

IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)  
Sustainable Approaches and Impact of Space Transportation Solutions on Earth + Space Environment  
and on General Safety (9-D6.2)

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REDEFINING “SPACE SUSTAINABILITY” FOR LAUNCH VEHICLES: FORECASTING THE  
ATMOSPHERIC IMPACT OF THE COMMERCIAL SPACE LAUNCH INDUSTRY IN 2050

**Abstract**

Discussions on “space sustainability” have largely centered on orbital debris, the burnup of vehicles during atmospheric reentry, and the resulting emissions from the burnup. However, few studies have examined the emissions from launches themselves. Along with reentry burnup, rocket launches are the only source of high altitude anthropogenic emissions. At such high altitudes, emitted particles can remain in circulation for years. With the annual growth rate of the commercial launch industry averaging 14.6

Taking inspiration from the Shared Socioeconomic Pathways (SSPs) defined by the IPCC Sixth Assessment Report in 2021, this paper outlines several potential future scenarios of the launch industry in 2050, corresponding to different geopolitical and technological developments. For each scenario, we estimate the number of launches for a distribution of rocket models, propellants, and origin spaceports. We simulate the chemical interactions of the launch plumes with the atmosphere using the global atmospheric chemistry model GEOS-Chem. Finally, we quantify the steady state impact of the resulting atmospheric chemistry on air quality, ozone, radiative forcing, and consequently climate and human health.

Our findings have important implications for commercial launch providers, research institutions, and policy on an international scale. As launch providers develop new rocket models—such as SpaceX’s Starship—they may choose different fuels, while NASA may choose to fund the development of more sustainable propellants. As COPUOS continues to lead discussions on space sustainability, it may cooperate with the Federal Aviation Administration in the United States, which licenses commercial space launches, and other agencies worldwide. Our paper expands the discussion on “space sustainability” to include the sustainable development of the launch industry.