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OCEAN-BASED ROCKET RECOVERY: A SUSTAINABLE APPROACH TO REUSABILITY IN SPACEFLIGHT

Abstract

Environmental considerations regarding rocket launch and recovery operations are coming into focus as space exploration accelerates. While vastly improving in economics and sustainability, reusable rockets still contend with land-based landings and ocean recovery modes, as currently being practiced, in terms of environmental sustainability, infrastructure demand, and operational efficiency. This paper proposes to investigate the feasibility of advanced ocean-based recovery for rockets as a potentially greener and cheaper solution. We propose an AI-enabled, autonomous maritime recovery system incorporating precision-guided descent methods and buoyancy-assisted deceleration for soft ocean landings with low structural stress. Unlike conventional land-based recovery, which typically depletes much of the fuel reserves for return burns, enhanced controlled oceanic retrieval can conserve energy while simplifying logistical challenges. AI guidance and navigation systems refine landing accuracy, safety, and operational efficiency. Likewise, we explore the integration of hydrogen buoyancy systems that will be able to keep recovered rockets afloat for simplified retrieval to minimize their exposure to saltwater and associated corrosion risks. This paper also explores the strategic placement of ocean-based launch and landing zones to counter atmospheric disturbances and carbon emissions and minimize spaceflight environmental footprints. The technical feasibility and advantages of this approach are reviewed through a description of past ocean recovery missions, up-and-coming technologies for maritime retrieval, and situational case studies. This study goes beyond technical considerations to address regulatory, economic, and policy-related challenges—maritime law compliance, international space agreements, and opportunities for commercial collaboration. Government-operated space agencies and commercial aerospace companies should employ advances in ocean-based sustainable rocket recovery methods to increase mission reusability, diminish operational costs, and decrease environmental disturbance. This study presents the potential for a paradigm shift in spaceflight logistics—in alignment with increasing global efforts toward sustainable development—while securing the space exploration endeavor for the future.