IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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REVIEW OF THE ENVIRONMENTAL IMPACT OF SPACE TRANSPORTATION SYSTEMS IN A FULL LIFE CYCLE ASSESSMENT

Abstract

In 2021, a new record was set with 145 orbital launches. This trend is expected to continue in the coming years due to the ever-increasing interest for satellite constellations for a variety of applications. In addition, there are suborbital launches, for which a significant rise is also expected in the next few years due to the growing space tourism activities. The environmental impact of space transport has thus come into greater public focus.

However, the effects of rockets have so far been little researched in science. Nevertheless, this paper will give an overview by comparing existing studies on production, emissions during flight and re-entry, in order to cover the entire life cycle of space transport systems and to identify gaps in knowledge. Based on this, possible measures to close the knowledge gaps will be discussed and suggested, such as measurement campaigns.

The production of launch vehicles is a very sensitive area, as a lot of know-how is capitalised here and data is therefore normally classified as confidential. Accordingly, there have only been a few studies on production to date, and these only provide relative values. However, these few studies are to be compared in order to identify key points.

The largest portion of conducted studies discusses emissions. First, an overview of the different fuels, engines and their emissions will be given. The primary focus so far has been on the impact on the ozone layer, since rocket engines emit ozone-depleting substances directly into the stratosphere. Particularly interesting are solid boosters with chlorine compounds which, once introduced into the ozone layer, have a catalytic effect and can thus deplete ozone over several years. Other emissions comprise aluminium particles and soot, which both have an impact on the Earth's radiation budget. Whether this effect cools or warms the Earth and even its significance is disputed, which is why the different studies are to be compared with each other. Water emitted by rockets is integrated into the water cycle in the troposphere, but can lead to cloud formation in the mesosphere, which impact is not fully understood. Furthermore, an estimation of the CO2 emissions of common launch systems will be made in order to approximate the overall contribution of rockets to climate change. This will also be presented in comparison with other sources, such as the aviation industry.

Studies on emissions during re-entry are also scarce, but these will be discussed and a qualitative analysis of the possible combustion products will be presented.