IAF SYMPOSIUM ON COMMERCIAL SPACEFLIGHT SAFETY ISSUES (D6)
Commercial Spaceflight Safety and Emerging Issues (1)

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A CRITICAL ANALYSIS OF REENTRY DEBRIS UNCERTAINTY AND INTERNATIONAL COORDINATION EFFORTS

Abstract

The recent rapid advancement of commercial space operations has highlighted high levels of uncertainty in modeling debris from spacecraft reentry and the lack of an international framework for exchanging information to ensure safe operations. The first step in determining hazards to the public from a reentry operation is to perform a flight safety analysis, which includes creating a catalog of debris for the object. This allows for the identification of designated hazard areas where mitigation measures need to be in place. Especially for reentries occurring on or near land, aerothermal demise of the debris fragments must be considered to more accurately predict the hazard areas. However, using current models, predicting aerothermal demise with a high degree of certainty is a time and resource intensive process due to a lack of data, the introduction of new materials, and the complexity of current models. Another layer of uncertainty is introduced for cases of uncontrolled or random reentry of an object. For random reentry cases, there is limited capability to predict when and where debris will impact Earth's surface due to a lack of knowledge of upper atmospheric properties.

Given the uncertainties associated with accurately predicting hazards from commercial reentry operations, there is a pressing need to have a robust coordination framework to mitigate risks to the public. Data associated with the identified hazard areas must be promulgated efficiently to protect and warn the public against risks. Currently, there is no centralized international framework that enables efficient data sharing, communication, or real time operational coordination for mitigating hazards from space operations, including reentries. For ground, maritime, and aircraft safety, the differences in jurisdiction, issues of sovereignty, lack of standardized procedures, and the high degree of uncertainty in the risk predictions pose challenges with respect to ensuring safety measures such as warnings and closures are in place ahead of time. There is a need for rapid integration responses to divert aircraft and maritime traffic, and a forum to communicate accurate data at the international level. Further challenges are posed by the lack of specificity in international space laws and treaties, and this paper specifically considers the implications under the Outer Space Treaty.

This paper investigates how shortcomings in modeling ability and a lack of a centralized coordination framework are related and how improvements are needed to ensure the necessary information is communicated with international partners to safeguard public safety across the globe.