Human Rights (1948) Article 27.

6.2.2. Lunar activities should be conducted, to the greatest extent possible, to avoid causing adverse changes to lunar cultural and natural heritage.

6.2.3. Lunar heritage is a non-renewable resource which includes both tangible and intangible components.

6.2.4. Lunar natural and cultural heritage duly proclaimed either at the national level or designated by the competent international authorities should be managed in accordance with well-established norms, with due regard to the interests of all the pertinent stakeholders.

6.2.5. Management of natural and cultural heritage values is a key part of sustainable lunar activity, which contributes to the free access to the Moon as well as the scientific exploration of the Moon.

6.2.6. The management requirements of lunar heritage should be examined on a case-by-case basis, balancing the specific characteristics and value of the heritage and the free access, exploration and use rights of all stakeholders. In this process, the principle of 'Do as much as is necessary and as little as possible' (Burra Charter 2013) should be considered.

6.2.7. An assertion of natural or cultural heritage significance shall not lead to a national appropriation to the relevant lunar sites or areas which is in contravention of the Outer Space Treaty (1967).

6.2.8. Management and mitigation strategies should be applied consistently across all classes of natural and cultural heritage according to the applicable national or international norms.

6.2.9. Safety of human persons takes precedence over conservation of heritage.

6.2.10. The determination of heritage significance, and management and mitigation strategies for lunar heritages must proceed from an expert assessment of heritage significance based on the national law, bilateral or multilateral agreements or the standards of an appropriate international authority.

6.2.11. When a State has reason to believe that an activity or experiment planned by it or its nationals on the Moon, would cause adverse changes to the cultural heritage sites formulated by others' lunar activities, it should undertake appropriate consultations with the relevant States before proceeding with any such activity or experiment, even if these sites are not yet designated as lunar heritage by relevant national law, by international agreements or by an appropriate international authority.

The following, more detailed, principles augment those in Chapter 6.

3.1 Heritage values

a) No assumptions should be made about heritage value until a detailed, professional assessment is made for each lunar cultural or natural heritage site.

b) Some lunar cultural or natural heritage sites may meet 'outstanding universal value' criteria as defined by the World Heritage Convention, and this should be recognised even though inscription on the World Heritage List is not possible at this time.

c) Lunar sites lie beyond national boundaries on Earth but are also connected to places and values on Earth, where they may form part of the cultural values of these places.

d) Not being included on a heritage list or register should not be taken to imply that a place lacks heritage values. A list is a management strategy rather that a definitive declaration of heritage value.

e) Any disturbance to a natural or cultural heritage place requires full documentation of the features of the place prior to any impacts.

3.2 Coordination and cooperation

f) Cooperation among States, lunar operators, international organizations, NGOs, scientific institutions, professional organizations, archaeologists, geologists, planetary scientists, and other interested parties is considered necessary to achieve the best outcomes for lunar natural and cultural heritage.

3.3 Information sharing

g) Lunar operators should share information about the location of heritage places, both known and newly discovered, their heritage values as assessed by appropriately qualified professionals, impacts on places caused by operations, any management plans or mitigation strategies, the results of scientific investigations and research into natural or cultural values (including analysis of samples), and relevant scientific methods and technology used in the investigation or management of heritage values.

h) An aim of sharing information is to increase public awareness and appreciation of the significance of natural and cultural heritage places, taking into consideration that the Moon is the province of all humanity.

i) Information sharing contributes to the training of heritage professionals in specific issues relating to the management and conservation of lunar natural and cultural heritage values.

3.1 Principles relating specifically to cultural heritage

j) Lunar cultural heritage hardware remains the property of the launching state under the terms of the Outer Space Treaty (1967).

k) National cultural heritage legislation can only be applied to human-manufactured objects and not sites or places, which include landscape features and environment, as this may be deemed a contravention of the non-appropriation principle of the Outer Space Treaty (1967).

l) A cultural heritage site on the Moon may have significance for communities at the local, regional, state, national or global levels.

m) The contributions of all nations, organisations or groups to a national or private mission should be taken into consideration in identifying stakeholders in a cultural heritage place.

n) A cultural heritage site may have multiple or conflicting heritage values which should be recognised according to Article 13 (Co-existence of cultural values) of the Burra Charter (2013).

o) In situ preservation is the preferred strategy for management of heritage values, following the precedent of Article 5.2 of the UN Convention on the Protection of the Underwater Cultural Heritage (2001), and the Burra Charter (2013) which identifies the setting and integrity as important components of cultural significance.

p) Non-invasive methods of documentation and research (ie imaging, remote sensing) should be prioritised before intrusive methods are considered (ie visitation, sampling)

q) Removal of cultural material from a site or for return to Earth may be undertaken to further scientific inquiry, acquire essential information to aid heritage preservation; or if impacts are likely to cause the destruction of a site or a component of a site; however, this latter is a last resort.

r) Management and mitigation strategies for a nation's space hardware can be consistent with their cultural philosophies concerning heritage. For example, natural decay and non-intervention may be more appropriate than active preservation for some nations. Following the Nara Document on Authenticity (ICOMOS 1994), 'the respect due to all cultures requires that heritage properties must be considered and judged within the cultural context to which they belong'.

s) While the Liability Convention (1972) is usually taken to apply to operating space objects, damage to the heritage values of another nation's heritage may also be considered.

3.2 Principles relating specifically to natural heritage

t) Unlike cultural heritage, natural heritage on the Moon has fewer affiliations with nation states or national cultures (although noting that there may be specific cultural knowledge associated with large scale geological features as observed from Earth, or with particular qualities of light, for example). Natural heritage should be considered in a lunar context as belonging to and contributing to the integrity of the whole Moon.

u) Management strategies for natural heritage values should be consistent across the Moon.

4.0 Evaluation methods for cultural and natural heritage significance

Significance assessment is the first step in effective heritage management (Pearson and Sullivan 1991; see also Appendix 5). The Burra Charter (2013) has been demonstrated to be an effective method of assessing the significance of cultural heritage sites in space (Gorman 2005, 2016, 2019). The Charter is used widely globally and has formed the basis for other nations' heritage systems, for example, the China Principles, China's heritage guidance charter (Qian 2010), as well as Türkiye, New Zealand and others. Its broad acceptance in the global heritage community, cross-cultural adaptability and backing of the international heritage advisory committee ICOMOS are additional reasons for taking it as a model.

The principles have also been adapted for the management of natural heritage in the Australian Natural Heritage Charter. The ANHC has been used as a model for lunar natural heritage in this report, particularly as it takes Indigenous values into account.

Traditionally, natural heritage values have focused on geodiversity, economic values, and tourist values. Increasingly, however, scholars in this field are including social and cultural values as part of natural heritage values (eg Harrison 2015). The Burra Charter significance categories can hence be applied to both natural and cultural values.

The Burra Charter (2013) defines the following categories of significance:

1. Historic – association with a historic person, phase, process or event
2. Scientific – rarity or representativeness, potential for research
3. Aesthetic – sensory engagement including scale, colour, visual qualities as well as aural and olfactory qualities
4. Social – contemporary community esteem or attachment
5. Spiritual – association with beliefs and cosmologies

Aesthetic, social and spiritual values may be deeply entangled, particularly in some Indigenous world views.

In assessing representativeness as part of scientific significance, the Moon introduces the unusual consideration that some examples of identical or similar objects or places may be on another planet (ie Earth). Conversely, in some cases the Moon may have the only known examples of objects manufactured on Earth. In relation to Apollo culture, for example, Westwood et al (2017:5) note that 'Tools and equipment for use on the Moon were designed and manufactured, but documentation was discarded so quickly that for some tools used for Apollo 11, only prototypes appear to exist on Earth'. Many of the only examples of particular tools were discarded when materials were jettisoned to make the Apollo 11 ascent vehicle light enough to take off (Westwood et al 2017:102). Hence some of the objects at Tranquility Base have extremely high scientific value as the only existing examples of these artefacts. It's likely that this may be the case for other missions as well.

Places on the Moon may have natural heritage significance because they are the oldest surfaces, are places that have helped define lunar geological eras, that represent 'typical' or rare lunar processes, or are landscapes valued for their aesthetic qualities. Table 3 shows the indicative values of a natural feature on the Moon, Tycho crater, using the Burra Charter criteria to demonstrate how they can be applied to natural heritage.

Place	**Value**	**Cultural**	**Natural**
Tycho crater	Historic	Named by the Jesuit astronomer Giovanni Riccioli in 1651. Appears in oldest geological maps of the Moon drawn from Earth. Association with astronomer Tycho Brahe. Some Apollo 17 samples thought to originate from Tycho. Surveyor 7 landed on the rim of the crater in 1968.	Recent crater (108 mya) in lunar impact history; Copernican era (1.1 bya until present). The crater's structure is typical of Copernican craters.
	Scientific	N/A	Well preserved and sharply defined, can help date younger lunar and planetary surfaces
	Aesthetic	The structure of the crater led it being called the 'navel of the Moon' by Pierre Gassendi. Some say it makes the Moon resemble an orange. Covers a huge area of 550, 000 km2.	Extremely prominent feature with clearly visible bright rays extending up to 2,000 km; visible to the naked eye as a bright spot.
	Social	Important to communities of amateur astronomers and moonwatchers. Featured extensively in science fiction literature and movies/series; location of the TM1 monolith in *2001: A Space Odyssey*	Important to communities of amateur astronomers and moonwatchers.
	Spiritual	Unknown	Unknown

Table 3: Indicative cultural and natural values of Tycho crater

An example of where natural and cultural scientific significance merges is seen in craters (a landscape feature) created by impacts from human objects. While such an impact forms an archaeological site with material culture, the crater also has scientific significance for the opportunity it provides to study an active process on the Moon and the contrast with naturally formed craters. Such craters could also be characterised as part of the Anthropocene era. They are structurally continuous with morphologies created by the bombardment of non-human objects and could be termed 'cultural meteorites'.

Table 4 is an example of the Burra Charter criteria applied to a cultural heritage site, the landing site of the USSR mission Luna 2 (Figure 2) in 1959, which combines two craters with numerous other features.

Place	Value	Cultural	Natural
Luna 2 landing site	Historic	First human object to make contact with the Moon in 1959. Associated with the astronomer Bernard Lovell, who verified that the mission's signals were real from Jodrell Bank. Established that the Moon did not have a magnetosphere.	A recent impact crater and the first human-made one on the Moon.
	Scientific	Illustrates the technological development of Soviet space endeavours.	The sodium cloud released has unknown impacts on the surface. As a geological feature, the known dimensions and qualities of the impactor make the crater a useful comparison.
	Aesthetic	The probe has a distinctive spherical design which was typical of early Soviet and US spacecraft. The angle of the antennas shows the design lineage with the Sputnik 1 satellite launched two years earlier.	The 144 scattered metal pennants are reflective surfaces unlike any natural lunar feature.
	Social	The probe and the rocket each carried a sphere of pentagonal medallions bearing Soviet insignia, showing its nationalist and Cold War symbolism. It represented the early Soviet lead in the space race and inspired Soviet workers. Unflown medallions are represented in museum collections in both Russia and the US.	Unknown
	Spiritual	Unknown	Unknown

Table 4: Indicative values of the Luna 2 spacecraft and site

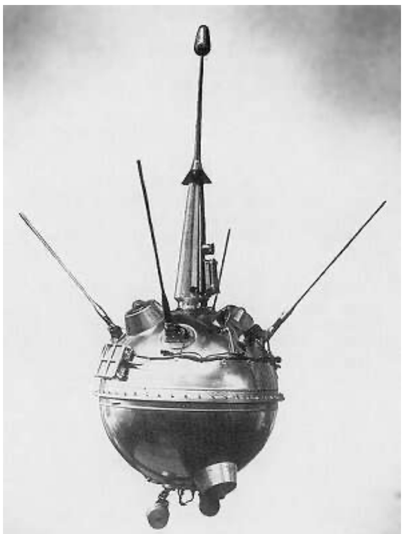

Figure 2: Luna 2 probe. Source: unknown

Significance assessment is the first step in arriving at an evidentiary basis for management decisions for both natural and cultural heritage. The Burra Charter criteria have been shown to be an effective mechanism for heritage locations in space, including the Moon. Appendix 6 demonstrates how the significance categories can be applied to one of the most well-known lunar cultural features, the Apollo 11 bootprints. It is recommended that they be adopted by lunar stakeholders in order to make significance assessments comparable across all classes of heritage place to facilitate coordination and cooperation. Significance assessment is also the basis of a number of other management options.

5.0 Mechanisms for heritage management

This section outlines some of the possible mechanisms for heritage management. This includes heritage registers, historic themes, Lunar Cultural Heritage Management Plans, Lunar Conservation Management Plans, heritage precincts and reserves, mitigation measures, the location of lunar installations and safety zones, procedures for sampling sites, and the identification of previously unknown heritage locations. This is by no means an exhaustive treatment of heritage management options but can be taken as starting point to consider appropriate and practical actions.

The underlying approach is management rather than preservation. It is accepted that preservation as such will not always be possible, although it is the preferred option. Management involves weighing competing interests to obtain outcomes with the greatest benefits for all stakeholders.

5.1 Heritage lists or registers

The idea of a heritage register of lunar sites was first proposed by Fewer (2002), based on the UK Sites and Monuments Records (now known as Historic Environment Records). The importance of this measure was reiterated by Spennemann and Murphy (2020) in their discussion of the impacts of the Google Lunar X prize, initiated in 2007.

Terrestrial heritage legislation often establishes registers or lists of heritage properties. Registration requires meeting significance criteria appropriate to local, state, national and global legislation or conventions. A good register should contain a representation of different site types, chronological periods, geographic distribution and environments. The sample of heritage places which are entered into a register also reflects community values as they change over time. The establishment of a list or register is, however, only the first step. It also requires the allocation of resources and dedicated administration.

Typically, registration offers some protection to a heritage place. There may be requirements to:

a) obtain permits prior to any alteration or disturbance to a heritage place;
b) prepare a conservation management plan (CMP), which outlines actions to conserve the fabric;
c) prepare a cultural heritage management plan (CHMP) or Environmental Management Plan (EMP), which outlines processes to protect cultural or natural significance during development activities in the locality;

d) consult with stakeholders (Gorman 2017).

Although the terms are often used interchangeably, there is an important distinction between a list, which may simply be a database, and a register (Hague Building Blocks 18.1 and 18.2). A database would list all known heritage places on the Moon, whereas sites are inscribed on a register through an agreed process after meeting significance criteria. A register is not fixed in stone: items can be added to or removed from it, with the removal also being the subject of an agreed process. A register is typically administered by a registrar, while decisions are made by a committee or advisory body.

A register has institutional or legal backing, whereas a list can be maintained by anyone. While establishing an 'authorised' register is advisable, having multiple locations and lists enables data validation and identification of problems. The Hague Building Blocks recommend having both.

Building on terrestrial precedents, a lunar cultural heritage register could contain the following information:

1) Location, using commonly accepted Geographical Information System (GIS) coordinates
2) Definition of site boundaries
3) Date of launch/landing and arrival at mission location
4) Date of abandonment of site, eg, the last transmission of data or other appropriate definition
5) Launching state
6) Legal status; ie who owns the hardware, previous heritage registration of objects on national heritage registers.
7) Description including history, fabric, and technology
8) Statement of significance (this is a short document based on the significance assessment)
9) Images. Ideally, these should illustrate fabric, setting and condition.
10) Identification of stakeholders. It should not be assumed that the launching state is the only stakeholder.
11) Bibliography
12) Contact details for the person who submitted the register entry.

Places of natural heritage significance with outstanding universal value are inscribed on the World Heritage List, but below this level of significance often are managed as parks or reserves on Earth at the national or state level. Without an existing system of reserves on the Moon, it may make more sense to include natural heritage places on a Lunar Heritage Register. The information recorded will necessarily include definitions of site boundaries and other locational information, images, a description, and a statement of significance.

A lunar heritage list might contain identical information to a register, but items can be placed on it without the requirement for consultation or other procedures. The Hague Building Blocks (Appendix 1) proposed the concept of 'internationally endorsed' heritage sites, meaning that something inscribed on a register requires broad support. This carries some risks, given possible conflicts of interest between lunar operators. The involvement of heritage professionals bound by codes of ethics is one way to mitigate this risk.

5.1.1 Sample criteria for heritage registration

While significance assessment is an essential part of the process, typically the criteria for registration are based on levels of significance. This section proposes criteria which could be used for the Moon in order to provide a transparent process for inscription on a heritage register.

> A place that is a component of the natural or cultural environment of the Moon may be inscribed on the Lunar Heritage Register (LHR) if it is of international or other special significance or value to humanity for present communities or future generations, because of any of the following:
>
> (a) its importance in the course, or pattern, of the natural or cultural history of the Moon;
>
> (b) it possesses uncommon, rare or endangered aspects of lunar natural or cultural history;
>
> (c) it has potential to yield information that will contribute to an understanding of the Moon's natural or cultural history;
>
> (d) its importance in demonstrating the principal characteristics of:
> - (i) a class of the Moon's natural or cultural places; or
> - (ii) a class of the Moon's natural or cultural environments;
>
> (e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
>
> (f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
>
> (g) its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
>
> (h) its special association with the life or works of a person, or group of persons, of importance in the Moon's natural or cultural history.

In the case of lunar cultural heritage, almost every mission will meet many of these criteria as they are currently few in number. Generally, it is not enough to meet only one criterion. For a long series such as the USSR Luna missions, the similarity between many of the spacecraft may mean some have a greater degree of eligibility than others. There will also be more natural heritage places or landscapes that meet the criteria than cultural heritage places.

5.1.2 Issues with heritage lists

Some artefacts on the Moon have been registered under US state heritage legislation (Tranquility Base artefacts in the states of California, New Mexico and Hawaii [Westwood et al 2010; Westwood et al 2017:9]; three Apollo rovers in the state of Washington). This means any disturbance to the objects at these sites may potentially mean the lunar stakeholder has committed an offence in these jurisdictions, even if they are not US citizens. The intersection of objects registered in terrestrial nations as well as, potentially, in an internationally agreed lunar heritage register, is a grey area that will need future exploration.

However, in the absence of international legislation, there can be no penalties for damaging cultural or natural heritage outside national legislation. Natural heritage is particularly vulnerable as there is no overlap with terrestrial natural heritage protection at all. There are no lunar natural heritage places on any national heritage list.

For cultural heritage, the Outer Space Treaty effectively separates artefacts from the sites they are part of and from which they draw their significance. A register that is not limited by this and that can include the entire site is essential; however, it may not have legal backing. There are some terrestrial precedents which can provide some guidance.

One is Australia's List of Overseas Places of Historic Significance to Australia, a 2007 amendment to the Environmental Protection and Biodiversity Conservation Act 1999. Its purpose was to

> symbolically recognise sites of outstanding historic significance to Australia located outside of the Australian jurisdiction . . . in a way that is respectful of the rights and sovereignty of other nations. (Commonwealth of Australia 2017)

Three properties in the UK, Türkiye and Papua New Guinea have been inscribed on the list. The list has no legal standing to protect the places as Australian jurisdiction obviously does not extend to other nations; but it lends 'moral weight', that is, a reason to comply in order to do the 'right thing'.

Heritage lists maintained by NGOS are not backed by legislation and have the capacity to inscribe places across national or planetary boundaries. The disadvantage is that they fail to provide any further protection than 'moral weight'. The American Institute of Aeronautics and Astronautics'(AIAA) list of Historic Aerospace Sites is perhaps the only one that includes off-world heritage places as well as terrestrial; Tranquility Base on the Moon is listed. Established in 1999, the aim of the programme was 'to promote the preservation and dissemination of knowledge about significant accomplishments of the aerospace profession' (AIAA n.d.). As the AIAA has members in many countries, this list is important because it represents the values of the international aerospace community.

5.1.3 Responsibility for maintaining a lunar heritage register

While each nation should ideally maintain a list of its own lunar cultural heritage, a formal lunar heritage register should be the charge of an independent and neutral international body to encourage trust and consensus. Spennemann and Murphy (2020:24) note the possible conflicts of interest which may arise if a private entity undertakes responsibility for such a list (particularly if using proprietary software).

The UN Register of Objects Launched into Outer Space, established in 1962, and maintained by UNOOSA, was proposed by Fewer (2002) as the basis for a heritage list. The Register currently contains over 15, 000 objects, most under the terms of the Convention on Registration of Objects Launched into Outer Space (1976), and others unregistered. As the infrastructure of the register is already in place, and the basic status of the objects recorded, it would seem a straightforward process to add layers of heritage information as outlined in Section 5.1.

However, as the UN organisation which overseas cultural heritage, a UNESCO space heritage register makes more sense. The International Council on Monuments and Sites (ICOMOS), which advises UNESCO on heritage matters and sets international principles and norms, can then oversee the process. The ICOMOS International Scientific Committee on Aerospace Heritage (ISCoAH), comprising experts from around the world, was formed in 2022 to further consideration of space heritage issues.

Other international NGOs that could take on a coordinating role are the Committee for Space Research (COPSAR), which administers the Planetary Protection Policy. Barclay and Brooks (2002) proposed establishing a Commission under the auspices of the International Union for the History and Philosophy of Science and Technology (IUHPST) to manage a space heritage list.

5.2 Heritage themes

Significance assessment and registration or listing of lunar cultural heritage sites can be aided by the use of themes. Themes help ensure representativeness, ie that a major category of site is not omitted, and aid in achieving comprehensiveness and consistency. They often relate to particular communities, societies or humanity as a whole and are widely used in historic heritage management. For example, the joint UNESCO-IAU thematic study on astronomical heritage identified the history of radioastronomy and the modern uses of astronomy as heritage themes (UNESCO nd).

An indicative list of lunar heritage themes is proposed below.

- i. Planetary and other science eg astronomy
- ii. Propulsion, energy and transport
- iii. Cold War history and politics
- iv. National space technology and history
- v. Amateur and citizen science
- vi. International co-operation
- vii. The evolution of space technology
- viii. Civil and commercial space – developing local, regional and national economies
- ix. Indigenous engagement with lunar exploration
- x. Labour history
- xi. Education
- xii. Cultural life – creative endeavours, social institutions, and popular culture
- xiii. Astrobiology

xiv. Human adaptation to the lunar environment
xv. The propagation of terrestrial life on the Moon
xvi. Robotics and artificial intelligence

For example, the Chang-e 4 mission, which carried seeds and biological materials to the Moon in 2019, relates to the themes of *National space technology and history*, and *The propagation of terrestrial life on the Moon.* As with the UNESCO-IAU thematic study mentioned above, themes can form the basis of further heritage research to inform significance assessment and proposals for inclusion in a register.

5.3 Lunar Cultural Heritage Management Plans (LCHMP)

A Lunar Cultural Heritage Management Plan is aimed at minimising harm to heritage sites. It contains measures for conserving heritage values before, during, and after operations which may impact a heritage site. It is specific to each operation and should be prepared by an appropriately qualified and experienced professional. A LCHMP could be included in mission planning and will define predicted impacts from equipment and activities, together with mitigation strategies. A LCHMP would include:

- Identification of site boundaries
- Assessment of known site condition
- Statement of significance
- Assessment of threats and impacts from the proposed lunar activity
- Management and mitigation strategies
- Provision for monitoring site condition

In the absence of any statutory or regulatory authority for lunar heritage, there is no requirement for legal compliance. Preparing a LCHMP can be undertaken voluntarily by a stakeholder in order to demonstrate accountability, commitment to sustainable principles, or to garner support for a Social Licence to Operate. A voluntary LCHMP also serves to demonstrate ‘due regard’ (Article IX, Outer Space Treaty 1967). Sufficient resources should be allocated to carry out the writing, implementation and monitoring of a LCHMP. This work may be aided by establishing a heritage advisory group for the project, which may include representatives of nations or communities whose heritage may be impacted.

A key part of a LCHMP is assessing impacts. This requires detailed knowledge of the works to be carried out and the equipment used, combined with scientific knowledge of lunar geology and environment. Impact assessment is predictive. Impacts can be categorised in different ways, but a basic measure is high, medium, or low, as this may then correspond to the mitigation recommendations. For example, walking around the Apollo 11 site may have a low impact on the hardware but a high impact on the footprints. A high impact may be irreversible, or destroy the scientific integrity of the site or landform. The highest level of impact comes from activities which cause a significant level of ground disturbance (for example, rocket ingress or egress, excavation, or construction) around sites or objects of high cultural significance. Significant impact may also be caused by the siting of installations where they interrupt the views and setting of the original site from being appreciated eg a mining installation within view of Apollo 11.

The highest level of impact is likely to occur if a safety zone is defined which includes heritage place. However, dust transport may also have low impacts on heritage places which are outside the safety zone or some distance from it. In this case an LCHMP could also be considered.

The LCHMP may be amended from time to time as new information comes to light, with the agreement of relevant stakeholders. A LCHMP should be lodged with any international regulatory organisation (eg UNOOSA) or other authorised body coordinating lunar operations. A preliminary template for an LCHMP is presented in Appendix 7.

5.4 Lunar Conservation Management Plans (LCMP)

For a site of high significance or which may be subjects to high impacts, a LCMP may also be considered. A conservation management plan is a set of policies to guide the management, and conserve the heritage values, of a heritage place. The main objective of the LCMP is to ensure that decisions about a place are carried out with regard to its heritage significance. They are more detailed than a LCHMP and may address specific rather than general threats or impacts to a distinct object or place. As with a LCHMP, the LCMP is based on the significance assessment. A LCMP can be applied to the conservation of both natural and heritage values.

A LCMP may include:

- Detailed assessment of the significance of different components within a site
- Detailed assessment of the condition of components
- Identification of components which are more vulnerable than others in the context of the lunar activity
- An elucidation of the contribution of different components to the site's heritage significance
- Management strategies for specific components
- Identification of opportunities and constraints (limits) based on the significance. Opportunities may include scientific research, tourist potential, educational and interpretation potential
- Policies and specific tasks for maintaining the condition and integrity of the site or object

For example, a complex site like Tranquility Base contains over 100 items manufactured from a range of materials (O'Leary 2009). Not all artefacts are of equal significance as individual items, although they contribute to the site's overall significance. A rare material or an uncommon artefact, such as the television camera or the medals commemorating Yuri Gagarin and Vladimir Komarov, may require separate specific consideration.

5.5 Heritage precincts and reserves

There have been many proposals for nature reserves or parks on the Moon (eg Krichevsky and Bagrov 2019, Walsh 2012) as a way of preserving or managing both natural and cultural heritage values. The concept is that an area is set aside from commercial activity or habitation in order to prevent any impacts on the heritage values, ensuring that it survives into the future. The area is not defined in relation to a specific lunar activity but on the basis of its heritage values.

The park or precinct may preserve rare or typical examples of natural and cultural landscapes or sites, as is already done in mixed properties in the World Heritage List, such as Kakadu National Park in Australia and the Ennedi Massif in Chad. A LCHMP can be created for an entire heritage precinct, while the individual sites within it may have LCMPs.

Analysing the geographic distribution of human material culture on the Moon, Capelotti proposed the creation of five cultural heritage precincts. It is arguable that some of them are multi-component sites rather than precincts (Table 1 and Figure 2). The heritage values of Capelotti's proposed precincts have not been assessed, nor the contribution of natural heritage to their definition. They provide a starting point for considering how to define parks or preserves, but could also form the basis of the first declared heritage precincts on the Moon.

Date range	Missions	Geological context	Number of elements	Notes
1967 - 1969	Apollo 11 + Surveyor 5	Mare (Sea of Tranquility)	107 objects	First human landing site on the Moon or anywhere outside Earth
1967 - 1972	Apollo 12 LM + ascent stage crash, Apollo 14 LM + ascent stage crash, Surveyor 3, S IVB (A 13), S IVB (A 14), S IVB (A 15), S IVB (A 16), S IVB (A17)	Landscape of natural and cultural craters. Ocean of Storms	TBC	Largest concentration of remains of Apollo programme. Only remains of Apollo 13 to reach the Moon.
1959 - 1971	Apollo 15 + lunar rover + Luna 2	Mare Imbrium, Hadley Rille	At least 146	First human object to make contact with another celestial body; first USSR lunar site; first lunar rover
1972	Apollo 16 + lunar rover	Descartes Highlands	TBC	
1972 - 1973	Apollo 17 + lunar rover + Luna 21 + Lunokhod 2	Taurus-Littrow Valley, Le Monnier Crater	TBC	Two rovers and landers. Lunokhod 2 is owned by Richard Garriott and is 42 km distance from Luna 21
1967	Surveyor 4, Surveyor 6	Sinus Medii	2	One crash, one soft landing

Table 5: Lunar heritage precincts

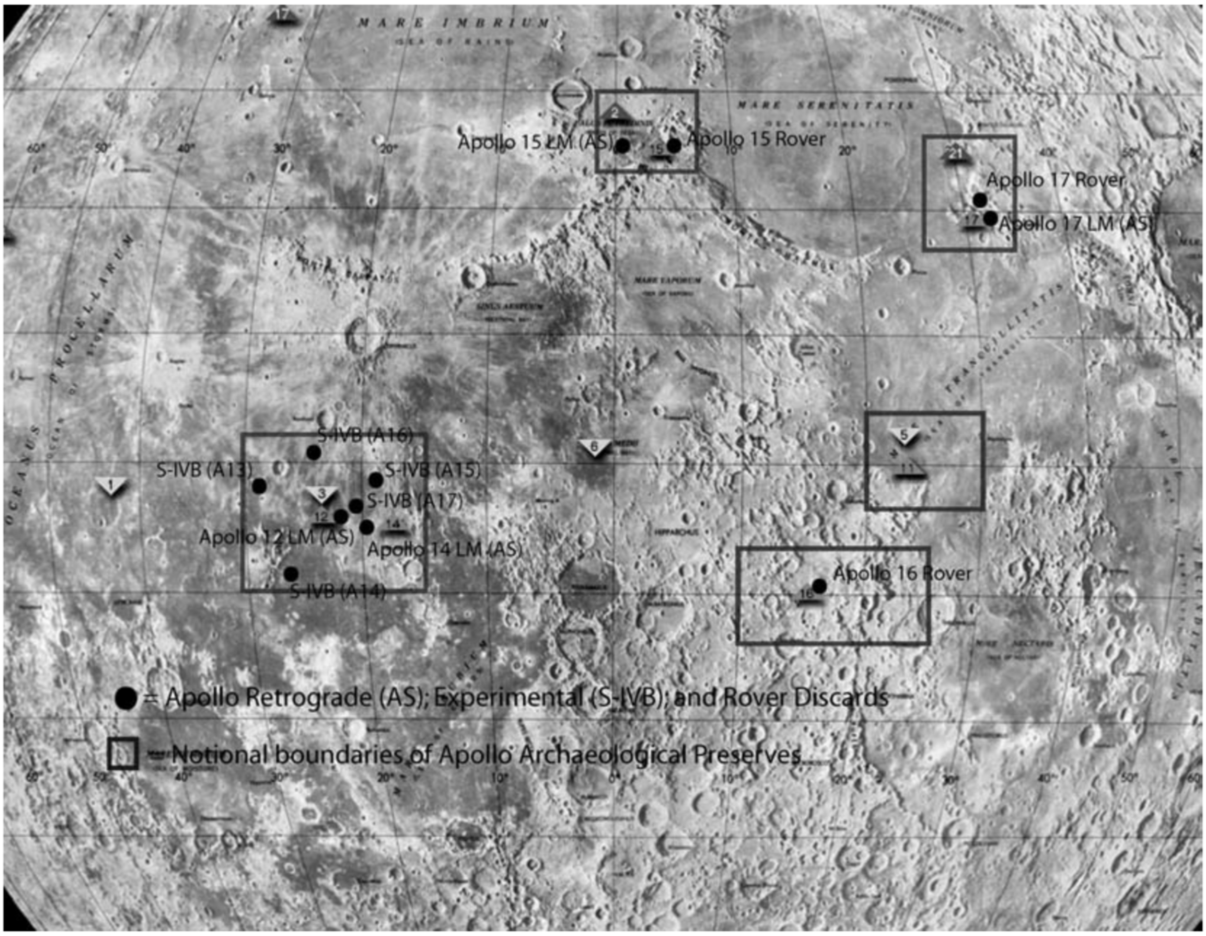

Figure 3: Location of heritage precincts (Capelotti 2010)

5.6 Mitigation measures

Mitigation is defined as elements of the design or other activities taking place as part of the proposed development that can be adopted to avoid, prevent, reduce or offset negative effects or impacts. This means first determining what might constitute an impact. Westwood et al (2017:123) note that an impact is something that affects, directly or indirectly, the characteristics that are the reason a site is registered or listed. Whether a place is registered or not, all impacts could be assessed according to their adverse effects on the features that give a site historic, scientific, aesthetic, social and spiritual significance. For example, moving or removing artefacts on a site destroys the spatial relationship between objects, so that they no longer represent the original actions or intents and lose their scientific significance. Stirring up dust near a heritage site could damage the fabric of the objects, as the dust is highly abrasive. The example of Surveyor 3, where only two landings of small craft caused pitting on the materials, indicates that repeated vehicle movement over time could have a very serious effect on the survival of space hardware.

Some commonly used terrestrial mitigation measures are suitable for lunar heritage. They are described below.

a) Buffer zones. This is a boundary placed around a site inside which no work is permitted to take place. This is distinct from a curtilage, which is an area of land surrounding a heritage item that contributes to its heritage significance, although the buffer zone and curtilage could coincide. The buffer zone should be sufficiently large to avoid impacts and ideally should include all parts of the site. In some cases, the size of the buffer zone may vary according to the nature of the planned activity. NASA defined a number of levels of buffer or exclusion zone in its 2011 heritage guidelines, based on the impacts of different vehicular approach, for example, a 50 m radius around the Apollo 11 landing module. Buffer zones should be defined on the basis of impact and would normally form part of a LCHMP. The buffer zone remains in place for the duration of the activities which cause the impacts.

b) Salvage. Salvage is undertaken as a last resort if major damage to a cultural heritage site is unavoidable, and involves fully recording a site according to accepted standards, before removing artefacts or samples of significant material from the site to preserve them. Salvage would require permission from the owner of the hardware (usually the launching state but may also be a private company). Consultation with other stakeholders must be undertaken prior to salvage. Salvage requires a plan for the safe keeping or appropriate disposal of the artefacts.

c) Offsets. An action may have adverse residual impacts on natural and cultural heritage places. Offsets are aimed at balancing these impacts. Although offsets are mostly used as an environmental measure, they also have applications in cultural heritage. Offsets can be direct, such as ensuring that a similar environment or heritage site in another location is protected, or indirect, such as research or education programmes. Offsets are only an option after avoidance or mitigation measures have failed to prevent any impacts. They do not make an unacceptable impact acceptable.

d) Memorialisation. If damage to a lunar heritage site is unavoidable, or a site is found to be destroyed after the fact, the location and cultural significance of the site could be represented in some form of monument or memorial of the kind already found on the Moon. This could be considered a form of offset. Such memorials should be made distinct from those already existing in association with sites, for example the Apollo 11 plaque.

e) Adaptive re-use. It’s unlikely that this would be a viable option for existing lunar cultural heritage sites, but may be applicable to future habitats or industrial installations. Adaptive re-use ensures the survival of significant fabric and contributes to sustainability by avoiding the discard of materials and the introduction of new ones. Interoperability would enhance the prospects for adaptive re-use of decommissioned installations. However, given our lack of knowledge about the impacts of the lunar environment on human-manufactured materials, it is possible that only a short exposure will render materials unsafe or too degraded for re-use.

f) Monitoring. Monitoring enables the condition of a site to be assessed over time, to determine whether the mitigation measures are being effective in reducing impact. If this is not the case, a more active intervention can take place. Given that approaching heritage sites in vehicles is a source of damage, this is best carried out remotely, from orbit. The

Lunar Reconnaissance Orbiter images provide an undisturbed baseline of many sites, although at low resolution. The accumulation of monitoring data can contribute to the scientific study of human materials in the lunar environment.

g) Digital recording. Advances in camera technology, digital imaging and photogrammetry offer the opportunity to make digital reconstructions of natural or cultural heritage places. If impacts are unavoidable, then this ensures that a form of data survives to enable future scientific study or for stakeholders and the public to experience aspects of the heritage place. Digital copies are not a substitute for the actual objects or places and should only be used to enhance mitigation of impacts.

h) Rehabilitation and restoration of natural heritage
The purpose of restoration is to return ecosystems to their original state before they were impacted by industrial activities such as mining, whereas rehabilitation recognises that there may be permanent alteration and aims to at least partially repair damage. An aspect of this is creating a stable situation where previous natural processes can eventually be re-established. In the absence of self-generating biotic ecologies, these processes have different implications for the Moon. The study of abiotic ecosystems and cycles will provide essential knowledge for possible rehabilitation and restoration.

Ideally, a place designated as natural heritage will be managed to avoid impacts as far as possible. However, if this is not possible, there is a balance to be achieved. Article 19 of the ANHC states that

> Restoration is appropriate only if there is sufficient evidence of an earlier state to guide the conservation process and if returning the biodiversity, geodiversity or habitat of the place to that state is consistent with the natural significance of that place.

Given the lack of information of active processes on the Moon, such as water cycles, it may be difficult to return a landscape to its former state in the short to medium term.

Lunar surface activities are likely to have an impact on albedo, a measure of the degree to which a surface reflects solar radiation and hence creates the appearance of brightness. This is a key feature of the aesthetic qualities of lunar landscapes. The IAU's lunar nomenclature includes a category for albedo features, although there is only one named at present (Reiner Gamma near the Marius Hills). The restoration of Arctic ice albedo has been the subject of research (Field and Sholtz 2020) so there are some terrestrial precedents to provide guidance.

It may also be undesirable to erase all traces of human activity as if it had never happened, as this is also evidence of processes creating new cultural landscapes (Evans 2011, Storm 2014:101). For the purposes of future scientific work, it may be important to understand the degree to which the landscape has been previously disturbed. Impacts may not always be negative. On Earth, Marescotti et al. (2018:229, 238) argue that abandoned mines provide access to unique geological elements and landscapes, thus contributing to geoheritage.

5.3 Location of installations and safety zones

The avoidance of harm to natural and cultural heritage places should form part of the earliest planning for a lunar surface mission, starting from consideration of location of landing and launch pads, transportation infrastructure, industrial and residential facilities. This is dependent on accurate information about the location of known places of natural and cultural heritage significance. Hence engagement with lunar GIS systems is essential from the outset.

In the past, the selection of landing sites was based on balancing scientific and safety criteria (Cui et al 2017). For longer term industrial and residential sites, the selection of activity areas is likely to be based on criteria which include proximity to target resources and access to solar energy. Landing sites and activity areas may be different locations, unlike the Apollo missions where they are one and the same. The extent of the impacted area will likely be greater than the most extensive lunar sites to date.

The construction and operation of various lunar infrastructure is likely to cause dust transport. The highly abrasive and adhesive dust can damage human-manufactured materials, as was evident from the analysis of Surveyor 3. Dust movement may also have long term environmental impacts which may be detrimental to lunar surface operations, for example, dust lofted into the exosphere (Metzger 2020). The location of infrastructure to minimise dust impacts to both heritage places and the installations of other lunar operators should be taken into consideration, for example by using natural barriers or the construction of berms (Gorman 2017, 2019).

To further the goal of sustainable lunar development, avoiding or minimising impacts on natural and cultural values should be a factor in selecting activity areas. The preferred option is to locate installations as far as possible from such places. The current location of many existing lunar heritage sites is known. However, the natural values of lunar landscapes are yet to be determined. This means the available information about a landscape, which is used in making decisions about the location of lunar activities, should also be used to make a preliminary assessment of the natural heritage significance. The precautionary principle is key here. The identification of places of natural or cultural significance in proximity to an activity area may then trigger cultural or environmental management plans, including mitigation measures.

5.8 Approval process for sampling or removing materials from natural and cultural heritage sites

The Apollo 11 mission in 1969 was the first to return samples of lunar regolith to Earth. The removal of a camera and other material from the Surveyor 3 probe by the Apollo 12 mission in 1969 was the first example of sampling a cultural heritage site. To date, removal of materials from heritage places has been predominantly for scientific purposes, although the knowledge gained from natural samples also has applications for identifying and characterising lunar resources for future use.

A designated or listed natural heritage site should not be sampled with a view to commercial exploitation. The purpose of the samples should be scientific investigation or in order to contribute to an understanding of natural or cultural heritage values. In some instances, it may be preferable to design an experiment rather than risk damage to a heritage place by removing samples.

The following principles offer some guidance to the sampling process.

- Non-invasive or experimental means of obtaining the same information should be considered first;
- Sample removal should minimise adverse impacts on the site or landscape;
- The least significant fabric should be targeted for sample removal in the first instance;
- Research questions and methods should be articulated and proposed analytical methods specified.
- The amount of material needed must be specified as well as the method of obtaining it.
- There should be a plan for dissemination of results and for storage, curation and accessibility of the sample to ensure its long-term preservation. This is consistent with terrestrial practice, for example in the UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001) Article 2.6.

In framing the research proposal, the applicant must demonstrate that the desired information does not already exist (ie from previous returned samples, spacecraft or analogue experiments). Samples should be taken from materials that are abundant rather than rare unless there is a justifiable rationale. The legal entity responsible for a lunar heritage site should have first preference in sample removal.

Some locations have experiment packages which may yield valuable scientific information, eg the Chang-e 4 biological experiment. Whether biological materials should be considered part of the fabric of the site is unclear (see Section 5.10).

5.9 Illegal or uncontrolled sampling

Uncontrolled removal of materials can damage sites, as well as destroying the integrity of the site and its scientific significance. A fundamental principle is that cultural heritage should not be commercially exploited through sale of artefacts or materials.

With increased lunar activity, there is the possibility that cultural heritage sites may be looted. As with the terrestrial antiquities trade, there is the potential for a black market in lunar artefacts to develop. NASA has been vigilant in prosecuting the illegal sale of moon rocks and Apollo artefacts. Other nations have legislation or protocols which control the trade in cultural properties.

The UNESCO Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property (1970) has been ratified by 141 states; this includes the US, India, Russia, France, Canada and numerous other European and South American nations. While aimed at the terrestrial antiquities trade, some principles are applicable to lunar objects. Lunar heritage objects and natural materials meet several of the Article 1 criteria for defining cultural property:

> (a) Rare collections and specimens of fauna, flora, minerals and anatomy, and objects of palaeontological interest;
> (b) property relating to history, including the history of science and technology and military and social history, to the life of national leaders, thinkers, scientists and artist and to events of national importance;
> (d) elements of artistic or historical monuments or archaeological sites which have been dismembered;
> (f) objects of ethnological interest;
> (g) property of artistic interest

The Convention encourages international cooperation as 'one of the most efficient means of protecting each country's cultural property' (Article 2). It requires nations to set up a system of providing certification for the export of cultural properties, and to 'to prevent museums and similar institutions within their territories from acquiring cultural property originating in another State Party which has been illegally exported' (Article 7). States Parties can request the return of illicitly obtained cultural properties (Article 13).

The companion convention, the 1995 UNIDROIT Convention on Stolen or Illicitly Exported Cultural Objects, deals with the restitution or return of illicitly acquired cultural properties. However, its language is more restrictive in that it only applies to properties obtained within a nation's territories.

5.10 Protocols for human biological remains

The six Apollo missions left behind an estimated 96 bags containing human waste, as well as urine collection devices. The legal status of the astronaut waste is not clear. Lopez (2020) argues that it does not satisfy the definition of a 'space object'. While NASA as the launching state owns the bags, it may not own the biological materials within.

These substances have scientific value for what they may reveal about the impacts of radiation on DNA, the human microbiome, particularly from the gut, and the survival of microfauna in extreme planetary environments. However, they also have a high sensitivity as they relate to living people or their descendants. In recent years sensibilities about genetic material and human remains have been a matter of much debate, particularly in relation to violations of the autonomy and dignity of Indigenous people and other groups such as criminals (Alpasian-Roodenberg et al 2021, Kowal 2013, McQueen 1998).

The analysis of the waste materials risks revealing personal and medical information about the astronauts which they may wish to keep private. In the case of DNA, contemporary methods such as the polymerase chain reaction (PCR) can replicate the DNA and produce large quantities for distribution and further analysis. Should this be done without the consent of the person to whom the DNA or biological material belongs? Who has rights to the genetic material?

Most contemporary institutions have ethics approval processes for conducting research on human subjects, including archaeological human remains. It will be critical to ensure that any study of Apollo astronaut waste complies with currently accepted standards for such research.

5.11 Location of previously unknown cultural heritage

There are several spacecraft and objects the location of which is currently unknown. They include the Apollo 11 ascent stage, which may have crashed, but which could also still be in orbit (Meador 2021). The procedure for response to the discovery of a previously unknown heritage site or object can be modelled on those in use on Earth. This may include:

- Ceasing activities at the location to avoid unnecessary impacts
- Determination of the co-ordinates
- Photographic documentation
- Verification of what it is and who owns it
- Notification according to Outer Space Treaty and Liability Convention
- Reporting to relevant lunar heritage authority
- Consultation with possible stakeholders

These procedures can be outlined in a LCHMP.

Conclusions

This report for the GEGSLA has been written with a view to providing definitions of natural and cultural heritage on the Moon, and proposing practical heritage management strategies based on contemporary heritage philosophy and practices. Terrestrial precedents have been adapted to take into account how the lunar environment differs from that of Earth, and the likely nature of activities proposed to take place in the future. The suggested strategies are a starting point for more detailed discussion of how best to manage the unique natural and cultural values of the Moon.

A fear is sometimes expressed that protecting lunar heritage will interfere with the ability to access all parts of the Moon and will limit access to resources needed for In Situ Resource Utilisation or commercial purposes. With appropriate planning, there is no reason why human activities and lunar heritage cannot co-exist to mutual benefit. Consideration for lunar natural and cultural heritage is integral to the sustainable use of the Moon.

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APPENDIX 1: HAGUE BUILDING BLOCKS

An excerpt from the Hague Building Blocks of the articles specifically dealing with heritage.

10. Avoidance and mitigation of potentially harmful impacts resulting from space resource activities

Taking into account the current state of technology, the international framework should provide that States and international organizations responsible for space resource activities shall adopt appropriate measures with the aim of avoiding and mitigating potentially harmful impacts, including:

- a) Risks to the safety of persons, the environment or property;
- b) Damage to persons, the environment or property;
- c) Adverse changes in the environment of the Earth, taking into account internationally agreed planetary protection policies;
- d) Harmful contamination of celestial bodies, taking into account internationally agreed planetary protection policies;
- e) Harmful contamination of outer space;
- f) Harmful effects of the creation of space debris;
- g) Harmful interference with other on-going space activities, including other space resource activities;
- **h) Changes to designated and internationally endorsed outer space natural or cultural heritage sites;**
- **i) Adverse changes to designated and internationally endorsed outer space sites of scientific interest.**

18.Institutional arrangements

The international framework should provide for:

1. a) The establishment and maintenance of a publicly available international registry for registering priority rights of an operator to search and/or recover space resources;
2. b) The establishment and maintenance of an international database, in addition to the international registry, for making publicly available:
    1. Advance notifications of space resource activities, including any area-based safety measures;
    2. Information and best practices;
    3. **The list of designated and internationally endorsed outer space natural and cultural heritage sites; and**
    4. **The list of designated and internationally endorsed sites of scientific interest;**

3. Information and best practices on the prior authorization and continuing supervision of space resource activities for which States and international organizations are responsible;

4. Notifications of the termination of space resource activities for which States and international organizations are responsible.

c) The designation or establishment of an international body or bodies responsible for:

a) The consideration and promotion of best practices;
b) The listing of designated and internationally endorsed outer space natural and cultural heritage sites, and sites of scientific interest;
c) The monitoring and review of the implementation of the international framework; and
d) The governance of the international registry, the international database and any other mechanism that may be established for the implementation of the international framework.

APPENDIX 2: THE ARTEMIS ACCORDS

Section 9 of the Artemis Accords deals with lunar heritage.

ACKNOWLEDGING a collective interest in preserving outer space heritage;

SECTION 9 – PRESERVING OUTER SPACE HERITAGE

1. The Signatories intend to preserve outer space heritage, which they consider to comprise historically significant human or robotic landing sites, artifacts, spacecraft, and other evidence of activity on celestial bodies in accordance with mutually developed standards and practices.
2. The Signatories intend to use their experience under the Accords to contribute to multilateral efforts to further develop international practices and rules applicable to preserving outer space heritage.

APPENDIX 3: THE VANCOUVER RECOMMENDATIONS

Articles 21 and 22 relate to cultural and natural heritage.

21. Encourage significance assessments of existing and future natural and cultural heritage sites, natural and cultural heritage impact assessments of all Space mining activities, and the development of publicly accessible international heritage site lists (natural and cultural), with input from states, science, industry, and other non-governmental stakeholders.
22. Consider how to protect sites where scientific studies are underway, including from possible secondary effects of Space mining such as unintentional seismic activity.

APPENDIX 4: THE ONE SMALL STEP TO PROTECT HUMAN HERITAGE IN SPACE ACT (US, 2020)

Public Law No: 116-275 (12/31/2020)
This summary is available from https://www.congress.gov/bill/116th-congress/senate-bill/1694

This bill directs the National Aeronautics and Space Administration (NASA) to

- add the recommendations described in the following clause as a condition or requirement to contracts, grants, agreements, partnerships or other arrangements pertaining to lunar activities carried out by, for, or in partnership with NASA;
- inform other relevant federal agencies of the recommendations; and
- encourage the use of best practices, consistent with the recommendations, by such agencies.

The recommendations described are

- NASA's *Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts* issued by NASA on July 20, 2011, and updated on October 28, 2011; and
- any successor recommendations, guidelines, best practices, or standards related to the principle of due regard and the limitation of harmful interference with Apollo landing site artifacts issued by NASA.

NASA may waive the conditions or requirements as it applies to an individual contract, grant, agreement, partnership or other arrangement pertaining to lunar activities carried out by, for, or in partnership with NASA so long as

- such waiver is accompanied by a finding from NASA that carrying out the first directed obligation of this bill would be unduly prohibitive to an activity or activities of legitimate and significant historical, archaeological, anthropological, scientific, or engineering value; and
- the finding is provided to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate no later than 30 days before the waiver takes effect.

APPENDIX 5: THE MOON VILLAGE ASSOCIATION BEST PRACTICES FOR SUSTAINABLE LUNAR ACTIVITIES

Article 5 relates to natural and cultural heritage.

5

Avoiding Harm

Space actors are encouraged to take measures to the extent possible:

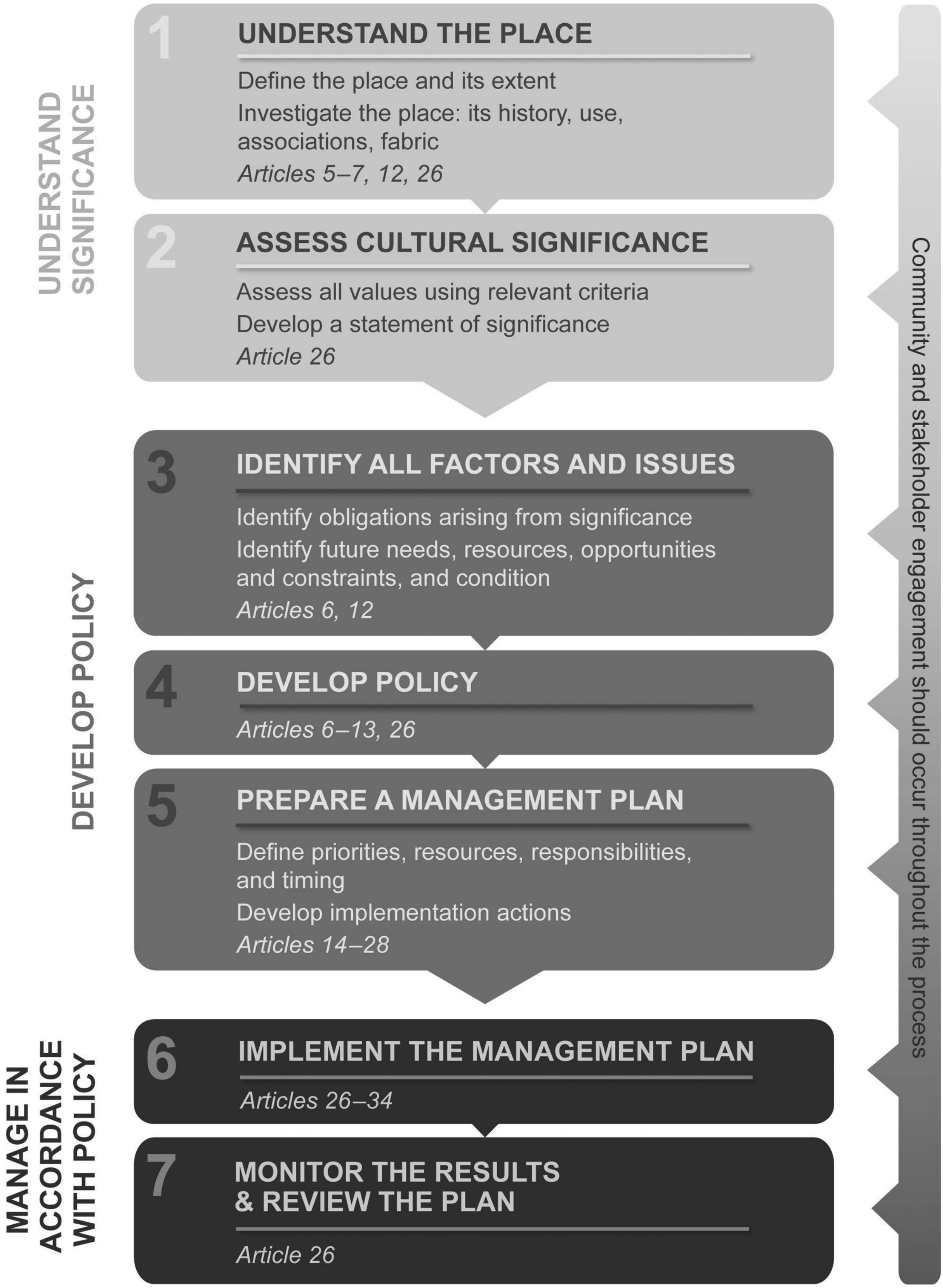
i. To avoid causing adverse changes to the lunar environment or cislunar space, including the harmful contamination of the Moon in contravention of planetary protection policies;

ii. To mitigate the creation of lunar orbital debris;

iii. To avoid causing harmful interference with existing or planned lunar activities; and

iv. To avoid causing adverse changes to internationally endorsed sites of significant scientific or historical interest.

APPENDIX 6: THE BURRA CHARTER PROCESS



Source: Pearson and Sullivan 1991

APPENDIX 7: SIGNIFICANCE ASSESSMENT OF THE APOLLO 11 BOOTPRINTS

This case study shows how the Burra Charter (2013) significance criteria can be applied to a heritage feature on the Moon, the astronaut bootprints which are part of the Apollo 11 site. The bootprints are one of the most well-known human traces and have been the focus of recent campaigns for greater recognition of lunar heritage. They receive no current heritage protection as they are not 'objects' which can be listed on US state heritage registers.

Historic significance: high
The bootprints are associated with a unique event, the first human expedition to another world; with the astronauts Neil Armstrong and Buzz Aldrin, who are rightly celebrated for this achievement; and with the historical processes of the Cold War 'space race' and early years of space exploration. The prints are the first human trace fossils outside Earth.

Scientific significance: high
The astronaut boot soles were an experiment in themselves: the bands were designed to convey information about regolith depth and reflectance. This is partially why so many photographs of the bootprints were taken. Further research could use them to assess and better understand surface processes and regolith behaviour.

Their placement shows where the astronauts walked over their two and half hours on the surface, and hence define the limits of the site. Images show that the prints are layered or superimposed, which enables a time sequence of activities to be derived. Their depth and angle indicate something about the gait adopted by the crew to maintain an upright posture in hypogravity, as well as the depth of lunar dust over the local area. A major research potential of the prints is a comparison of the six landing sites, over which the duration of surface became progressively longer, and the succeeding crews had the benefit of learning from the preceding ones (Gorman 2016).

As a recent geological disturbance to the regolith, the sharp ridges of the prints create a baseline to assess natural erosion processes on the Moon such as micrometeorite impacts and dust levitation.

The mechanics of the bootprints could also be usefully be compared to robotic and rover traces (Gorman 2016).

Aesthetic significance: high
The geometric, banded appearance of the trace fossils is demonstrably unlike any other geological features on the lunar surface. The prints are 35.5 cm x 16 cm in size. The rectilinearity and regularity of the imprints are a stark contrast to the predominant circular patterns created by bombardment craters and the irregular shadows and textures of rocks. The contrast between light and dark in the ridges is a distinct and unique pattern in the lunar environment.

Social significance: high
The first footprint of Neil Armstrong has become a 20th century icon, reproduced in countless formats and instantly recognisable. Although the Apollo missions were political in nature and opposed by various sectors of society, the overriding social meaning of the bootprint is human ingenuity and courage. Its creation was watched by millions of people across the world and hence has a resonance far outside the space community. The bootprints are associated with Armstrong's famous first lines about 'one small step', a phrase which has become incorporated in popular culture, advertising and literature.

Spiritual significance: low
While an argument for spiritual value is not as obvious as social value, the reverence in which the bootprints are held is equivalent to a secular belief relating to humanity's place in the universe. The bootprints have contributed to the conviction, strongly held by some groups, that the Apollo landings were a hoax (Link 2021). They have also been used by scholars of religion to explore concepts of faith and divinity (eg Gordon 2019, Stavrakopoulou 2011).

APPENDIX 8: DRAFT LUNAR CULTURAL HERITAGE MANAGEMENT PLAN (LCHMP)

This draft has adapted standard components of terrestrial CHMPs with a view to their applicability to the unique circumstances of lunar activities. It is intended as a first approximation which could be further developed.

Standard components of a LCHMP could include the following:

Introduction

- The reasons for preparing the Management Plan (eg voluntary, required by regulation)
- A brief description of the location of the activity area or safety zone, including relevant coordinates
- The time frame for application of the LCHMP, in terms of the duration of the activity or the safety zone
- The name of the lunar operator (space agency, private company, consortium etc) with all contact details for enquiries or reporting
- The name of the heritage expert who undertook the work and their qualifications and experience

Activity description

- Clear, relevant and detailed information about the nature and extent of the proposed activity to be covered by the LCHMP, including ancillary works, in order to assess the scope for potential impact on lunar cultural heritage.
- A description of the likely impact on the surface from the activity and how this relates to impacts on heritage sites
- Appropriate images of the activity area.

Documentation of consultation

- The names and roles of any persons or parties consulted in the process of creating the LCHMP
- Records of formal consultation meetings or processes, including date, location, agenda items
- Outcomes of consultation meetings, including the documentation of disagreements
- Details of informal consultations (eg personal communications)
- Details of meetings of any advisory groups established for the purposes of the project
- If the proponent of the development and the LCHMP is different to the launching state of the heritage site, official representatives of the launching state may need to be signatories to the LCHMP as a way of avoiding disputes and ensuring agreement to the mitigation measures.

Dispute resolution

Procedures for dispute resolution are a typical feature of terrestrial CHMPs. The LCHMP may set out time frames for communications regarding the dispute, and preferred methods, for example, mediation or negotiation, or the appointment of a neutral evaluator. Any mechanisms which have been established for more general disputes in lunar governance systems would be appropriate to use.

Results of cultural heritage assessments

Cultural heritage sites should be identified by unique designators to avoid confusion. If a lunar heritage register has been established, these designators should be used.

Desktop assessment

- Search of relevant international or national heritage registers to locate registered lunar objects and registered terrestrial heritage sites which are related to the lunar site
- Search of literature and UN Register of Space Objects to identify sites not present on national heritage registers or international space heritage registers
- Search of relevant museum collections to identify material culture related to heritage sites in the activity area
- Literature review of previous reports, academic literature, and archives where applicable
- Satellite imagery of the activity area
- Assessment of the likelihood that previously unknown heritage locations or objects might be present
- Identification of relevant stakeholders. A cultural heritage site may exist across more than one safety zone or activity area.

Field assessment

Where a field assessment, either using human personnel or robotic means, can be undertaken without creating harm to a heritage site, it should include:

- Survey methods eg remote sensing, instruments used, location of transects, scale of observation
- Maps, images or new data obtained about the location and condition of existing sites
- Maps, images or new data obtained about the location and condition of previously unknown sites
- Obstacles and limitations of the survey
- Details of any samples removed or any other disturbance of the site, whether deliberate or accidental

Details of cultural heritage in the activity area (if any)

The aim of these sections is to provide sufficient information to make evidence-based management decisions.

- Details of the assessments undertaken to determine the nature and significance of each place or object, including analysis of site formation processes;
- Results of the assessments
- Precise coordinates of location and extent of the site
- A detailed plan of the site showing the relationship between objects and traces

- A detailed description of the material remains at the site, including any catalogues of data recorded.
- Historical background of the site
- An assessment of the significance of the place, site or objects. It is recommended that the significance criteria of the Burra Charter be used for consistency.
- Any images of the site
- Impact assessment, including the cumulative impact of ongoing activities in the area
    - Whether the activity will be conducted in a way that avoids harm to the place or object
    - If there is potential harm, whether the activity will be conducted in a way that minimises harm to the place or object
    - What aspects of cultural significance will be affected by the activity
    - Any specific measures required for the management of the place or object, before, during and after the activity.
    - Any contingency plans required in relation to disputes, delays and other obstacles that may affect the conduct of the activity

Specific management and mitigation measures

The Management Plan should clearly explain why the activity cannot be conducted to avoid harm to cultural heritage if this is the case. If harm is likely to be caused, then mitigation measures to minimise the harm should be outlined.

Based on the significance assessment, specific management measures should be identified. They could include:

- Avoidance of the site as the preferred management strategy in the first instance ie locate the activity as far away as possible
- If a heritage site is not going to be impacted by the activity, then no action should be taken that will create unnecessary disturbance.
- Adjust the design of the activity (eg location of specific elements, construction methods, operations methods) to minimise harm
- A salvage strategy to recover information only when it is not possible for that cultural heritage to be preserved in situ.
- Note that disturbance and salvage is destructive and should only be carried out when necessary to identify and document the extent, nature and significance of the cultural heritage that may be threatened by the proposed activity. Disturbance or salvage should not occur if it causes more harm to the heritage than the activity.
- Removal and curation of heritage objects. A plan should be provided specifying secure storage location (whether that is on the Moon or Earth), resourcing, and any relevant factors relating to the long-term survival and safety of the objects. Potential repositories should be identified in advance. For example, the Smithsonian Institution has a Memorandum of Understanding with NASA for the deposition of materials related to US space activity.

- Removal of human biological material, for example, from the Apollo missions or cremated ashes, must be handled sensitively, with a view to preserving the dignity of the people to whom they belong (or their family and descendants). Protocols established for ethically dealing with human remains in other disciplines can provide guidance here.
- Any removed objects must be catalogued, labelled and documented to the fullest extent possible.
- A monitoring plan to collect information on the condition of sites at regular intervals during the activity. This can be done by remote sensing.
- At the end of the activity or safety zone, an audit of the impacts of the activity on heritage places
- Any combination of the above measures.

Contingency plans

A Management Plan must include contingency plans for the discovery of previously unknown lunar heritage during works. This could include:

- Stop works for a specified time and/or within a specified distance (ie buffer zone), leaving the remains in situ, until an assessment can be prepared and appropriate management recommended.
- Verification of the identity of the material and the launching state
- Notification to the legal owner of the object/s (Liability Convention 1972)
- A plan for consultation with the legal owner and other stakeholders
- Consultation with a heritage expert to provide a significance assessment
- Dispute resolution in relation to the cultural heritage eg between the lunar operator and the legal owner of the heritage objects, where these are different, about how the heritage place is to be managed; or between different stakeholders. Dispute resolution should specify appropriate time frames and processes, using, for example, any mechanisms which have been established for more general disputes in lunar governance systems.

Other Considerations

A LCHMP may also provide for the following:

- Disaster management provisions
- Protocols for handling sensitive information
- Cultural heritage training or inclusion of heritage in induction procedures for employees or contractors
- Evaluation of the LCHMP by an independent expert prior to adoption or implementation
- Evaluation of the LCHMP by relevant stakeholders