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A CONCEPTUAL FRAMEWORK FOR CLIMATE CHANGE MITIGATION ACTIONS EMPLOYING IN-SPACE GEOENGINEERING

Abstract

The possibility of direct climate action from space in the form of reversible in-space geoengineering introduces novel concepts for large scale space systems and applications to achieve desirable long-term outcomes for planet Earth. The objective of this paper is to broadly address opportunities for innovation and collaboration in building and advancing the future vision of transformational in-space geoengineering architectures. In previous work the authors surveyed proposed space geoengineering approaches and provided top-level comparisons based on critical metrics, including sustainability and reversibility, scientific and engineering feasibility, cost, and time of execution. In this paper, we introduce a conceptual framework for in-space geoengineering. This framework offers a taxonomy for comparing different approaches and driving progress across the entire span of complex issues that are involved. These include mission-specific considerations, policy and geo-political activities, biosphere sustainability, economic/industrial viability, and operational aspects. We consider and preliminarily analyze each of these perspectives.

In particular, regarding mission-specific considerations we consider: current state of the art, technology maturation roadmaps, design reference architectures (orbits, launch vehichles, number of satellites, Technology Readiness Levels), and bases for conducting technical trade studies and systems engineering analyses. Regarding policy and geo-political activities, we discuss: state of the art in terms of analogous global endeavours/interventions, policy, legal precedents, norms, funding, international cooperation, standards, key policy actors (sovereign civil space stakeholders, sovereign national security stakeholders, UN, NGOs such as World Economic Forum, etc.). Regarding biosphere sustainability we examine: state of the art in terms of analogous global endeavours/interventions, implications for atmosphere, ocean, terrestrial environments, biodiversity and food webs, agriculture, etc. Regarding economic/industrial viability we explore: sovereign wealth funds' investment into key strategic space infrastructure, private capital sources' prioritization of sustainability platforms, identification of revenue generation opportunities to incentivize industrial workforce planning and cooperation, etc. Finally, regarding operational architectures we consider: launch and communications infrastructure considerations, interoperability, scalability, stewardship of orbital slots (including disposal for Earth-Sun L1), hazards and risks.

The proposed framework will provide a point of departure for future design and development activities as well as a reference for evaluating the feasibility, completeness, and sustainability of alternative architecture concepts based on objective criteria.