A Call to Address Humanity's Cosmic Footprint

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Contextual note: as of 25/7/24, 100 individuals and entities endorse this letter. To support follow-up and implementation of its conclusions, and to bring them to the United Nations (UN), the Cosmic Footprint Society (non-profit) was formed. Scientists, stakeholders and the general public are invited to support the initiative by endorsing the call or joining the Cosmic Footprint Society (free – supports UN recognition efforts). To support the initiative, fill out the form 🖊(1 min).

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This is a critical moment in the history of Earth: Humans are ending 3.5–3.8 billion years of relative isolation[1,2], and may now leave lasting physical, chemical, biological, and unforeseen impacts on space environments. Crewed missions, alongside technological advancements in the New Space age—such as miniaturization and the use of artificial intelligence—accelerate this trend. Decisions with potentially far-reaching cosmic consequences are being made. Hence, there is an urgent need for action.

Amongst the array of possible effects following our space endeavors, some may lead—through chain reactions or exponential mechanisms—to significant, large scale and/or irreversible changes, such as: (1) geomorphologic alterations[3] impacting entire planetary landscapes; (2) changes of celestial dynamics[4], leading to asteroid impacts or exponentially growing orbital debris; (3) large scale spread of chemicals[5], altering chemical evolution and the potential for emergence or evolution of lifeforms on a given body; (4) the spread of terrestrial lifeforms, inducing the creation of new biospheres or destruction/interaction with pre-existing ones[6,7,13]; and (5) the changes in Earth's electromagnetic signature, thereby increasing the potential for the identification by putative extraterrestrial intelligences[8,9].

The above scenarios may result in unprecedented consequences and prompt critical questions, such as: is it acceptable to spread terrestrial lifeforms to other celestial bodies, knowing their introduction could significantly impact environments and potential local life or even create new biospheres? Do humans have a responsibility to do so? Or rather to prevent it? Do we, as a species, want to create, destroy, or interact with extraterrestrial bio- and geo-spheres, either by accident or intentionally? Is it acceptable to signal nearby exoplanets? Beyond the scientific considerations, is it acceptable to allow biological or chemical contamination onboard spacecraft, even when landing in places in the solar system likely to host life? Is it desirable that such actions are decided by informed groups, having, however, limited representation with respect to the majority of humanity? Or unilaterally by governments, corporations, or individuals? How to respect the variety of cultural representations? Is there a need for specific laws, regulations and governance structures addressing these questions[11]?

These questions concern the intergenerational responsibility of humanity, which extends beyond our own species and biosphere[12]. They address the large-scale, irreversible impacts that humans have and will continue to have, following today's decisions. They connect contemporaneous actions, with consequences at scales unheard of in history, raising ethical questions we have no easy answer to. They relate to one overarching consideration: what is humanity’s responsibility, concerning its footprint on the cosmos?

Established in 1967, the Outer Space Treaty included the imperative to avoid "harmful contamination" of celestial bodies. Since then, several relevant issues related to humanity's cosmic footprint have been addressed; notably, the Committee on Space Research (COSPAR) Panel on Planetary Protection developed guidelines for biological transfers in order to safeguard studies regarding the origin of life and to protect our planet from contamination. Further, a broader interest in space ethics has emerged, encompassing questions concerning humanity’s impact on the cosmos. In 1999, the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) created a Sub-Commission on the Ethics of Outer Space. For 2024-2025, COMEST aims to formulate ethical principles for space exploration and exploitation. In 2010, the United Nations Office for Outer Space Affairs (UNOOSA) established the Working Group on the Long-term Sustainability of Outer Space Activities.

These initiatives, especially at the multilateral UN Level, are commendable and should be supported (for example through the Committee on the Peaceful Uses of Outer Space). However, no entity today is dedicated explicitly to the empirical evaluation of our overall cosmic footprint or to the exploration and development of responsible strategies to address it.

In response to this situation, we, stakeholders and specialists from various nations, involved in a broad spectrum of space-related disciplines and activities, collectively call to humankind, the nations of Earth, scholars, experts, policymakers, stakeholders, space-related corporations and ethics committees, to unite in recognizing the need to assess and responsibly address humanity's impact beyond Earth.

Acknowledging prior work completed by dedicated individuals and organizations, we encourage everyone, from their respective areas of expertise or position of action, to engage in a comprehensive evaluation of our cosmic footprint, explore the related ethical considerations, challenge the current governance practices, and take action. In particular, we urge:

- All stakeholders, to develop enduring strategies and structures designed to keep humanity accountable for its cosmic footprint over the long term. Such governance should be transparent, responsible, sustainable, and self-reflective, aiming to represent the perspectives of all humanity while considering our accountability to the entire biosphere.

- The establishment of an international registry of our anthropogenic footprint beyond Earth. Its role will be to develop a comprehensive and scientific representation of our cosmic footprint, providing a common ground for informed discussion. This development will require: a) listing types of anthropogenic impacts in space; b) identifying, merging, and maintaining existing databases (*e.g.,* spacecraft); c) conducting scientific research to develop missing databases (*e.g.,* electromagnetic footprints); and d) modeling and evaluating these footprints. The registry should be publicly accessible, and actively engage stakeholders and the public through regular scientific communication—including reports, visualizations, and summaries.

To amplify the impact of this work, we invite all interested parties to co-endorse the 'Cosmic Footprint' initiative, alongside the individuals and institutions listed here: Endorsement

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Note: References 12, and 13 were present in early drafts of this manuscript and are restored here for the benefit of the reader; they do not appear in the final published version.

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