Global Expert Group on Sustainable Lunar Activities

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

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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 ***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. 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'.

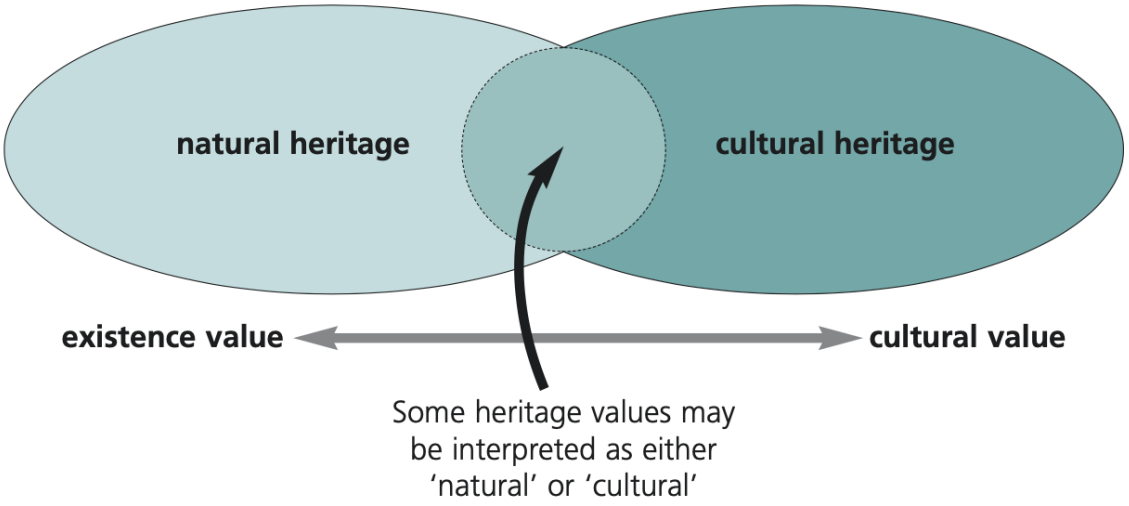

Figure 1: The intersection of natural and cultural heritage (from the Australian Natural Heritage Charter)

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

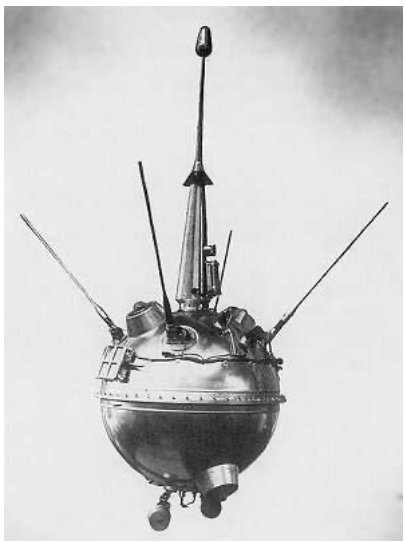

Figure 2: Luna 2 probe. Source: unknown

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

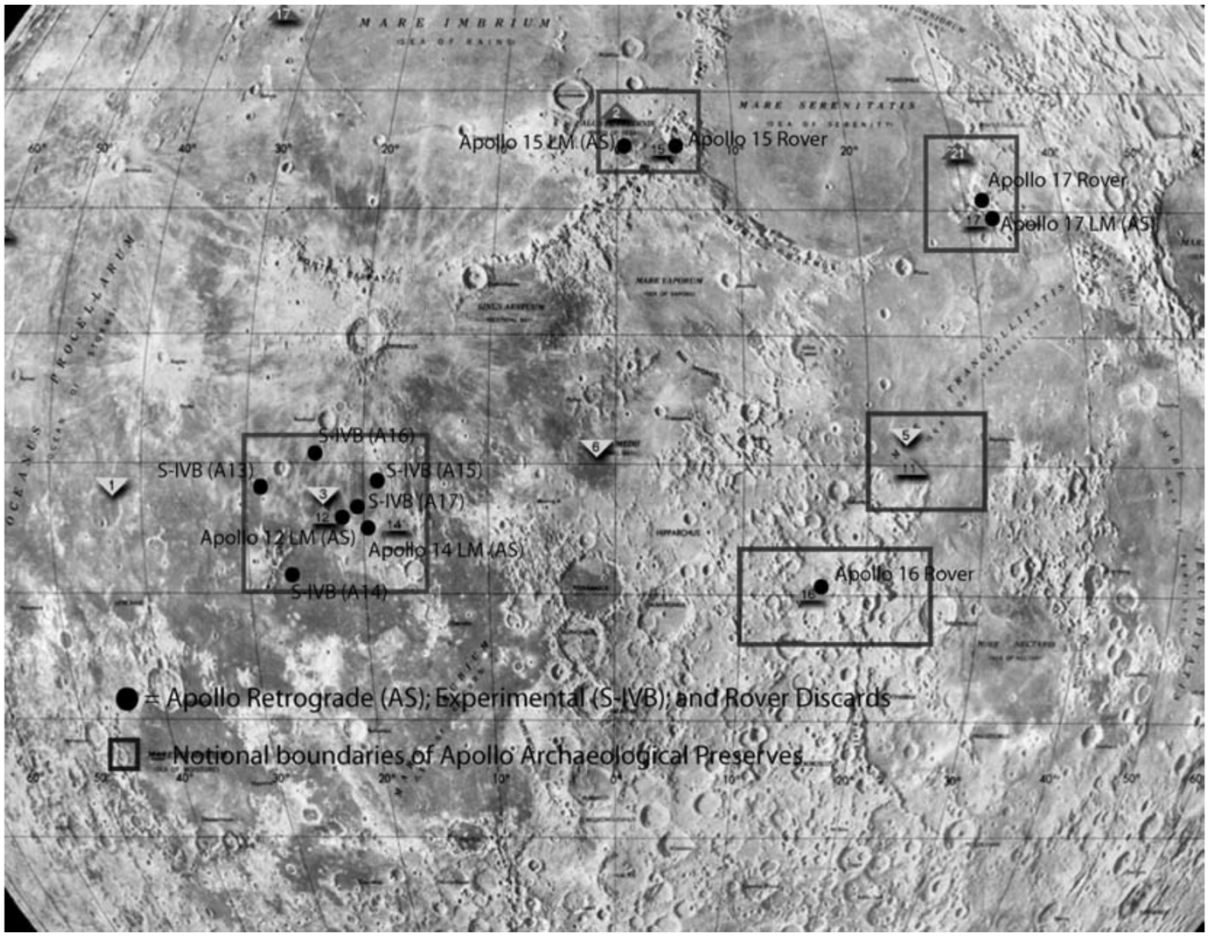

Figure 3: Location of heritage precincts (Capelotti 2010)

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:

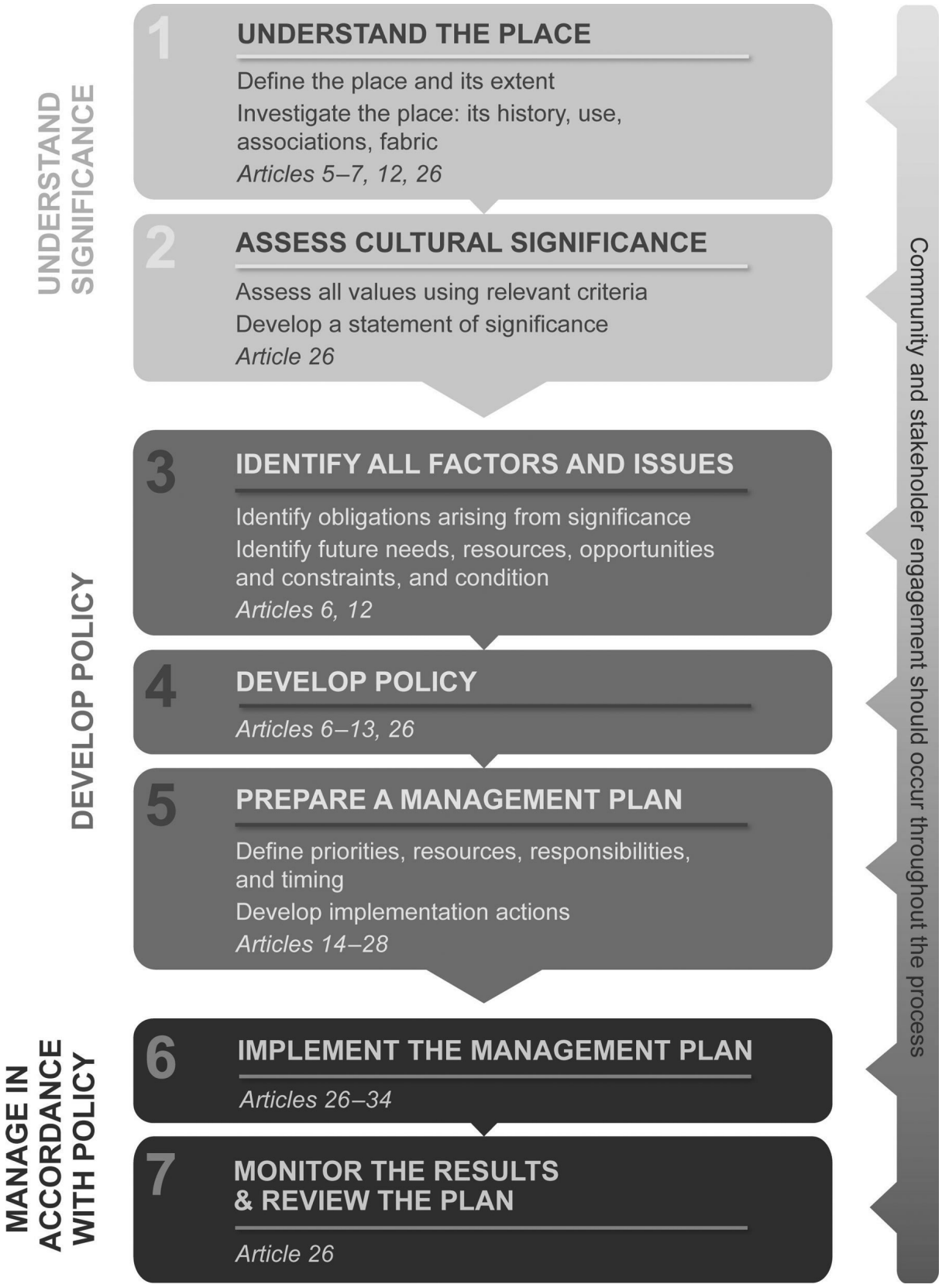
i. To avoid causing adverse changes to the lunar environment or cislunar space, including the harmful contamination of the Moon in contravention of planetary protection policies;

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