The price for access-to-space

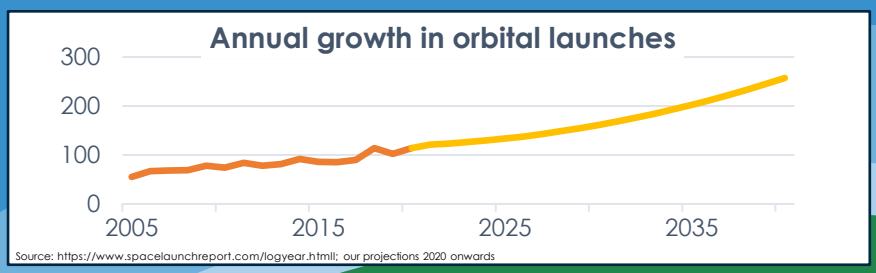
What is the real environmental impact of launcher propellants?

With the space industry undergoing transformative growth globally, the number of rocket launches per year has been steadily increasing [1] – a trajectory likely to increase over coming decades. Despite the hazardous implications of spaceflight, earth-to-orbit traffic has been too insignificant to command much support for significant regulations [2]. This may well need to change as expanding space services necessitate a higher emphasis on human safety and environmental impact: rockets can not only pollute the mesosphere and ionosphere [3], they also affect ozone distribution as well as temperature levels in Earth's atmosphere [4].

Spacecraft launches themselves can hardly be limited without a serious disruption to the world economy. Accordingly, much effort is expended on encouraging manufacturers to adhere to contemporary 'green' standards. Propellants, which account for the largest proportion of a rocket's mass, are in the very forefront of this trend – prudence in propellant choice is recognised as the most significant method of minimising rocket emissions [5] as well as mitigating raw material processing for single-use applications, such as space engineering.

Conventional propellants are highly hazardous to human health and the environment, many to a degree greater even than most war gases [6]. Usually, their adherence to evolving 'green' standards is modelled by considering inherent chemical qualities and traits, while modern-day propellant research seeks to find alternatives to improve them. However, this approach tends to overlook the impact from the propellant's entire life-cycle itself. Without taking into account this wider context, propellant assessment and, consequently, evaluation is incomplete.

In our minds, the wider context involves the propellant's ecosystem itself. From resource sourcing and their transportation, to manufacturing processes and eventual chemical decomposition during flight, each procedure undertaken always has a consequence, be it environmental, safety or cost-based. Some cryogenic propellant manufacturing processes, for instance, are expensive and at present not environmentally friendly [7], despite the 'green' nature of their eventual combustion.



Source: https://www.spacelaunchreport.com/logyear.html; our projections 2020 onwards

In this project, we aim to reassess the 'green' virtues for a range of common propellants, analysed within the context of their full life-cycle. We wish to inform the industry on the true impact of all aspects of the propellant life-cycle and evaluate their 'green' credentials, counteracting common misconceptions about eco-friendliness. This will be the groundwork for a further quantitative analysis on the topic.

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[5] Larson, E. J. L., R. W. Portmann, K. H. Rosenlof, D. W. Fahey, J. S. Daniel, and M. N. Ross (2017), Global atmospheric response to emissions from a proposed reusable space launch system, Earth's Future, 5, 37–48, doi:10.1002/2016EF000399.
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[7] Fernández-Dacosta, Cora & Shen, Li & Schakel, Wouter & Ramirez, Andrea & Kramer, Gert Jan, 2019. "Potential and challenges of low-carbon energy options: Comparative assessment of alternative fuels for the transport sector," Applied Energy, Elsevier, vol. 236(C), pages 590-606.

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