Minimizing the Environmental Impact of Scientific Space Projects

White paper from the Scientific Community (264 Signatories) submitted to the CNES 2024 Prospective Seminar on the theme "Environmental Footprint of Scientific Space Activities"

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The unequivocal evidence that climate change and biodiversity loss are caused by human activity compels us to justify the environmental impact associated with the development of our research projects and to rethink our academic model. In a world that is suffering (mass displacement of populations, increasing inequalities, water crises, extreme weather events, mega-fires, disruption of livelihoods, deterioration in quality of life...), research, as a pursuit of knowledge for the common good, has a dual responsibility: to avoid exacerbating the situation while also proposing solutions to the problems our societies are facing. Many research institutes are committing to more environmentally conscious research by reconsidering policies related to professional travelling, procurement, energy use, and even the development of new projects. Simultaneously, many researchers are questioning the purpose of their work, while others see frugality as a way to restore meaning to their activities.

In its report entitled "**Integrating environmental issues into the conduct of research – An ethical responsibility**" the CNRS Ethics Committee (COMETS) formulates recommendations for CNRS and its personnel, and invites to "**recognize that taking the environment into account is an integral part of research ethics; affirm the responsibility of research actors to think about their activity with regard to environmental issues; this responsibility concerns not only the impact of research practices but more generally the negative or positive environmental impacts that the choice of this or that research topic and this or that path to treat it can generate for the environment in the broad sense, in the short, medium, or long term.**" If considering environmental impacts is to be considered an ethical responsibility of research, then the methods by which research projects are conducted must also be reconsidered. The **Labos1point5** research collective highlights the excessively productivist nature of research, advocating instead for "**reimagining a new horizon for academics that breaks free from frenetic competition based on the illusion of abundant and limitless energy.**" This white paper aligns with this vision, viewing scientific space research as a tool for generating knowledge that could contribute to the emergence of solutions for mitigating and attenuating current environmental disruptions (e.g., through a better understanding of the Earth system).

Space projects, and more generally large and expensive research infrastructures, are projects with important environmental impacts. They contribute to climate change, biodiversity loss, and have significant needs for raw materials, without forgetting their impacts linked to the growing congestion of orbits, the generation of space debris, the impact of gases and particles injected into the upper atmosphere during launch and deorbiting, and the creation of light pollution. How the development of new space projects can be reconciled with a drastic reduction of their environmental impacts is an important question, which leads some researchers to the conclusion that we must do fewer projects and make the ones we do more environmentally friendly. Doing less projects, because it is indeed unlikely that developing a space project that respects performance requirements under controlled risks can be done with a significantly reduced environmental impact (beyond 20-30 %) compared to projects developed under current conditions and methods. Focusing on greenhouse gas emissions, making French space science projects more virtuous should start with simple compliance with the rules of the French Ministry of Higher Education and Research, which sets an annual emission reduction target of 5% (with a minimum threshold of 2%), aiming to achive carbon neutrality by 2050. As a reminder, the COP21 Paris Agreement stipulates that, to limit global warming to 1.5°C, greenhouse gas emissions have to peak before 2025 at the latest and need to have decreased by 43% in 2030. It is therefore urgent to act, while these objectives already seem beyond the reach of public policies which are struggling to be put in place.

The signatories of this white paper to the CNES scientific propective seminar, wishing to minimize the environmental impact of new space projects, are calling for support by CNES for this purpose. CNES has defined its corporate social responsibility strategy by integrating the sustainable development objectives of the UN 2030 agenda and the commitment to the French road map. This white paper describes the expectations of the scientific community in this context. It is articulated around two pillars:

Towards Fewer but More Collaborative Space Projects?

- All new space projects should be assessed based on the expected scientific return, their relevance to the scientific community, and an environmentally sustainable footprint—measured through a rigorous **life cycle analysis (LCA)** from cradle to grave since project inception, including raw material extraction, manufacturing, development, deployment, usage, maintenance, transportation, and end-of-life treatment. The CNRS Ethics Committee emphasizes that "**Environmental considerations for researchers should extend beyond greenhouse gas emissions to include all environmental impacts of their activities. This means that selecting research topics and**

methodologies (using large research infrastructures such as telescopes, satellites, vessels, high-performance computers, numerical modeling, polls) needs to take into account their potential harmful environmental impacts in order to minimize them as much as possible." Only a comprehensive LCA allows for estimating the global environmental impacts beyond just greenhouse gas emissions and their contribution to climate change. The LCA should evolve as the project matures. To allow considering environmental impacts in the adoption decision of a new project, an effort must be made to ensure that LCA results are available from the upstream phases on of the project.

- New space projects should prioritize **international scientific collaboration** over competition, which often leads to redundant projects with similar objectives.
- **Archival data should be made more accessible** and usable for extended periods, receiving dedicated funding beyond the nominal mission lifetime. Too often, new projects are started before existing datasets in related scientific fields have been fully exploited.

Towards More Sustainable and Responsible Space Projects

- **Develop expertise in measuring environmental impacts.** Conducting an LCA requires specialized expertise, currently lacking in many research institutes. Data collection (inputs: raw materials, processed materials, energy; outputs: emissions, waste) needs cooperation by all stakeholders, including industrial and institutional partners at national and international levels. In the short term, external expertise may be required to conduct LCAs, with associated costs that need to be covered by the project. In the mid term, LCA skills should be developed and maintained in-house and sustained through support by funding agencies.
- **Appoint an "Environmental Impact Architect"** within each space project under direct responsibility of the Project Manager and responsible for implementing measures to ensure compliance with environmental requirements. These measures should be documented in an **Environmental Quality Plan**, reviewed at key project milestones alongside standard management and quality assurance plans.
- **Provide training on eco-design methods** to project teams and regularly inform them about environmental issues.
- **Optimize high-energy-consuming infrastructure** (e.g., clean rooms, test facilities, integration platforms, digital resources) necessary for project development and operation. If possible, these resources should be **shared across space science institutes and CNES** to reduce their number and hence their environmental impacts.

- **Establish strict oversight** for compliance with environmental requirements through a **competent evaluation structure**, jointly recognized by CNES and the other funding agencies of space research institutions.
- **Communicate the societal and economic benefits of space projects** while demonstrating that scientific space research respects planetary boundaries, of which several have already been breached.

Urgent Need to Integrate Environmental Considerations into Space Research

Integrating environmental concerns into space activities and reevaluating knowledge production methodologies is now an urgent necessity for the academic world. This white paper, while centered on space projects in the context of the CNES prospective seminar, could also be extended to other research infrastructures with significant environmental impacts.

To conclude with a positive note, implementing the proposals outlined above, combined with more frugal daily scientific activities, could yield multiple benefits: restoring meaning to our work, ensuring that future generations can conduct research under conditions comparable to those we have enjoyed, and ultimately, reducing environmental impacts while enabling scientific space research to contribute to a **more just and sustainable world.**

List of 264 signatories edited as of February 1st, 2025

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