



PROTECTING & PRESERVING APOLLO PROGRAM LUNAR LANDING SITES & ARTIFACTS

In accordance with the
NASA TRANSITION AUTHORIZATION ACT OF 2017

Product of the
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

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Background

The Moon continues to hold great significance around the world. The successes of the Apollo missions still represent a profound human technological achievement almost 50 years later and continue to symbolize the pride of the only nation to send humans to an extraterrestrial body. The Apollo missions reflect the depth and scope of human imagination and the desire to push the boundaries of humankind's existence. The Apollo landing sites and the accomplishments of our early space explorers energized our Nation's technological prowess, inspired generations of students, and greatly contributed to the worldwide scientific understanding of the Moon and our Solar System. Additionally, other countries have placed hardware on the Moon which undoubtedly has similar historic, cultural, and scientific value to their country and to humanity.

Three Apollo sites remain scientifically active and all the landing sites provide the opportunity to learn about the changes associated with long-term exposure of human-created systems in the harsh lunar environment. These sites offer rich opportunities for biological, physical, and material sciences. Future visits to the Moon's surface offer opportunities to study the effects of long-term exposure to the lunar environment on materials and articles, including food left behind, paint, nylon, rubber, and metals. Currently, very little data exist that describe what effect temperature extremes, lunar dust, micrometeoroids, solar radiation, etc. have on such man-made material, and no data exist for time frames approaching the five decades that have elapsed since the Apollo missions.

While some of the hardware on the Moon was designed to remain operational for extended periods and successfully telemetered scientific data back to the Earth, much of what is there was designed only for use during the Apollo mission and then abandoned with no expectation of further survivability. How these artifacts and their constituent materials have survived and been altered while on the lunar surface is of great interest to engineers and scientists. The Apollo artifacts and the impact sites have the potential to provide unprecedented data if lunar missions to gather and not corrupt the data are developed. These data will be invaluable for helping to design future long-duration systems for operation on the lunar surface. NASA has formally evaluated the possible effects of the lunar environment and identified potential science opportunities. For example, using Apollo 15 as a representative landing site, the crew left 189 individually cataloged items on the lunar surface, including the descent stage of the Lunar Module, the Lunar Roving Vehicle, the Apollo Lunar Surface Experiments Package, and a wide variety of miscellaneous items that were offloaded by the astronauts to save weight prior to departure. The locations of many of these items are well documented, and numerous photographs are available to establish their appearance and condition at the time they were left behind.

What needs “protecting and preserving?”

There are no legal definitions of “preservation” and “protection” precisely applicable to lunar sites and artifacts. However, the Secretary of the Interior has defined “preservation” as “the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property” (36 CFR 68.2.). For purposes of this Report, “preservation” refers to the fact of a site or artifact not being disturbed or harmed, using the Interior Secretary's definition as a starting point.” Additionally, “protection” means preventing further damage, whether by nature or human activity.

The U.S. Government (USG) recognizes that the increasing technical capabilities of other countries and of commercial entities throughout the world potentially increases the number of lunar missions in the

near future. Several private companies are interested in landing spacecraft on the surface of the Moon and, through encouragement from public prizes, are seeking to approach USG space assets on the lunar surface.

For example, shortly after the Google Lunar XPRIZE (GLXP) was announced in 2007, representatives of commercial entities planning to compete for the prize contacted NASA seeking guidance for approaching USG space assets on the lunar surface out of respect for hardware ownership and a sincere desire to protect scientific and historic aspects of these sites. Because there was no precedent for this situation throughout nearly 50 years of spaceflight, there were no USG guidelines or requirements for spacecraft visiting the areas of existing USG-owned lunar hardware. In 2010, NASA convened a Lunar Historic Site (LHS) team to address the query and assist the commercial community. The team included NASA personnel from flight operations, engineering, scientists, material specialists, legal, public affairs, and interagency and international affairs, and historic preservation representatives from state and federal governments, academia, and museums.

In addition, NASA met with the developers of potential future missions (then GLXP contestants) to explain the work being done as well as the draft recommendations, and to obtain input from those flight teams before the recommendations were finalized. The LHS team assessed the lunar artifacts and activities on the lunar surface where humans, robots, or U.S. flight hardware have a presence and recommended notable U.S. government hardware, areas, and activities as worthy of protection and preservation for both historic and scientific reasons. Two critical locations are the Apollo 11 and Apollo 17 sites—the first and, at present, the latest human missions to the lunar surface.

The LHS team identified the following significant artifacts and USG activity:

- Apollo lunar surface landing and roving hardware—the descent stage of the landing modules and associated equipment used in the Apollo 11, 12, and 14–17 missions. Three separate lunar rovers operated by astronauts to traverse the lunar surface in the Apollo 15–17 missions.
- Unmanned lunar surface landing sites (e.g., Surveyor sites).
- Impact sites (e.g., Ranger, S-IVB, LCROSS, lunar module ascent stage).
- Experiments and operational equipment. Miscellaneous extravehicular activity hardware and various scientific instruments deployed through the Apollo Lunar Surface Experiment Package, including, among others, the Laser Ranging Retroreflectors.
- Specific indicators of U.S. human, human-robotic lunar presence, including footprints and trails taken by astronauts, particularly the Apollo 11 mission, rover tracks, the American flags raised by astronauts, etc., (although not all anthropogenic indicators are protected as identified in the recommendations).
- Various personal items (e.g., boots and life support systems) and trinkets (e.g., gold olive branch and silicon disk containing statements from leaders of 74 countries).

White House Space Policy Directive 1, signed by the President in December of 2017, provides for a U.S.-led, integrated program with private sector partners for a human return to the Moon, followed by missions to Mars and other destinations. The policy calls for the NASA Administrator to “lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities.” The effort will more effectively organize government, private industry, and

international efforts toward returning humans to the Moon and should be leveraged when considering opportunities to preserve and protect lunar artifacts.

Risks to the protection and preservation of sites and artifacts

The primary risk to Apollo sites and artifacts is associated with potential future lunar missions. A visiting vehicle approaching a historic site can generate a significant amount of damage to the site in a variety of ways:

- Landing on top of or too close to the site. A crash or off-nominal landing near a heritage site may produce an enormous amount of debris, dust, and chemical contamination.
- Sandblasting effects from rocket thrusters as propellant gases dislodge and propel lunar soil (regolith) at high speeds in the local area (e.g., erasing footprints and treads, damaging nearby hardware). Due to a lack of atmosphere and low gravity, the regolith can travel many miles and at speeds exceeding two kilometers per second for the smaller particles.
- Disrupting the local area with dust lofting or biological contamination.

According to stated goals of GLXP teams and other private companies seeking to land vehicles on the Moon, near-term risks to Apollo lunar artifacts could be from probes, rovers, hoppers, and prospecting activities. Long-term risks are associated with future missions to mine and extract resources from the Moon and potential colonization. Although the GLXP expired at the end of March 2018 without a winner, several of the finalist teams and other commercial endeavors plan to continue their efforts to successfully send robotic missions to the Moon in the next few years.

NASA has analyzed the effects of landing spacecraft near existing surface hardware on the Moon and other planets in previous work focusing on human and robotic missions to the Moon and Mars. The Apollo 12 crew landed very near Surveyor 3 to test precision landing capabilities and took samples from the robotic spacecraft back to Earth for regolith impact assessment. In addition, NASA has performed recent propellant/plume and lunar regolith impingement analyses to better understand the risks and concerns of damage to the heritage Apollo landing sites resulting from future spacecraft descent/landing and associated surface and low-altitude flight mobility.

While commercial robotic missions create risks to the protection of lunar scientific and heritage sites, the U.S. Government fully supports commercialization of the space sector and commercial robotic missions to the Moon. Therefore, the risks to damage lunar heritage sites must be balanced against other national and international interests. The lunar heritage sites can be protected, at a reasonable cost, while still fostering commercial space activities and government-sponsored missions back to the Moon. There are approximately a dozen U.S. and foreign companies at various stages of planning lunar robotic missions. These include the five GLXP finalists and other companies from the United States, Japan, India, Israel Germany, and other countries.¹

Measures to protect and preserve lunar sites and artifacts

Future visiting vehicles landing near, flying over, or roving to the Apollo lunar landing sites *could* cause damage to scientific value of the artifacts, mar footprints left by our early explorers or damage ongoing science experiments. However, *carefully* approaching these sites is potentially beneficial and can yield

¹ For information about the five GLXP finalists, see <https://lunar.xprize.org/teams>.

new science, capture new visions of historic events, and support the emerging commercial spaceflight communities. Analysis reveals that it is possible for the historic sites to be safely revisited by lunar spacecraft to both document their historic and inspirational nature as well as obtain additional and valuable science.

NASA Recommendations

To proactively identify lunar surface approach strategies and determine a safe method of visiting historic sites, NASA leveraged the LHS team to help guide the flight and surface planning of future visiting vehicles to those USG historic sites. Along with documenting a technical analysis of damage mechanisms, the NASA LHS team identified a small set of flight operations recommendations and surface mobility methods which, if followed, help protect the sites, while allowing robotic missions, including commercial ventures, to achieve their mission objectives. These measures are captured in the “NASA Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts,” (Technical Guidelines) published in 2011.²

Until more formal USG guidance is developed and perhaps a multilateral approach is established to reflect various nations’ views on lunar hardware of scientific and historic value, the Technical Guidelines developed by the NASA LHS team provide interim recommendations for lunar vehicle design and mission planning teams. While the Technical Guidelines do not represent mandatory USG or international requirements, they inform lunar spacecraft mission planners interested in helping preserve and protect lunar historic artifacts and potential science opportunities for future missions.

Moon Express (U.S.), PTScientists (Germany), and Astrobiotic (U.S.) have already announced their intentions to follow NASA’s LHS Technical Guidelines.

Existing International Treaties

International law relating to outer space includes several provisions that are relevant to the protection of lunar artifacts. Specifically, the 1967 Outer Space Treaty (OST) includes provisions relating to national jurisdiction and control, due regard and consultation, and liability. Specifically, Article VI provides that the appropriate State shall authorize and continue to supervise activities of nongovernmental entities. Article VII sets out a general rule of liability for damage, which is supplemented by the 1971 Liability Convention, and provides for fault-based liability for damage to space objects. Article VIII specifies that parties to the treaty retain jurisdiction and control over objects launched into outer space that are listed on their registries while they are in outer space, and that ownership of objects launched into outer space is not affected by their presence in outer space or by their return to Earth. Article IX specifies that nations are to be guided by the principle of cooperation and mutual assistance in lunar exploration and use, with due regard to the corresponding interests of other parties to the treaty; and states that international consultations must take place prior to the commencement of an activity that any party has reason to believe would cause potentially harmful interference with activities of other parties.

Taken together, these existing provisions create a system in which other space-faring countries have an obligation to exercise control over their own activities in outer space as well as those activities of their private actors. Any activities in space that could interfere with U.S. space objects—including equipment on the Moon—should include advance consultation with the United States. The United States continues

² <https://www.nasa.gov/directorates/heo/library/reports/lunar-artifacts.html>.

to own and have jurisdiction over U.S. origin lunar equipment, and other states could be liable to damage to U.S. objects. Although not specifically about lunar artifacts, these provisions could be leveraged to discourage activities that would put those artifacts at risk.

New Treaties

Amending existing multilateral agreements, such as the OST, or drafting and negotiating an additional agreement specifically relating to preservation of lunar artifacts could provide explicit and detailed international legal protections. Depending on the content, new rules could protect artifacts in a variety of ways, such as by creating setoff zones, specifying particular liability rules, and/or creating whatever other protections might be warranted. However, the difficulties and risks of negotiating and bringing such an agreement or amendments into force would likely outweigh any benefits.

First, negotiating any international agreement—particularly one involving such a high-profile issue as outer space—is inherently difficult. Similar agreements have taken up to 15 years to complete. It would be necessary to identify the substantive provisions desired, and then enter into negotiations with other countries in order to reach agreement on a text. The ultimate success of such an effort would depend on getting numerous states to join the agreement or amendment, but it is unclear whether space-faring nations or developing space-faring nations would agree to do so.

More generally, some states might see a U.S.-led attempt to protect space artifacts as a subterfuge for securing indefinite rights over lunar territory, and perhaps even creating a mechanism to “plant the flag” and claim additional territory in the future under the guise of preservation and protection of lunar sites and artifacts. Regardless of the merit of these fears, the effort could lead to a backlash against any new international protections, and even undermine the existing legal protections described above.

Finally, any attempt to create new legally-binding international law regarding space could undermine the longstanding U.S. argument that current space law is sufficient, and prompt other states to pursue their own initiatives, some of which might not be consistent with U.S. national interest, such as a prohibition on the extraction of space resources.

Voluntary Guidelines

Another possibility would be for the Department of State, NASA, other interested Departments and Agencies, and the U.S. private sector to work bilaterally and multilaterally with their counterparts in appropriate fora to consider development of voluntary mechanisms for cooperation among nations and between and with private companies to protect lunar heritage and scientific sites. This work could build upon the success of voluntary guidelines such as the Long-Term Sustainability of Outer Space Activities Guidelines, the first set of which was agreed upon by the Committee on the Peaceful Uses of Outer Space in June 2016, the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines, and the 2002 Hague Code of Conduct against Ballistic Missile Proliferation (a multilateral transparency and confidence-building measure).

Domestic Laws

Pursuant to the U.S. Constitution (the “Property Clause”) and the Federal Property and Administrative Services Act of 1949, as amended, the U.S. Government continues to maintain ownership of NASA artifacts (hardware and other personal property) on the surface of the Moon. Legislation supporting Executive branch initiatives regarding the protection of lunar and scientific sites could be helpful but is not necessary.

Recommendations

1. The National Aeronautics and Space Administration, the Department of State, and other interested Departments and Agencies, with guidance from the National Space Council, should strategically look for opportunities to leverage lunar missions by and with other Governments and commercial entities to assist in preserving and protecting Apollo lunar artifacts. This effort should also include investigating opportunities to partner on missions with various entities to observe the effect of the lunar environment on different materials used in Apollo lunar artifacts and the artifacts of other States.
2. The National Aeronautics and Space Administration, in coordination with the United States Department of State and other interested Departments and Agencies and with guidance from the National Space Council, and other relevant U.S. entities should continue discussions regarding lunar heritage site preservation with foreign space agencies, as appropriate. This effort should include discussion of rights and responsibilities in the 1967 Outer Space Treaty as well as opportunities and challenges shared by space-faring and emerging space countries. Fora for these discussions include the annual International Astronautical Congress, future International Space Exploration fora, the International Space Exploration Coordination Group, the United Nations Committee on the Peaceful Uses of Outer Space, and other multilateral and bilateral meetings.
3. The United States Department of State, the National Aeronautics and Space Administration, and other interested Departments and Agencies, with guidance from the National Space Council, and other relevant U.S. entities should investigate the feasibility of working with the international community to develop non-binding best practices for preserving and protecting lunar artifacts on a “reciprocal, transparent, and mutually beneficial” basis.
4. The National Aeronautics and Space Administration, Department of State, and other interested Departments and Agencies, with guidance from the National Space Council, and other relevant U.S. public and private entities, should discuss the pros and cons of beginning international dialogue on the best ways to mitigate risks presented by future human and robotic exploration to the lunar artifacts of the United States and other countries.

About This Document

This report is submitted in fulfillment of a reporting requirement contained in the National Aeronautics and Space Administration Transition Authorization Act of 2017 (Public Law 115-10). In addition to authorizing appropriations and outlining high-level policy direction for NASA in 2017, the law directs the Office of Science and Technology Policy (OSTP) to deliver a report on protecting and preserving historically important Apollo Program lunar landing sites and Apollo Program artifacts residing on the lunar surface.

Specifically, Section 831 states:

- (a) Assessment. – The Director of the Office of Science and Technology Policy, in consultation with relevant Federal agencies and stakeholders, shall assess the issues relating to protecting and preserving historically important Apollo Program lunar landing sites and Apollo program artifacts residing on the lunar surface, including those pertaining to Apollo 11 and Apollo 17.*
- (b) Contents. – In conducting the assessment, the Director shall include:*
 - (1) a determination of what risks to the protection and preservation of those sites and artifacts exist or may exist in the future;*
 - (2) a determination of what measures are required to ensure such protection and preservation;*
 - (3) a determination of the extent to which additional domestic legislation or international treaties or agreements will be required; and*
 - (4) specific recommendations for protecting and preserving those lunar landing sites and artifacts.*

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About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government. More information is available at <http://www.whitehouse.gov/ostp>.

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