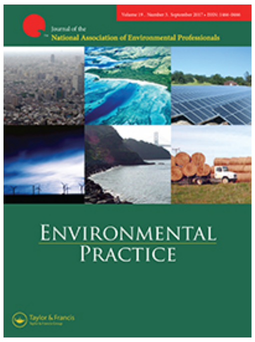

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RESEARCH ARTICLE

In dreams begin responsibilities – environmental impact assessment and outer space development

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ABSTRACT
Although exploitation of outer space resources is still considered science fiction by many, space-faring nations as well as private entrepreneurs such as SpaceX and Deep Space Industries are planning ventures to mine asteroids, the Moon and Mars. They are proposing to construct permanent human habitations and begin a variety of extraterrestrial industries within the next few decades. They are failing, however, to identify and assess the potential environmental impacts of these near-future actions. Without formal analyses of extraterrestrial environmental impacts, space projects may produce the unintended consequences of environmental degradation, lost opportunity, and the inefficiencies experienced here on Earth. Rather than calling for legislated requirements for assessment, industry-developed, -administered, and -enforced standards and practices are suggested. The extraterrestrial action area presents a potentially lucrative opportunity for professionals who are skilled in environmental impact assessment. This article discusses why impacts are to be expected, their nature, who is likely to initiate them, and how they may adversely affect the success of other future actions.

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A future for the environmental professional

Planned outer space developments, such as mining and other human actions on the Moon, Mars, and asteroids, will very likely result in adverse extraterrestrial environmental impacts. Whether through international law, treaty, national regulation, industry-initiated standards, or some other practice, it is foreseeable that those proposing extraterrestrial actions will begin to include environmental impact assessment as part of their overall planning. It is in their best interest to do so. Our experiences here on Earth demonstrate that impact assessments can be effective in assisting project developers in identifying potential flaws in design and timing, increasing investor confidence and reducing chances for unforeseen adverse consequences that will later require mitigation (Sadler, 1996; Glasson, Therivel and Chadwick, 2013). Documents produced during the assessment process can be useful by providing a depository for environmental information in all its forms. Accumulated reports archive a broad range of environmental data. They catalog how specific actions affect various environments and describe measures that have been successful (and unsuccessful) in mitigating adverse outcomes. Over time, they grow a valuable database that helps to sustain a resource, preserve future development options, and encourage innovation.

As evidenced by the paucity of published articles, few, if any, environmental impact assessment practitioners have considered applying assessment in extraterrestrial contexts. Predictably, professionals will be needed to carry on such work, and those individuals and firms who begin to explore their potential role as leaders in this field will be well placed to succeed.

Recognizing problems

William Butler Yeats, the Irish poet, wrote "In dreams begin responsibilities" as an epigraph in a collection of his work in 1914 (Yeats, 1916). Its meaning is literal. While early acknowledgment of problems may dampen the enthusiasm that accompanies a new technology and may be discouraged or suppressed, the most effective and efficient time to begin discussion of a potential environmental problem is when a new technology is first identified—when it is first dreamed—not

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after it has become so engrained in our lives that mitigation is expensive and painful or even impossible.

Although we imagined exploring outer space millennia ago, we have dreamt of exploiting its resources only since the early years of the 20th century. Now, in the 21st century, we have reached the moment where space exploitation has evolved from science fiction and fantasy to a planned reality. Hundreds of books and articles have been published promoting space exploitation within the past 30 years. Titles such as *How We'll Live on Mars; Mars, Our Future on the Red Planet; Marketing Mars; The Case for Colonizing Mars; On To Mars - Colonizing a New World*, and others describe the physics of how humans can get there, how they can survive, and how colonies will function to reap amazing monetary gains as well as societal progress and spiritual growth (Zubrin, 1996; Zubrin and Crossman, 2002; Joseph, 2010; Petranek, 2015; David, 2016). There are frequent and significant international conferences, such as the Humans 2 Mars Summit Series, the Lunar Exploration Analysis Group, and The Mars Society's annual conventions, that focus specifically on that process. To the best of my knowledge, none of these acknowledge the probable adverse environmental impacts that will accompany our actions. Some academic work demonstrating concern for environmental impacts on extraterrestrial bodies has been published, but while presenting a strong case, it has failed to demonstrably affect policy (Hofmann, Rettberg, and Williamson, 2010; Lyall, 2010). But, as Yeats cautioned, we must take responsibility for the fruition of our dreams. It is time both to recognize that outer space exploitation will very likely produce extraterrestrial environmental consequences and to begin planning a process that will help to avoid or mitigate their unintended adverse effects.

Status of regulations

The 1967 United Nations (UN) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, *Including the Moon and Other Celestial Bodies* (the Outer Space Treaty) provides international coordination and a degree of uniformity regarding nations' space activities (US State Department, undated). Negotiated during the Cold War just prior to the Apollo 11 landing in 1969, its most significant purpose at that time was to prevent any nation from militarizing the Moon or other extraterrestrial bodies and keep nations from orbiting weapons of mass destruction (Johnson, 2017). It also disallows nations to claim sovereign territories in space.

Currently, 104 nations have signed the Treaty, including all spacefaring nations such as the United States, Russia, China, India, Iran, and member nations of the European Space Agency. Thirty-four nations that have joined the Treaty do not have space programs of their own, but likely have signed to protect their rights should they become spacefaring nations or participate with nations that are. "Many experts in international law believe that the fundamental provisions of the treaty are so well-observed and respected that they exist as an entirely different set of legal rules, outside of the textual treaty, as 'customary' international law. And, as customary international law, the Outer Space Treaty reflects rules that bind even those states who are not formal parties to the treaty itself" (Johnson, 2017).

The UN's Office of Outer Space Affairs maintains a registry of all vehicles launched, both public and private, but it cannot prevent launches; that function is left to each individual nation. Of those 70 nations that maintain government space agencies, 13 currently have launch capabilities. Each has its own regulations regarding launch review and licensing. Launches from French areas, such as Tahiti, are regulated by France; those launched from Florida are regulated by the U.S., etc. The Federal Aviation Administration (under the Department of Transportation) is currently the authority that issues licenses to launch commercial and private space vehicles in the US (Commercial Space Launch Act of 1984, 51 U.S.C. 50901-50923). However, as of May 2017, the draft American Space Commerce Free Enterprise Act of 2017 is being circulated among members of the US Congress and others for discussion (Smith, 2017). It would transfer FAA's space responsibilities, in whole or part, to the Department of Commerce.

While there are volumes of regulatory law, required procedures, and international agreements on the use of outer space, there are few requirements addressing foreseeable problems of environmental damage above altitudes favorable for satellite operations (i.e., where "space debris" and satellite orbit trajectories are a significant concern) (Matte, 1989). Beyond low Earth orbit, regulations include prohibitions on testing nuclear weapons and limiting the introduction of Earth organisms (forward contamination) to areas that potentially host extraterrestrial life, such as Mars (United Nations Office for Outer Space Affairs, 2008). U.S. environmental laws, such as the National Environmental Policy Act (NEPA), have not generally applied. For example, NASA's 2005 *Final Programmatic Environmental Impact Statement for the Mars Exploration Program* contains detailed discussions and analyses of the program's impacts on Earth (such as air quality near the launch pad and impact on the economies of nearby communities), but there is no mention of potential impacts to Mars (NASA, 2005). Likewise, the 2006 *Final Environmental Impact Statement for the Mars Science Laboratory Mission* considers potential impacts to the Earth's upper atmosphere, but does not address the impact of the Mars rover Curiosity on Mars itself (NASA, 2006). Eight years later, the 317-page environmental impact statement (EIS) for the Mars 2020 mission describes the affected environment as "…the areas on or near the vicinity of the launch site and portions of the global environment" (NASA, 2014, p. vi). No agency or personal comments offered in response to the Draft EIS mentioned impacts to the Mars environment. I believe that a significant omission.

Applying NEPA to mining the Earth's deep-sea mineral resources in international waters has been offered as a possible analogy applicable to assessing the potential environmental impacts of outer space exploitation. The International Seabed Authority (ISA), established under the 1982 United Nations Convention on the Law of the Sea (UNCLOS), regulates such mining among the 167 states that have ratified the Convention (United Nations, 1982). However, while the U.S. does comply with parts of UNCLOS as customary law, it has not ratified it. As such, U.S. companies cannot pursue ISA permits. The issue of NEPA's applicability was tested in 2015 when the Center for Biological Diversity (CBD) sued the U.S. National Oceanic and Atmospheric Administration (NOAA) for issuing its first exploratory permit that would allow OMCO Seabed Exploration LLC, a U.S. subsidiary of Lockheed Martin, to pursue deep-sea mining in international waters in the eastern equatorial Pacific (Jeffers, 2015). NOAA was acting under the authority of the US's Deep Seabed Hard Mineral Resources Act (DSHMRA). In November 2016, the US District Court, District of Columbia, dismissed the case recognizing that both CBD and NOAA settled by agreeing, *inter alia*, that "NOAA will conduct an environmental analysis, consistent with its obligations under NEPA and DSHMRA, if and when NOAA authorizes Lockheed Martin to conduct at-sea… exploration (US District Court, 2016, at Number 6)." While this case is important in extending the geographic reach of NEPA to international areas and remote environments, two factors distance it from outer space applicability. First, CBD's argument for NEPA relied heavily on potential disturbance of abyssal and other biological communities, and second, the Court ruled (at Number 3) that the Agreement between the parties "has no precedential value and shall not be used as evidence in any other proceeding." Still, the case demonstrates the potential legal challenges that outer space mining faces. The scenario would likely rapidly (and dramatically) change should extraterrestrial life be discovered on the celestial body in question.

It may be argued that NEPA does not include impacts to Mars because NEPA is limited to impacts on the "human environment" (US Code of Federal Regulations (CFR) Title 40, Chapter V, Part 1508.14): "Human environment shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment." But humans do not need to be present or directly affected for an action to qualify under NEPA. For example, no one lives at the bottom of Lake Tahoe, yet a major Federal action affecting the environment there would clearly be considered under the Act because the Lake and its ecosystems affect humans; they are part of our greater human environment. Robotic exploration that affects the environment could also be considered an extension of human presence; humans need not be directly present. As for outer space, when Neil Armstrong first stepped onto the Moon in 1969, it arguably *became* part of the human environment, and when the first robotic rover landed on Mars, that planet was added. Considering all the other probes and landers launched by the U.S. and others, the entire solar system is now arguably part of the human environment.

Our changing relationship with outer space

Accessing outer space through remote sensing has been of scientific interest since the invention of the telescope, but technology has now progressed to the stage where venturing beyond Earth's orbit can be reliably planned by commercial enterprises. This recent evolution of purpose is highly significant in that commercial profits are potentially astronomical. Just a few examples include the following.

- "The business of space is growing rapidly. It is currently a $330 billion industry with accelerating growth. The number of new private companies being created to use space commercially is at an all-time high, with $13.3 billion invested in over eighty space startup companies since 2000" (Deep Space Industries, 2017).
- It is estimated that Anteros, a 2-km-long asteroid that will pass within 7 million miles of Earth in 2038, contains $5.5 trillion of magnesium silicate, aluminum, and iron silicate "for anyone who can figure out how to mine it" (Gramer, 2016, p. 19).
- "A forty-foot-long S-type asteroid… is likely to contain more than a million pounds of nickel, gold, platinum, rhodium, iron, and cobalt" (Petranek, 2015, p. 72).
- The Moon would provide a source for gadolinium and terbium. Helium-3, a potential fuel for nuclear fusion, is another potential treasure (Palmer, 2012).
- Neil deGrasse Tyson, the noted astrophysicist, stated "The first trillionaire there will ever be is the person who exploits the natural resources on asteroids (Kramer, 2015a)."
- Deep Space Industries, a private company, intends to start prospecting on asteroids in 2023, only 6 years from now (Petranek, 2015).
- The government of Luxembourg has established a $200 million fund to support investment in asteroid mining. The country will "create a legal framework for asteroid mining, which will make it the first country in the European Union to do so" (Gramer, 2016, p. 20).
- Mars One, a private venture created in the Netherlands in 2011, has a goal of establishing a permanent human settlement on Mars. Their current projected timeline includes landing an instrument package on the planet in 2022, a rover in 2026, cargo in 2029, and a crew of humans in 2032 (Mars One, 2017). The number of humans will be regularly supplemented approximately every two years after that date. They have already begun training the crew for the 2032 mission. While their plan is aggressive and perhaps overly optimistic, it demonstrates that there is resolve, technology, preliminary financing, and humans who are volunteering for such missions.
- Elon Musk, founder of SpaceX in 2002, stated "The economic base of a Mars colony will be what people do on Earth – everything from opening an iron foundry to a Pizza Hut. The intention is to have a viable population of about 50,000 within a few decades (Petranek, 2015)." SpaceX is planning an unmanned mission to Mars in 2018 and crewed missions by 2025 (Renstrom, 2016).

A sampling of private enterprises that have announced space ventures includes the following.

- Inspiration Mars — Plans to send humans to orbit Mars and return in 2021
- Deep Space Industries — Exploitation of asteroid minerals
- Planetary Resources — Asteroid mining

- Space X — Interplanetary transport and colonization
- Lockheed Martin Space Systems Company — Space vehicles
- Moon Express — Lunar mining
- Blue Origin — Space transportation
- Boeing — Space transportation
- Aerospace Corporation — Space transportation and communication
- Orbital ATK — Space logistics, communication, and "space buses"
- Bigelow Aerospace — Human habitats in space
- United Launch Alliance (Boeing and Lockheed) — Space launch systems
- Astrobotic — Space launch systems
- Masten Space Systems — "Extending human presence across the solar system"
- Virgin Galactic — Space tourism

This list demonstrates that the prospects for an extended and permanent human presence on the Moon and Mars for commercial, scientific, political, and even tourism purposes are no longer remote; they are reasonable expectations. And because ores collected from asteroids would not likely be processed on Earth due to the difficulty and liabilities of efficiently delivering them to Earth's surface, it is more likely that they would be refined on the Moon, Mars, or in space. Except for minerals of high value per unit of weight (e.g., gold), most metals may be used to manufacture finished products off Earth rather than on it. Materials could be manufactured on the Moon or Mars for construction on those bodies. This would require refineries and supporting infrastructure such as energy production facilities and the people to maintain and operate them there. Many of the same issues regarding development that we experience on Earth would be expected.

Dale Boucher, CEO of the Canadian firm Deltion Innovations, Ltd. (a company that specializes in developing space mining technology), stated "If things go well, you will see our logo on the Moon in 2018. Watch us (Haddow, 2013)." Questioned informally by the author in 2016 as to whether any degree of environmental impact assessment would likely be considered in proposals for extraterrestrial mining, Boucher did not envision any need (Kramer, 2016). As he described, a hypothetical initial operation may require a 100-meter square area that would be excavated to perhaps a depth of several meters. Minerals (in this example, water ice) would be separated for processing and tailings would be pushed back to fill the hole. Boucher speculated that there would be little evidence that any mining had taken place and that such a small area would be inconsequential to the extraterrestrial landscape. As for construction and maintenance of roadways, equipment, power generation, shelters for personnel, processing and refining regolith and rock, facilities for storing and processing the water, and spacecraft landing and launch facilities, those impacts were not discussed. The conversation also did not consider whether Boucher's hypothetical description of a 100-meter square site would likely be exploratory, a test for a much larger operation that may be repeated over the surface of the Moon. Article IX of the Outer Space Treaty states that parties must avoid harmful contamination of celestial bodies, but, as Eric Mack, a science reporter, asks, "Can you build a city of a million that likely includes mines, fuel-manufacturing facilities and nuclear power stations without 'harmful contamination' of a planet? Maybe. But our existing data set of exactly one planet does not demonstrate that humans have much of a track record for such capability" (2016).

The Outer Space Treaty prohibits any nation, corporation, or individual from owning the Moon or Mars. That has not been an issue because only a minimal amount of material has ever been removed from it (e.g., rocks returned from the Moon with the Apollo missions). However, Naveen Jain, the co-founder of Moon Express, stated, "But that's going to change when the mining starts." Comparing outer space to the UN Convention on the Law of the Sea, he continued, "No one owns international waters, but those who invest their money and effort to find fish are entitled to profit (Palmer, 2013)."

The U.S. Commercial Space Launch Competitiveness Act (Space Act) signed by President Obama on November 25, 2015, is a step in that direction. It allows that a "US citizen engaged in commercial recovery of an asteroid resource or a space resource shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell it according to applicable law, including US international obligations (§51303).” (Note: The Space Act applies only to abiotic resources such as minerals, metals, water, and gases, not to any life discovered).

While maintaining that the Space Act does not conflict with the Outer Space Treaty by stating the U.S. does not assert “sovereignty or sovereign or exclusive rights or jurisdiction over, or the ownership of, any celestial body” (Section 403), Title IV, the Space Resource Exploration and Utilization Act of 2015, directs federal agencies to:

- facilitate the commercial exploration for and commercial recovery of space resources by U.S. citizens;
- discourage government barriers to the development of economically viable, safe, and stable industries for the commercial exploration for and commercial recovery of space resources in manners consistent with US international obligations; and
- promote the right of U.S. citizens to engage in commercial exploration for and commercial recovery of space resources free from harmful interference, in accordance with such obligations and subject to authorization and continuing supervision by the Federal government.

The Space Act clarifies U.S. intent to allow and encourage private enterprises to move forward with exploitation of extraterrestrial resources.

Benefits of extraterrestrial environmental impact assessment

Most publications regarding outer space resources maintain that those resources are nearly limitless, and many business models for exploitation do not imagine that resources on Mars, for example, will ever be exhausted (Lewis, 1996; Zubrin, 1996; Renstrom, 2016). Ever is a long time. While the statement may be figuratively true for some mineral ores that may last through an individual company’s project timeline, it is not necessarily true for long-term planning. There will likely be competition for the rarest (most valuable) minerals. Without some form of planning and regulation, they may be extracted in an inefficient and environmentally damaging manner and be quickly depleted (as exemplified by hydraulic mining for gold on Earth, which wasted much of the resource and resulted in extensive environmental damage) (Merchant, 1998).

How might resources be put to their highest and best use unless regulated? Both the Moon and Mars have water ice which will be crucial for human survival, but water also has lucrative industrial uses; it is potentially the raw material for manufacturing both rocket fuel and oxygen. Conflicts over resource allocation may be better addressed during an assessment process that seeks to balance highest and best use with discovery and first use. Who gains access to specific areas for mining becomes more problematic in that the Outer Space Treaty does not allow “ownership” of extraterrestrial territory; there is no guarantee that companies such as those listed previously will gain access to the most productive sites. The China National Space Administration is planning to place a crew on the Moon by 2024, so competition for the best sites will be intense (Kramer, 2015b; China Digital Times, 2012).

Space industries generally are not considering that their proposed actions may preclude alternative uses such as scientific research and human settlement. There will be a stream of not yet imagined uses that could be adversely affected or foreclosed. Many of the same conflicts between land use and human habitation experienced on Earth may emerge on extraterrestrial sites. On the Moon, for example, there are preferable sites for collecting solar energy. These “peaks of eternal light” are areas nearly always or constantly exposed to sunlight at the poles. They are very limited in both distribution and size (Elvis, Milligan, and Krolikowski, 2016). If a mining operation were to determine such areas suitable for their operations, or if mining created a constant plume of dust that would diminish the effectiveness of solar panels, how might such a situation be resolved?

Should potentially dangerous industries such as fuel manufacturing or storage be located near living areas? Would hydraulic fluid pipelines be closely monitored for leaks that may affect subsurface ice deposits mined for drinking water? How might vibrations from detonations affect unrelated structures or scientific instrumentation, such as telescopes? And how might a search for life, whether extinct or still living, be affected by human presence and our trail of bacteria and organic wastes? Humans' biological pollution of Mars, for example, may greatly affect the results of any search for extraterrestrial life there (Kramer, 2009; McKay, 2009). Peter Doran of the Planetary Protection Subcommittee of the NASA Advisory Council offered, "The big issue with all missions to Mars is we don't want to create a situation where we are impacting future life-detection science. Picture humans … walking around shedding microbes everywhere we go. Space suits as we know them do not take care of this problem (Mack, 2016)."

Scope of an assessment

U.S. Code at 43 CFR 46.310 lists the minimum requirements for preparing an environmental impact assessment. While this paper does not suggest that Federal oversight through §46.310 is desirable, the spirit and intent of that section are useful as a guide, as a starting point for consideration.

In addition to describing a proposed action, an extraterrestrial environmental impact assessment would be useful in the following areas.

(1) Broader data dissemination and public participation:

- A series of environmental impact assessments will help to build a database, a library of great historical and scientific value. It will aid in establishing a baseline of pre-action conditions that may be impossible to know or re-create a century from now.
- Proprietary data serve a purpose where patents, publications, industrial advantage, and other issues related to competitive profits are significant. But at this early stage of space exploration, all but the most sensitive extraterrestrial environmental data should be available to all. In those cases where proprietary data need to be withheld as confidential, existing environmental regulations have provided means to effectively protect them. Such administrative procedures could likely be extended or adapted for extraterrestrial use. Environmental assessments and environmental impact statements (as developed under NEPA) are typically public documents, freely accessible and open to public review and comment. Applying that standard to extraterrestrial actions would open the decision-making process to the broader public and would be especially useful in consideration of Article I of the Outer Space Treaty's declaration that the resources of outer space "shall be the province of all mankind." Where the integrity of landscapes (and potentially life), whether of Earth or elsewhere, may be dramatically affected by the actions of a few, other perspectives, including indigenous belief systems, should be encouraged, documented, and considered (Kramer, 2011, 2015b).

(2) Potential extraterrestrial life

- Formal assessments of extraterrestrial environments now presumed sterile will be crucial should life subsequently be discovered. Given the predictably immense scientific and potential economic value of such a discovery, international agreement on standards for how that life might be procedurally addressed (its regulatory status) may be especially challenging. It would be far more productive to establish assessment procedures regarding extraterrestrial environments now, prior to any discovery of life, and then amend those protocols as needed to fit specific scientific data and economic interests at some future time, should life be discovered (Kramer, 2012).

(3) Fostering best management practices

- Best management practices (BMP) are standards and practices that help guide (in this case) construction and resource management activities that may adversely affect the environment. They are appropriate and useful where the desired outcome is known but the means of achieving it are less well defined or are likely to change. A simple example here on Earth would be the initiation of effective erosion control measures such as settlement ponds or silt curtains when grading on a slope. BMPs evolve to become better with each use. They are most effective, economical, and practical when involved industries freely trade information on the efficacy of the practice among themselves and with regulating government agencies, determining what techniques work best under specific conditions. They may be required through U.S. government regulation (such as when made part of a permitting process like the National Pollution Discharge Elimination System) and are generally encouraged by governments for a range of actions, as they provide effective and flexible solutions for mitigating common environmental problems (US EPA, 1993). An extraterrestrial assessment process would assist governments and involved industries in developing a catalog of BMPs to reduce adverse impacts in these new environments. Post-construction monitoring would be critical in assessing BMP efficacy, and documentation of effective and ineffective practices should be shared to improve overall efficiency.

A proposal for establishing international standards

Article IX of the Outer Space Treaty states that parties must avoid harmful contamination of celestial bodies. Joanne Gabrynowicz, editor-in-chief emerita of the Journal of Space Law, cautioned that "The US government would have to take responsibility for making sure an American company like SpaceX doesn't go to Mars and turn it into a big red landfill. [SpaceX and the federal government] should begin speaking with one another early enough to allow the government to understand a company's needs and for the company to understand U.S. legal obligations. That way, they can fashion the least restrictive regulations possible (Mack, 2016)." But a more productive option than industry speaking with the U.S. government would be for industries to speak among themselves, to be proactive as a group in resolving the foreseeable problem of extraterrestrial environmental impacts *before* it reaches a level where any government intervention is required. This case is strengthened considering the international requirements of the space industry. Achieving agreement with only the U.S. may not meet industries' international needs, and seeking resolution at the international level among governments (e.g., under the umbrella of the Outer Space Treaty) could be arduous. Given the speed at which space industries are forming and planning, having regulatory international law in place is unlikely. In addition, laws and treaties tend to be authoritative and prescriptive, binding and inflexible, slow to adapt to changing conditions, challenging to enforce, and difficult to judge and punish when violated (Kramer, 2014). They are neither politically expedient nor practical for the industries involved.

Other mechanisms are generally preferable. Among these, industry-generated standards and guidelines similar to those developed by trade organizations and other non-governmental organizations, international codes of conduct, and other forms of "soft law" have several significant advantages.

- They are relatively quick to approve. They may be drafted entirely within the bounds of any one nation or by an international consortium of industries.
- Standards and BMPs tend to support the overall objectives of the industry group and

are efficient within the economic and physical capacities of the industries themselves.

- They need not be legally binding, making them less onerous and politically threatening. Those who may not wish to commit to the standards or code of conduct are under no legal obligation to do so, but standards could be imposed through peer pressure, diminished opportunities to be granted launch licenses, withdrawal of venture capital and other outside investment, ostracism from the community of outer space industries, and negative public image.
- They are highly adaptive. Work in extraterrestrial environments is characterized by novel and evolving challenges. Whereas legislative or regulatory actions are generally required to modify laws, standards can be altered quickly among the private parties to address unique problems.
- While there is likely a financial cost for adherence to environmental standards, many kinds of planning (e.g., engineering and human factors) are already critical to meeting mission objectives, including financial objectives. An environmental impact assessment is a planning document that aids in identifying potential obstacles and developing practical alternatives. It contributes to informed decision-making, which ultimately serves to reduce costs and increase the potential for mission success.
- In that the Outer Space Treaty recognizes that outer space is "the province of all humankind" and is to be to be used for the benefit of all, corporate responsibility to use resources wisely is important. Pledging to an international code of conduct, BMPs, or similar instruments provides evidence that the action proponent intends to act in a responsible manner in this expanded "global" commons. Such evidence of intention may prove crucial in securing financial backing or receiving government contracts or scientific assistance.

It would be to an involved industry's advantage to participate in drafting any standards early in the process to secure a degree of control ("a place at the table") to better insure that its interests are represented.

As with the Outer Space Treaty, should such non-legislated practices and standards become widely accepted and routine in the industry, they may become customary law.

The role of the environmental professional

Professionals versed in environmental assessment will be needed to assist with planning, implementing, and monitoring extraterrestrial actions. While sites such as the Moon, Mars, and asteroids will certainly pose unique challenges, many of the issues common to actions we are familiar with here on Earth will remain. Blasting will still create vibration and dust; wastes will still need to be disposed of, so they will not escape and contaminate; pipelines will leak and their proximity to resources, such as water, will need to be considered; and conflicting uses on sites will still need to be resolved. Assessment expertise will be essential. Environmental consulting firms, especially those with international reach, should consider this future potential. Those interested can prepare by learning about the space environment and how it functions as a system and by staying abreast of the amazing progress of space resources industries. On-line information is readily available to track industry progress and there are frequent open-attendance conferences.

Currently, there does not seem to be much interest in environmental impact assessment within the commercial space community. The hundreds of articles and books on outer space resource development seldom mention that such actions may adversely affect the environment in ways that will potentially disadvantage their enterprises and the humans that will be required to implement them. There is little acknowledgement that there will likely be unintended environmental impacts and consequences that may later be regretted and costly to mitigate. That attitude will predictably change as industries learn that it is in their best interest to assess potential impacts. It is in the best interest of continued outer space development. Environmental impact professionals should strongly consider that this is a foreseeable opportunity, advocate for the application of assessment to outer space activities, draw on their experiences here on Earth to work with space industries in developing environmental management strategies, and position themselves to profit from that process.

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