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OVERVIEW OF ATMOSPHERIC EFFECTS

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Effluents from the transportation system are the major cause of SPS-related atmospheric effects. These effects include inadvertent weather modification, air quality degradation, compositional changes in the stratosphere and mesosphere, formation of noctilucent clouds, plasma density changes, airglow enhancements, and changes in composition and dynamics of the plasmasphere and magnetosphere. In most cases, these effects have been difficult to assess because they involve processes that are either not well-understood by the scientific community or are speculative in nature, or because they involve extrapolations of known effects to unprecedented scales. Hence, with few exceptions, the results should be regarded as tentative.

HLLV launches have been found to have a significant potential for inadvertent weather modifications on a local scale. Under selected meteorological conditions such launches can affect convective patterns, alter cloud populations and induce trace precipitation. None of these effects are judged to be serious.

Air quality impacts of HLLV launches are predicted to be very small except possibly for nitrogen oxides. If a short-term air quality standard is set as anticipated, then ground-level concentrations of NO_2 due to rocket launches could exacerbate existing problems. However, the launches by themselves are not expected to exceed the expected standard. NO_2 production can also lead to slight increases in acidity of precipitation on a local, intermittent basis. It seems unlikely that the enhancement is great enough to cause significant environmental effects.

Stratospheric CO_2 and H_2O injections are estimated to be completely negligible from both the ozone depletion and greenhouse effect points of view. Small ozone reductions (a few %) are expected above 70 km, but the effect on the total ozone column would not be detectable.

Repeated injections of H_2O in the mesosphere will cause a long-term modification of the water concentration profile on the order of 15% near the launch latitude, with larger increases on a short-term, smaller scale basis associated with individual rocket launches. Short-term, small-scale ice clouds (noctilucent clouds) are expected to be formed but are not expected to reach global scales and therefore are not expected to cause climatic impacts.

Several mechanisms that are not completely independent of each other have been shown to produce both positive and negative large changes in D- and E-region plasma densities. It is presently not clear how large the net plasma density changes will be or even what sign they will take.

In the F-region, however, the picture is much clearer. We can predict with considerable confidence the scale of and with somewhat less confidence the duration of F-region holes caused by various engine burns of SPS space vehicles. Each POTV injection burn will result in an ionospheric hole on the scale of the continental U.S. HLLV circularization burns will produce holes one-tenth the size but twice per day. More speculatively, the periodic engine burns may lead to a chronic low-level depletion in a ring-shaped global region centered around the launch latitude. Crude estimates suggest a 10% plasma reduction in this region superimposed on periodic, small-scale, but much deeper, depletions. Confirmation with more detailed model calculations is required. Probably the major consequences of this depletion ring will be perturbations of VLF, HF, and possibly VHF wave propagation. Another impact of potential importance is the enhancement of airglow. The greatest enhancements observed to date are on the order of 10 kilo Raleighs for certain emissions in the visible and near IR. Assessment of these effects is beyond Task Area 3's scope.

The effect of POTV and COTV emissions in the magnetosphere is perhaps least-well understood at the present time and least-well supported by observations. The masses and energies injected are large compared to naturally occurring values and therefore give cause for concern. Heating by the argon plasma beam is expected to lead to enhancement of dosage of trapped relativistic electrons. Production of artifical ionospheric electric currents similar to those associated with naturally occurring magnetic storms could be driven by the magnetosphere-argon ion beam interactions. Such currents could result in long telephone line and power line circuit-breaker tripping and enhanced pipeline corrosion. The presence of large quantities of neutrals (from POTV) and heavy ions can lead to substantial depletion of high energy charged particles and modification of auroral response to solar activity. The possibility also exists for the formation of plasma instabilities that could cause satellite communication signal interference. Finally, an appreciable amount of airglow may be generated especially near LEO by the impingement of the dense Ar^+ beam on the thermosphere. The significance of this airglow should be assessed by the remote sensing community.

The sun-weather effect that has been widely debated in the recent climate literature, if it is real, is likely to involve a coupling of the upper and lower atmospheres. Several mechanisms have been proposed to explain such a coupling. It has been conjectured that, if indeed modifications in the solar wind can influence climate through some such coupling scheme, then perhaps the SPS upper atmospheric effects we have been discussing could play a role in disturbing the coupling scheme. In that sense, upper atmospheric SPS effects may be casually connected to possible climate effects. However, until the sun-weather effect is placed on a firmer footing, and until the SPS upper atmospheric effects themselves are better understood, the potential effect of SPS upper atmospheric effects themselves are better understood, the potential effect of SPS on climate and weather cannot be evaluated.

One final effect that has been investigated in the current assessment is the inadvertent weather modification likely to be caused by the rectenna's structure coupled with the release of waste heat. From the weather and climate points of view, the rectenna seems likely to have effects comparable with those due to other nonindustrial land-use changes covering the same surface area. That is, local, detectable meteorological effects that probably have little consequence.