1995 IISL/IASL Symposium

The Impact of Space Systems on the Terrestrial Environment

by
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March 1995

Summary

Dr. Crowther discussed the impact of space systems on the terrestrial environment. Sources of terrestrial pollution, he said, are *chemical* including releases into the atmosphere; *radiological* including emission of electromagnetic waves and emission from radioactive materials; and *biological* including both forward and backward contamination. He described the terrestrial atmosphere and where the various types of pollution can have effects. Chemical pollution in the atmosphere is associated with launch vehicle activities and includes stratospheric ozone depletion, global warming, acid rain, and toxicity, he said. He described the major types of launch vehicle propulsion according to vehicle type, propellant components, and exhaust products. Propellant components on solid boosters on the space shuttle, Titan, and Ariane vehicles include ammonium perchlorate/aluminum. Propellant components on liquid boosters such as Long March and Energia contain LOX, LH_2, N_2O_4, and Kerosene. Exhaust products are HC_1, H_2O, Al_2O_3, CO_2, N_2 and H_2O, N_2, NO_X, CO_2 respectively.

Dr. Crowther then discussed stratospheric ozone depletion. Ozone (O_3) is continually produced and destroyed by naturally occurring photochemical processes, he said. Chlorine (Cl), Oxygen (O), Hydrogen (H), and Nitrogen (N) can destroy ozone, and the following are produced by space launch vehicles: HCI (Solids), H_2O/H_2 (Solids/Liquids), and N_2O_4 (Solids/Liquids). He described the contribution of rockets to global stratosphere as being Cl <1%, H_2O <0.001%, H <0.005%, and NO_X <0.002%.

Global warming, he said, is caused by trapped solar radiation. The worst potential villains are carbon dioxide (CO_2) and Aluminum Oxide (Al_2O_3) particles. Acid rain caused by launch vehicles is another concern with solid rockets contributing hydrochloric acid, and liquid/solid motors contributing nitric acid. The effects are global, he said, and include plant damage and fish mortality. He attributed sources of global acid rain at the following:

US energy production	33,000 ktons/yr
US transportation	9,100 ktons/yr
US industry	6,100 ktons/yr
Oceans	330,000 ktons/yr
Volcanoes	5,000 ktons/yr
9 Shuttles & 6 Titans	3 ktons/yr

This indicates that at current launch rates space launches are not a significant contributor, but with anticipated increased launch rates, there may be cause for concern. He discussed the toxicity of solid and liquid rockets indicating that solid rockets produce hydrochloric acid, a severe irritant, and aluminum oxide, which has been discussed as a contributor to Alzheimer's Disease. Liquid rockets produce nitrogen tetroxide, associated with Pulmonary Oedema, and dimethylhydrazine and hydrazine, both known carcinogens. He noted that the greatest risks with these chemicals, however, comes from handling.

In discussing radioactive emissions, he said nuclear power sources (NPS) must be designed to avoid release of radioisotopes in launch accidents, in leakage in orbit, and in reentry into the atmosphere. To avoid reentry into the atmosphere, he discussed options involving placing the NPS intact into a disposal orbit at approximately 1000 km where radioactive materials might decay faster than the orbit, placing the NPS intact or fragmented in low altitude orbits, e.g. <600 km, where the orbit would decay faster than the NPS, but the source would burn up on reentry.

In closing, he provided the following chart which is self explanatory.

POLLUTION SOURCE	ENVIRONMENTAL IMPACT	LOCAL	GLOBAL	COMMENTS
Chemical Propulsion	Ozone Depletion	√	X	More research on chemical processes.
Chemical Propulsion	Global Warming	X	?	Research needed into aerosol deposition.
Chemical Propulsion	Acid Rain	√	X	Must consider test firings.
Chemical Propulsion	Toxicity	√	X	Handlers most at risk.
Communication Links	Interference with Radio Astronomy	√	X	Both Earth and satellite transmissions.
Nuclear Power Sources	Radioactive Contamination	√	√	Impact of debris on orbiting systems.
Biological Transmissions	Backward/Forward Contamination	X	X	No known risk.