Studies Analyze Ozone Loss From Launches, Re-Entries

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WASHINGTON-A series of U.S. Air Force-sponsored studies have found that space hardware re-entering the atmosphere contributes to ozone destruction.

As it burns up during re-entry, space hardware produces materials that combine with other elements in the Earth's upper stratosphere which can produce a chemical reaction that leads to ozone depletion. The studies also found that conventional rocket propellants released during launches produce byproducts that also are harmful to stratospheric ozone.

A November 1994 study by The Aerospace Corp., "Stratospheric Ozone Reactive Chemicals Generated by Space Launches Worldwide," reported that space launchers contribute over 800 tons of chlorine and 1,000 tons of aluminum oxide particles to the stratosphere each year. While this pollution is considered a small amount given the vastness of the Earth's atmosphere, it is on the increase and could double by the year 2000, the study noted.

By far the largest polluter to the ozone is the U.S. space shuttle followed by the Titan 4, Delta 2 and Europe's Ariane 4 booster. When the European Ariane 5 rocket enters commercial service, the launcher will dramatically add to the mix of other human-produced chemicals that have been found to damage the ozone, the study reported.

Each of these vehicles relies on solid-propellant strap-on motors that spew hydrogen chloride, which reacts with ozone. Solid-propellant boosters not only create a local ozone hole in the atmosphere but also contribute to a long-term global effect, according a May 1994 TRW study, "Utilization of Alternate Propellants to Reduce Stratospheric Ozone Depletion."

A series of separate space debris and ozone impact reports completed in 1994 were prepared for the Environmental Management Division of the U.S. Air Force's Space and Missile Systems Center in Los Angeles by TRW's Space & Electronics Group in Redondo Beach, Calif., and The Aerospace Corporation in El Segundo, Calif.

"The impetus for these studies is to get our arms around what environmental impacts are there, potentially, in using space. This is a new frontier and a lot of this analysis hasn't been done before," said John Edwards, project officer of the studies and chief of the Air Force's Environmental Management Division.

Valerie Lang, an atmospheric scientist for The Aerospace Corp., said the work is geared to avoid environmental surprises that could mean scheduling delays for future Air Force space missions.

"The impetus here is to keep track over the next decade or so of any further contributions and any other unusual types of chemistry" that could be deposited in the atmosphere from re-entering debris and rocket launches, Lang said.

According to the TRW study completed in May, "Effects of the Impact of Deorbiting Space Debris on Stratospheric Ozone," objects re-entering the atmosphere can affect ozone in several ways, but not on a significant level globally.

As an object plows through the Earth's stratosphere, a shock wave is created that produces nitric oxide, a known cause of ozone depletion. Spacecraft and rocket motors are composed of metal alloys and composite materials that melt away during re-entry. TRW researchers found that these materials, as they undergo intense heating, also form chemicals that react directly of indirectly to consume ozone.

There are upwards of 8,000 pieces of orbiting space junk 10 centimeters (4 inches) or larger in size, and 35,000 to 150,000 objects in the 1-10 centimeter range and perhaps 40 million pieces of space flotsam less than about a half-inch in size, the TRW study reported.

Edwards said that stratospheric contamination from re-entering space debris was identified several years ago by Michael Zolensky, associate curator for interplanetary dust at NASA's Johnson Space Center in Houston.

Zolensky led a team that found a ten-fold increase in the abundance of large solid particles in the stratosphere between 1976 and 1984. Using high-altitude aircraft, the NASA sampling program was directed at snagging particles of dust from comets and asteroids as they filter down through the atmosphere.

However, when the collection plates were later analyzed, exhaust residue from solid rocket motor firings, protective paints that shed from the outer hulls of spacecraft in orbit, and particles of mostly aluminum from re-entering space hardware were identified.

"The results still stand," Zolensky said, "but nobody has taken another look to verify or extend our findings to the present day. We're trying to get support to do that, but without success."

Zolensky said atmospheric chemists are using the wrong density of particles and types of particles in their computer models. Zolensky said that more research needs to be done on whether or not the amount of incoming space debris has increased over time. "We just don't know without taking another look," he said.

Edwards said a state-of-the-art sensor has been designed to better measure ozone depletion resulting from rocket launches. The High Resolution Ozone Imager prototype is under development by members of the Space and Environment Technology Center of The Aerospace Corp., Edwards said.

The ozone imager would be mounted on a satellite in polar orbit, some 800 kilometers (500 miles) above the Earth. It would scan the exhaust trail left by some rocket launches within one to three hours of the rocket's liftoff. The spaceborne sensor would measure and compare ozone loss resulting from various launch vehicles.

The sensor itself is part of an Air Force Phillips Laboratory program designed to study the effects of space launch vehicles on the stratospheric ozone layer and to develop alternative propellants with reduced impacts. The $4.2 million for the sensor is being drawn from several parts of the Air Force including it's research laboratories to develop and fly the instrument by 1997.