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RE-ENTRY OF SPACE OBJECTS AND CONTAMINATION OF EARTH ENVIRONMENT: A POTENTIAL THREAT TO LIFE ON EARTH

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Protection of earth environment, which includes the terrestrial environment, atmosphere and outer space, is essential for sustainability of habitat and usability of outer space for sustaining life on earth. Space ventures, though for the benefit of mankind, are inherently risky and cause space pollution, commonly known as space debris, and have a potential for threat to life and property on earth if not mitigated beforehand. Though there is a space governance mechanism in terms of treaties, policies and regulations to control space activities, these are grossly inadequate in keeping pace with the extent of space activities as seen in the past decade.

The inherent risks of failure during a rocket launch and during its transit through the atmosphere means that any mishap during this phase could result in a risk to life and property at the debris impact zones. Also, the large amounts of expelled propellants –both solid and liquid – as well as combustion gases are potentially hazardous. Similar risks also exist during re-entry of space objects, especially the uncontrolled ones. At the international level, these issues are addressed to a certain extent in Article VII of the Outer Space Treaty which addresses the liability rules for space launches including damages caused during a space launch for damage on earth or in airspace of a member state. The Liability Convention of 1972 provides the framework by which aggrieved states can pursue claims for damage caused by a space object to another space object, to aircraft in flight, or on the surface of the earth.

Significant amount of debris has been created in the six decades of space history. This consists of dead satellites, spent rocket stages and other bits and pieces left in space by astronauts or created during the launch of satellites and debris as a result of collisions in space. Re-entry of space debris (like those suspended in the lower fringes of low earth orbit) also pose a potential risk of falling on inhabited territory, though major portions of the debris may eventually burnout in the atmosphere. The US Space Surveillance Network tracks around 23000 pieces of debris, each of which is capable of destroying a satellite. Some of these would eventually decay their orbits and re-enter the atmosphere and not burnout completely. In such a case, some fragments would still impact on earth.

In this context, debris mitigation procedures, prevention of damage on earth due to debris impact and preservation of earth environment assume significance. Controlled re-entry of spacecraft and spent rocket stages is slowly becoming the norm, though the gap in technology advancement between developing countries like India and the leading space faring nations would be a restricting factor. Technology sharing agreements would thus play a critical role in space debris mitigation. The Inter Agency Space Debris Coordination Committee (IADC), an international forum of experts, has created guidelines for disposal of spacecraft at the end of their useful life. However, these disposal techniques fall short when control over the spacecraft is lost.

There have been many instances of space objects re-entering the atmosphere and impacting the earth. The biggest among them was the 'Skylab' US space station which orbited the earth from 1973-1979 and impacted near Perth, Australia in 1979. Fortunately, none of these incidents caused harm to humans, barring the impacts caused by meteors and explosions of rockets following failed launches. More recently, the Chinese space station 'Tiangong-1' went through an uncontrolled re-entry after being abandoned in 2016. The remnants from burnout were expected to impact over a wide swath with an estimated ground footprint of 2000 km and between latitudes 42.8 degrees North and 42.8 degrees South in the first week of April 2018.[1]The actual impact occurred over the South Pacific Ocean off the coast of Chile. Though the probability of the space debris falling in populated areas is minimal, there was a period of uncertainty as the exact impact zone cannot be pinpointed owing to the dynamics of re-entry and unpredictability of break-up and burnout of spacecraft during re-entry.

The seriousness of the event gives enough reason for a further study of spacecraft and satellite design considerations. What happens to a spacecraft after its useful life is as important as what it does within its lifespan. A viable option could be to design any space object which is to be positioned in lower orbits to burn out completely during re-entry. This assumes more relevance in view of the IADC guidelines of ensuring re-entry of satellites at the end of their life, which could prevent bunching up of satellites in useful orbits leading to congestion. The US space agency –NASA has recommended that if a satellite has a 1 in 10,000 chance of surviving re-entry and causing a casualty, its re-entry must be controlled[2]. Objects which are designed as recoverable, e.g. space shuttles, would obviously be in a controlled descent. A design for complete burnout would mean making hardware components and satellite parts of material which would have a melting temperature below the peak temperatures expected during re-entry and shapes which would not survive the atmospheric deceleration and extreme temperatures following a break-up of the space object. It is predicted that certain materials like stainless steel and titanium and rounded shapes like tanks have a high potential of re-entry survival, particularly if high melting temperatures are combined with low area-to-mass ratios.[3] This is a complex subject as robustness of the structure needs to be kept intact to survive the severity of launch, space weather, small debris collisions (< 1cm), counter-space activities and a lifetime of orbiting. Also, adequate fuel must be left in the satellite to execute the re-entry manoeuvre. This is again a moot point as the dependence on a satellite would lead to life extensions-consuming all fuel onboard, unless replacements are readily available. The situation could again result in leaving the satellite as debris in orbit.

The back contamination of earth environment due to other factors like exhaust gases and spent stages of rockets also needs to be pursued. Use of recoverable stages of rockets, cleaner propellants and better rocket technology which are in various stages of development and testing will make space ventures cleaner and safer in times to come.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

Keywords: Space Exploitation, Re-entry, Environment, Space Debris, Space treaty.

Notes:

[1] Mike Wall, "Chinese Space Station's Crash to Earth: Everything You Need to Know", at https://www.space.com/40076-chinese-space-station-crash-to-earth-guide.html, accessed on March 25, 2018.

[2] "Limiting Future Collision Risk to Spacecraft: An assessment of NASA meteoroid and Orbital Debris Programme ", Chapter-8 (Washington D.C., National Research Council of the National Academic, 2011), athttps://www.nap.edu/read/13244/chapter/10, accessed on March 27, 2018.

[3] H Klinkrad, "Re-Entry Prediction and On-Ground Risk Assessment", at http://aero.tamu.edu/sites/default/files/faculty/alfriend/Russia6thWorkshop/S2.3%20Klinkrad.pdf, accessed on March 27, 2018.