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LDEF ENVIRONMENT MODELING UPDATES

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ABSTRACT

An updated gas dynamics model for gas interactions around the LDEF is presented that includes improved scattering algorithms. The primary improvement is more accurate predictions of surface fluxes in the wake region. The code used is the Integrated Spacecraft Environments Model (ISEM).

Additionally, initial results of a detailed ISEM prediction model of the Solar Array Passive LDEF Experiment (SAMPLE), A0171, is presented. This model includes details of the A0171 geometry and outgassing characteristics of the many surfaces on the experiment. The detailed model includes the multiple scattering that exists between the ambient atmosphere, LDEF outgassing and atomic oxygen erosion products. Predictions are made for gas densities, surface fluxes and deposition at three different time periods of the LDEF mission.

INTRODUCTION

The objectives of this study were to update the scattering algorithms used in ISEM and to perform more detailed modeling of the AO171 experiment tray. These models were then delivered to NASA, MSFC for use by analysis personnel.

The changes in the scattering algorithms affected, primarily, the wake regions where self scattering is important. This update was initiated after in flight observations of

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the Environment Monitor Package,EMP, showed that the wake region wasn't being adequately predicted. The EMP was an instrumented payload deployed from a rocket flight and had a multitude of sensors and objectives(ref.1). Previously ISEM had two scattering algorithms, one for thermal speed collisions and one for collisions with the high speed incoming ambient. These corresponded to a cosine scatter and a cosine to the 20th power scatter. The new center of mass scattering gives nearly the same scattering distributions and ram densities at LEO but does a much more accurate job for low density ambient atmospheres and self scattering in the wake regions behind the spacecraft. Currently the updated scattering algorithms are standard in ISEM (ref. 2).

RESULTS

Updated LDEF Predictions

The fluxes of ambient and contaminant species were predicted in an earlier study (ref. 3). A comparison of some of the previous results with the more recent results are presented to show the influence in the wake regions. The entire set of updated predictions can be found in the final report for the current study (ref. 4).

Figure 1 shows the previous predictions using the old scattering algorithms for the outgassed and erosion products at 463 km. Figure 2 is the same predictions only with the new scattering algorithms. Comparison shows that the surfaces in the wake were influenced the most where the surface flux is near three orders of magnitude greater with the updated scattering algorithms. Surfaces on the ram side show no changes in flux. The same is true for atomic oxygen as can be seen by comparing Figures 3 and 4. It is interesting to note that now the scattered flux of contaminants to the wake surfaces is the same order of magnitude as the scattered atomic oxygen flux at this time in the mission. This same type of increase in the wake flux for the updated algorithm predictions exists for different time periods throughout the mission.

AO171 Experiment Tray Model

The AO171 experiment tray was modeled as a series of six surfaces with the scattering volume surrounding these surfaces as shown in Figure 5. Figure 6 shows the points where the flux to the surfaces was calculated. At these points the flux to both a horizontal and vertical surface was calculated for the different time periods on orbit. Outgassing rates were assigned based on mass loss measurements of some of the post flight samples averaged over time. The actual rate was not considered absolutely necessary for this study since relative differences around the tray were being looked for to explain the different observed discolorations.

Figure 7 shows the flux of atomic oxygen across the tray for flat surfaces. The shadowing of the oxygen by the tray lip is evident in the figure. Figure 8 shows the flux of outgassed products on flat surfaces. The outgassing sources for the six modeled sections of the tray were lumped together as the total outgas plot and separated out for the two tray sections that influenced the modeled point locations the most. See Figure 6 for locations of panels 2 and 5.

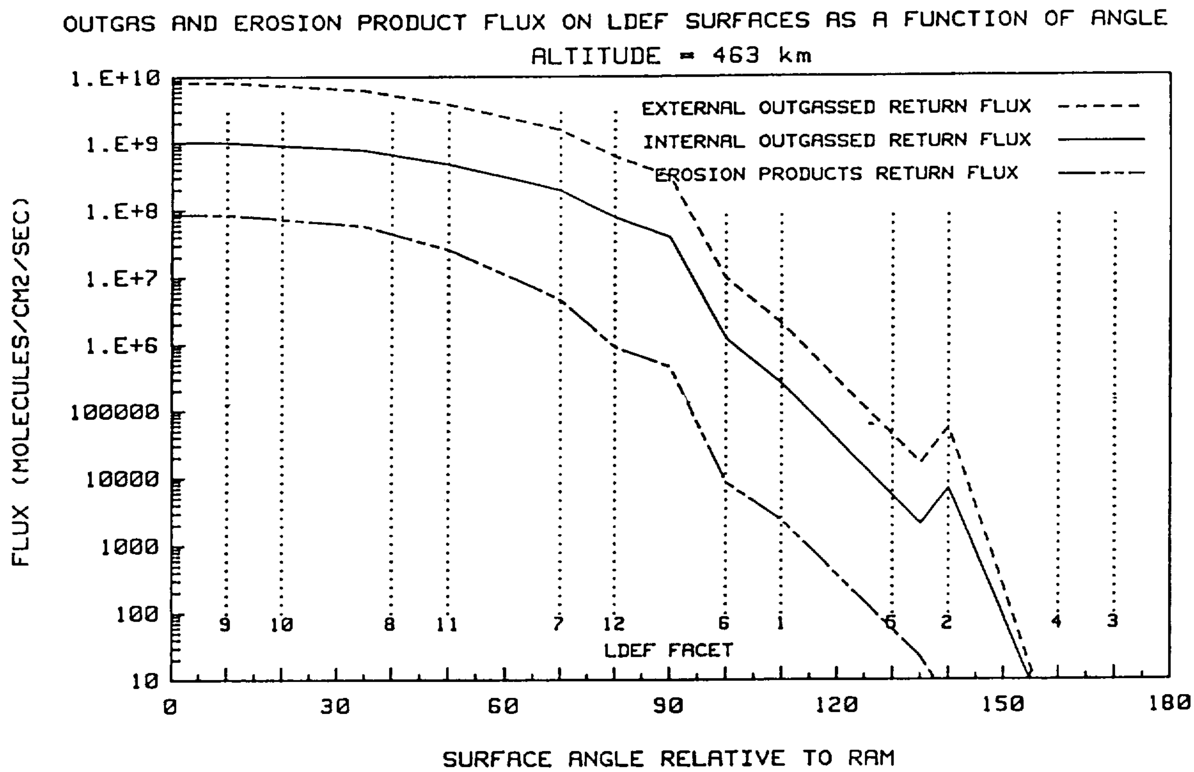

Figure 1. Results Using Old Scattering Algorithm

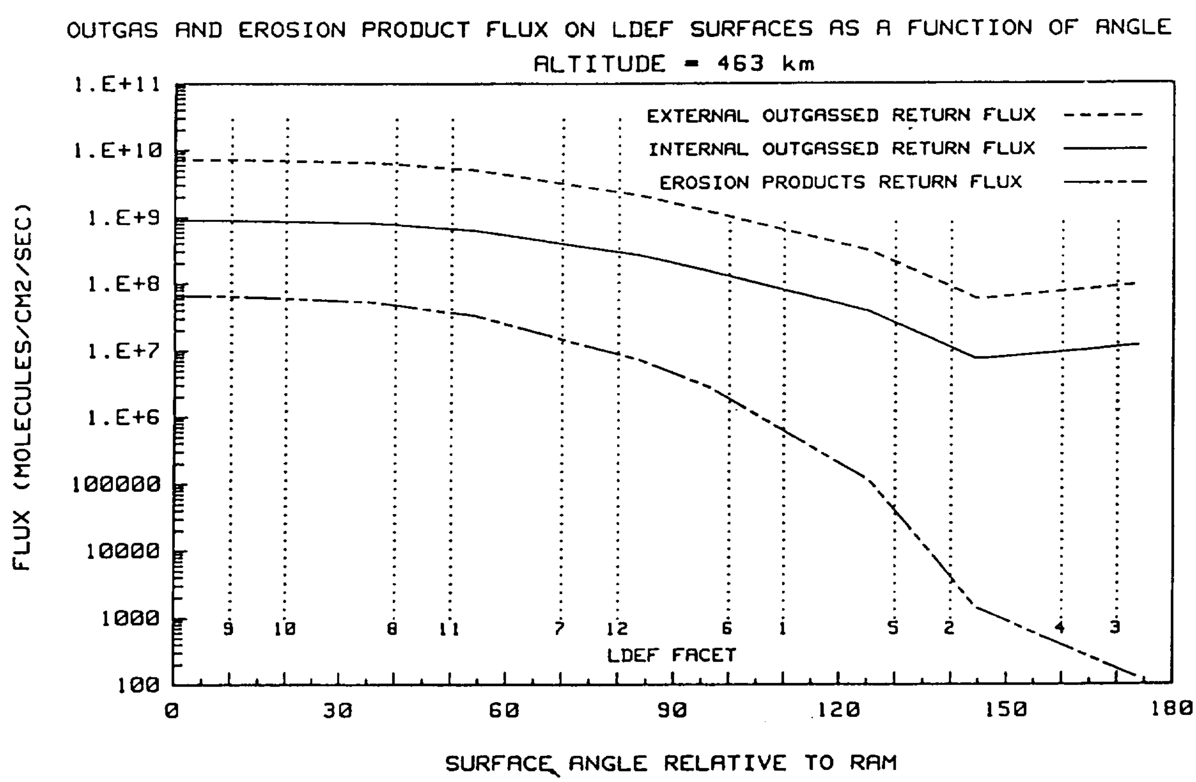

Figure 2. Results Using New Scattering Algorithm

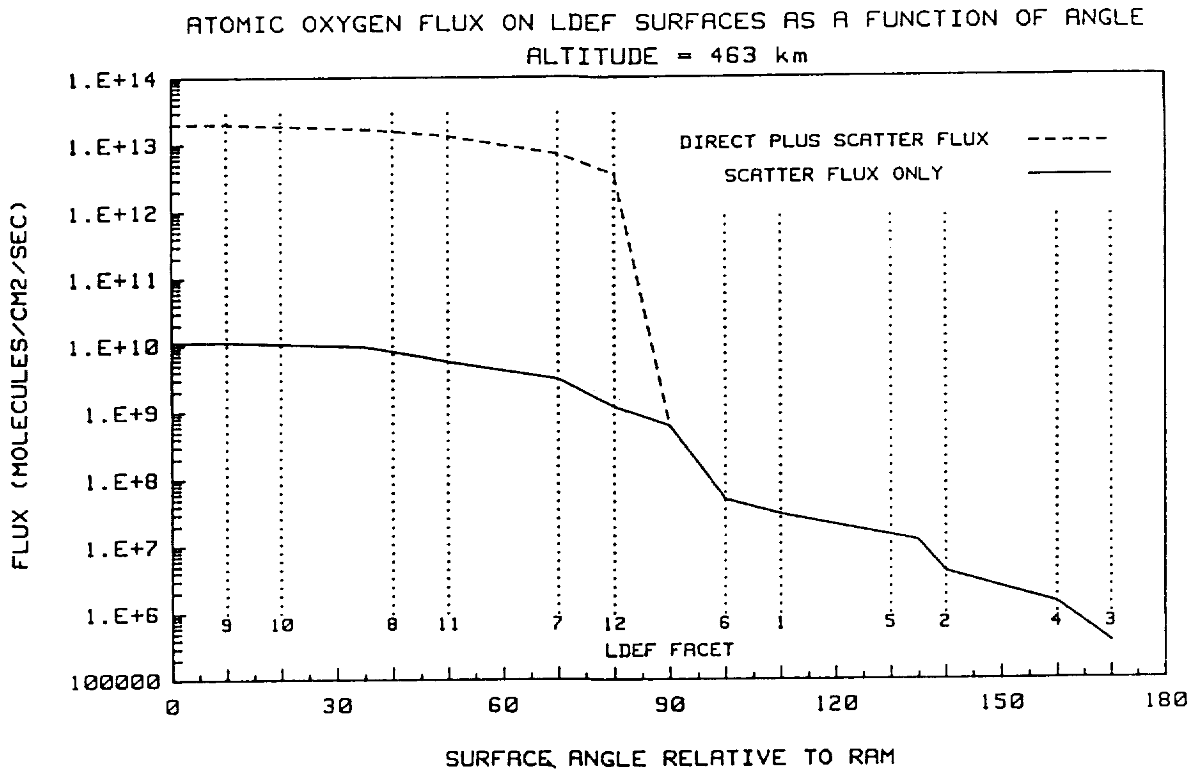

Figure 3. Results For AO Using Old Scattering Algorithm

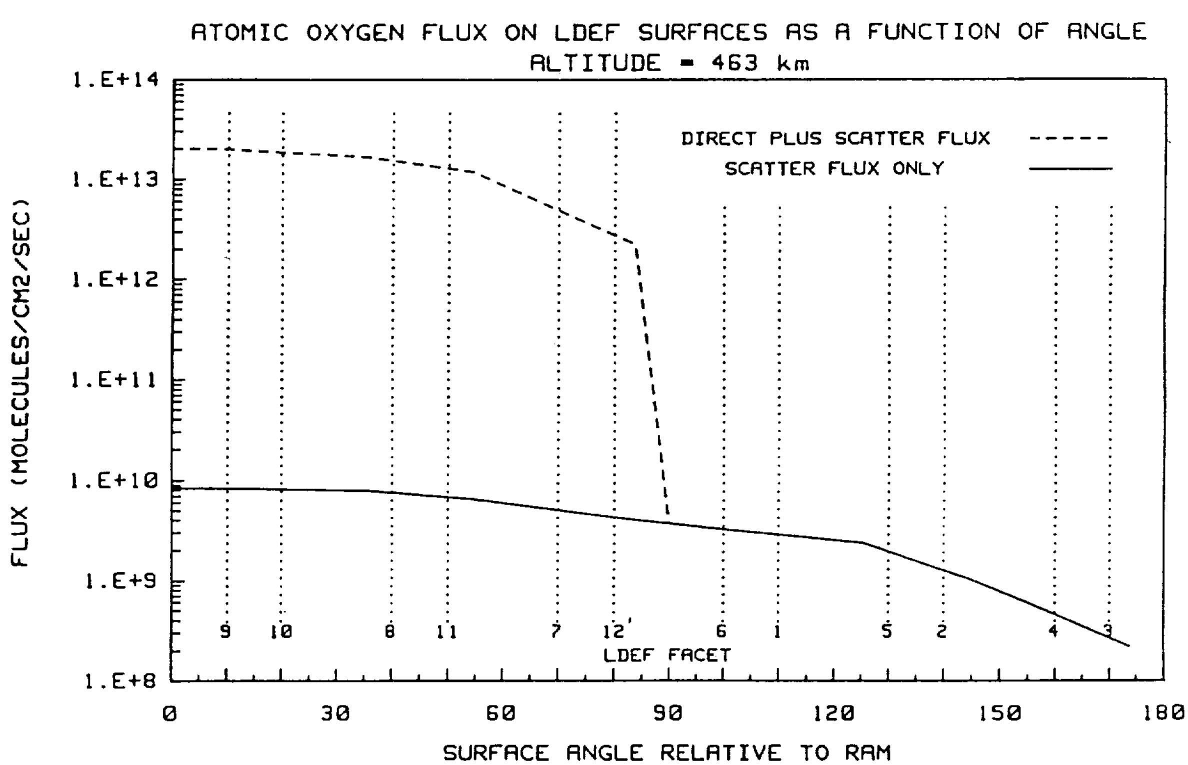

Figure 4. Results For AO Using New Scattering Algorithm

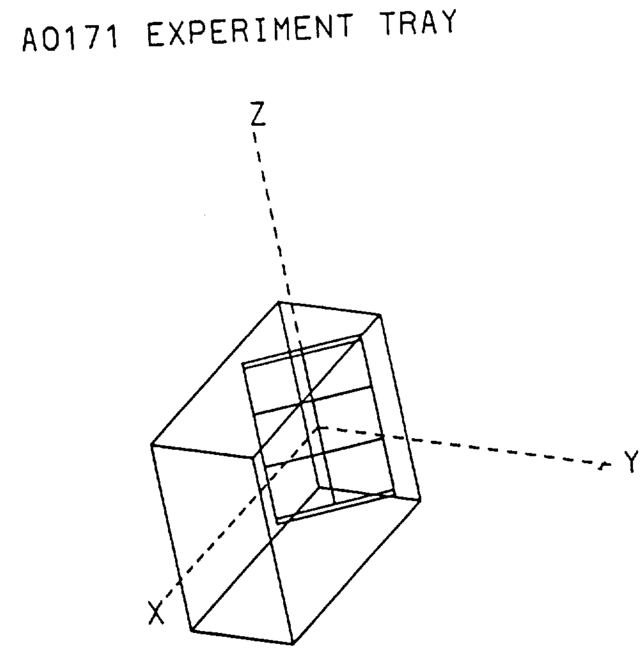

Figure 5. AO171 Experiment Tray Orientation

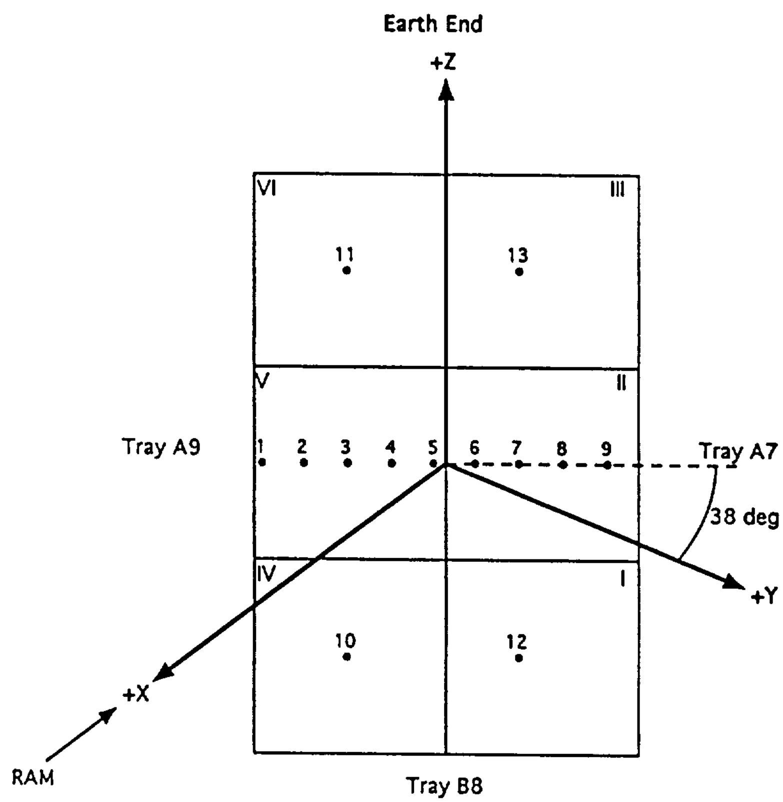

Figure 6. AO171 Model Flux Computation Points

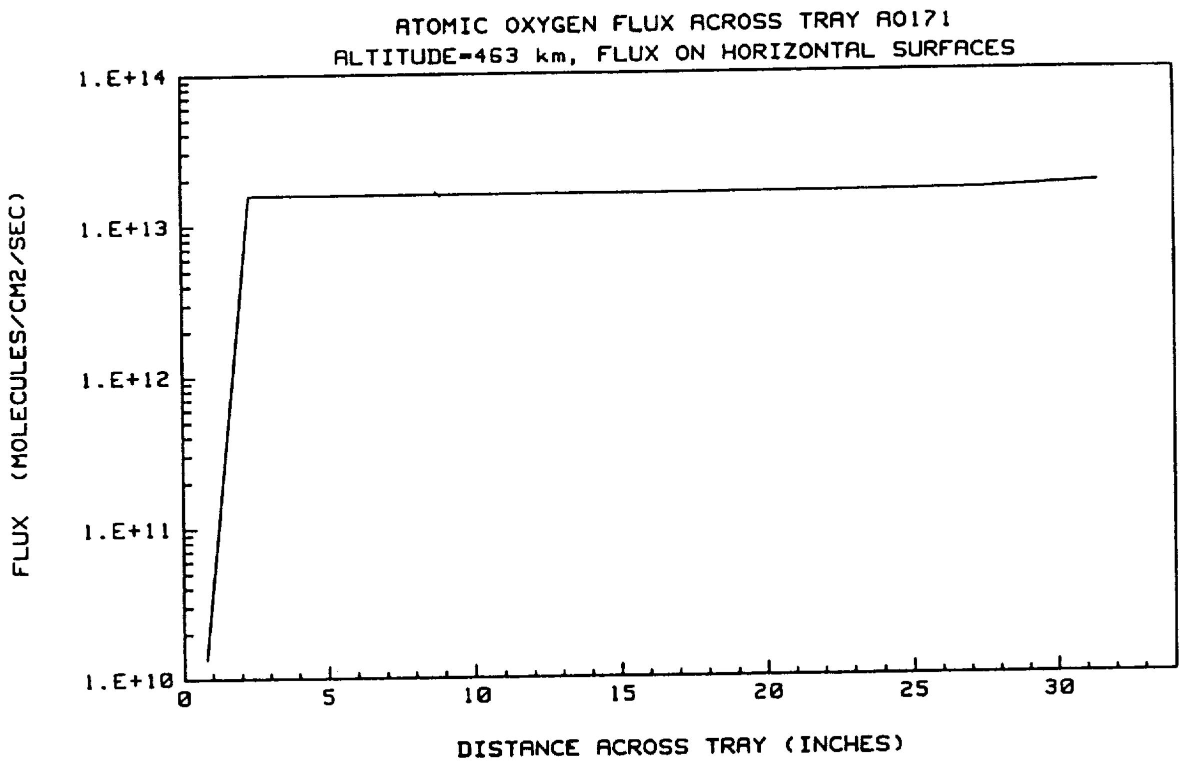

Figure 7. Atomic Oxygen Flux Across Tray

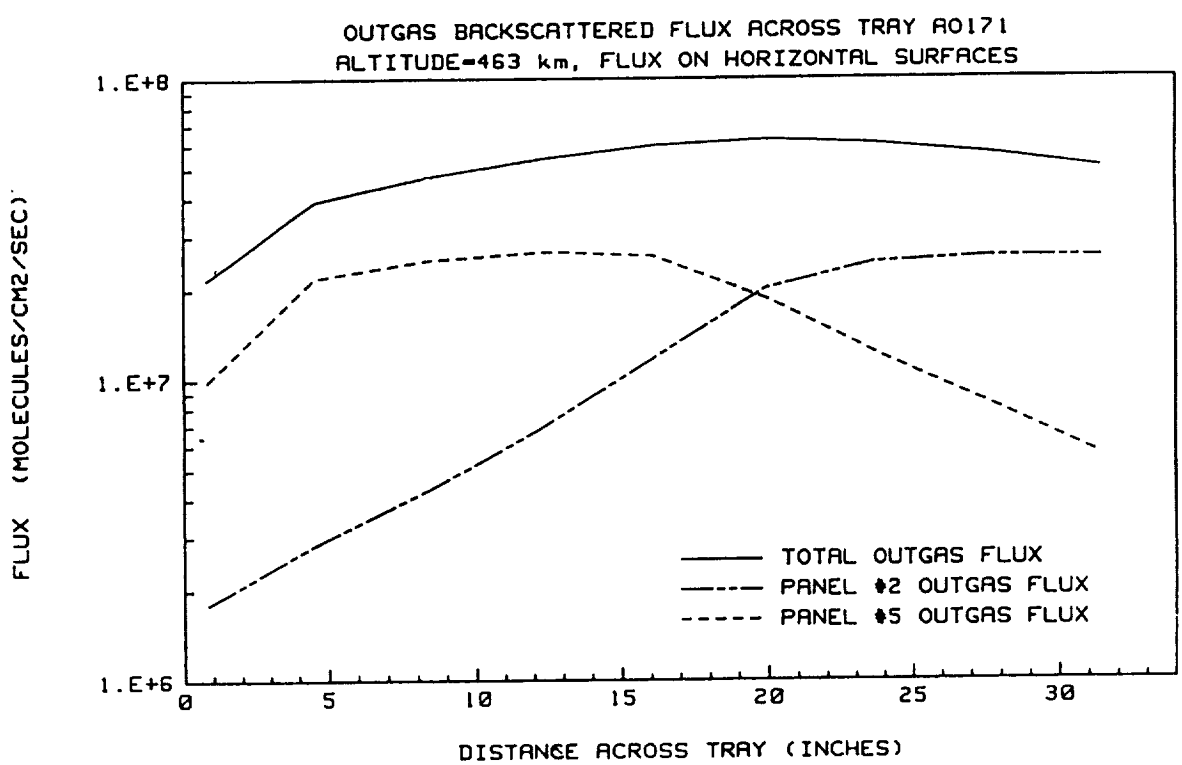

Figure 8. Outgas Backscatter Flux Across Tray

Micro Model

A micro model was utilized to develop fine detail around a sample that was on the tray. For this case a two inch by two inch by one quarter inch thick sample was used and was assigned the outgassing rates measured for RTV 511. It is mounted on a 4 x 4 inch square plate.The modeling volume for scattering was broken down into volumes less than a tenth of an inch in size. Figure 9 shows details of the geometry and the points to which the flux was calculated as a result of outgassing from the small sample and scattering interactions with the ambient. Figure 10 shows flux of atomic oxygen and outgassing downstream relative to the sample. The sharp rise in oxygen near 0.2 inches downstream is a result of shadowing by the sample. This is the region where discoloration is observed near samples on the tray.

CONCLUSIONS

From the results of the three models it appears that the flux of atomic oxygen correlates to the discolorations observed on the experiment. Darker discolorations received the highest atomic oxygen flux. Areas that should have received the same contaminant flux as the darker areas but no atomic oxygen, because of shadowing, were not discolored upon visual inspection.

The source of the contaminant is not clear at this time. The LDEF had outgassing occurring from external surfaces as well as outgassing from internal sources that leaked out and was scattered back to surfaces on the exterior. Similar discolorations were observed on interior surfaces that received atomic oxygen flux through openings to the exterior. This is further supported by the observation of heavy external discoloration near areas that received fluxes of internal outgassing through penetrations to the inside and simultaneous flux of atomic oxygen.

The overall LDEF model that was updated for this study shows that the scattered atomic oxygen flux on the wake surfaces was on the order of 10^{10} $cm^{-2}s^{-1}$ early in the mission while the flux of the ram surfaces was on the order of 10^{13} $cm^{-2}s^{-1}$. The flux of LDEF outgassing at 463 km was 10^8 to 10^9 in the wake region and 10^9 to 10^{10} $cm^{-2}s^{-1}$ on the ram side. Thus the AO scattered flux was comparable to the the scattered outgassed flux in the wake region at 463 km. At 333 km the AO flux was near 10^{15} $cm^{-2}s^{-1}$ on the ram side and 10^{10} $cm^{-2}s^{-1}$ on the wake surfaces. The outgassing scattered back to the surfaces was near 5×10^8 on the ram side and near 10^6 $cm^{-2}s^{-1}$ on the wake surfaces. The relative lower outgassing resulted from the drop in outgassing rates later in the mission.

The tray model showed that the return flux of contaminants to surfaces of the tray that originated from the tray were nearly the same.

The micro model of the nonmetallic sample showed that the atomic oxygen flux occurred about 0.2 inches downstream from the 0.25 inch thick sample. This kind of behavior was observed on the experiment where discolored areas appeared near the downstream side of the materials on the tray. Over the one inch downstream distance the outgas flux from the experiment varied over one order of magnitude.

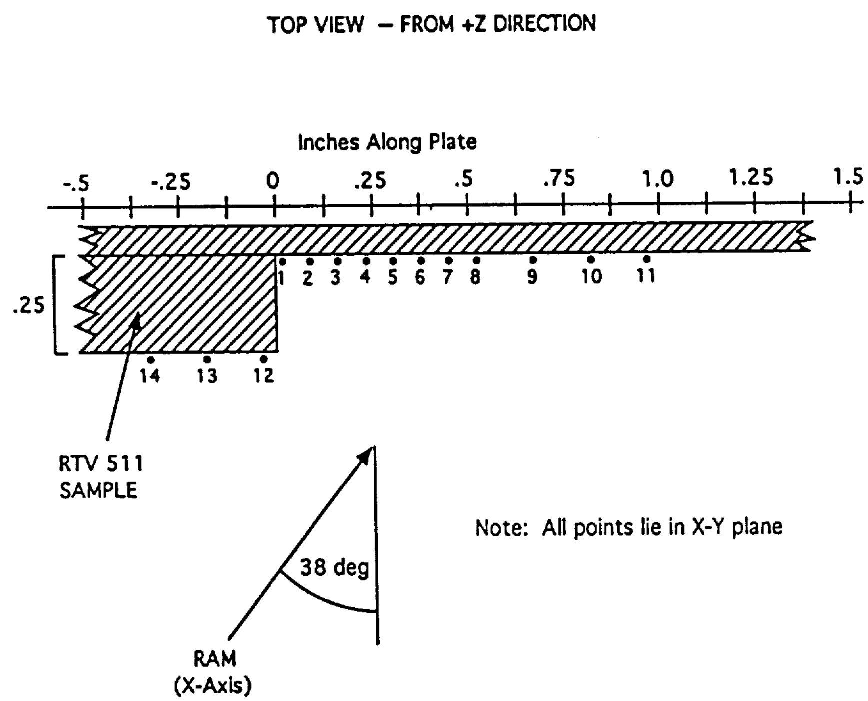

Figure 9. Micro Model Flux Computation Points

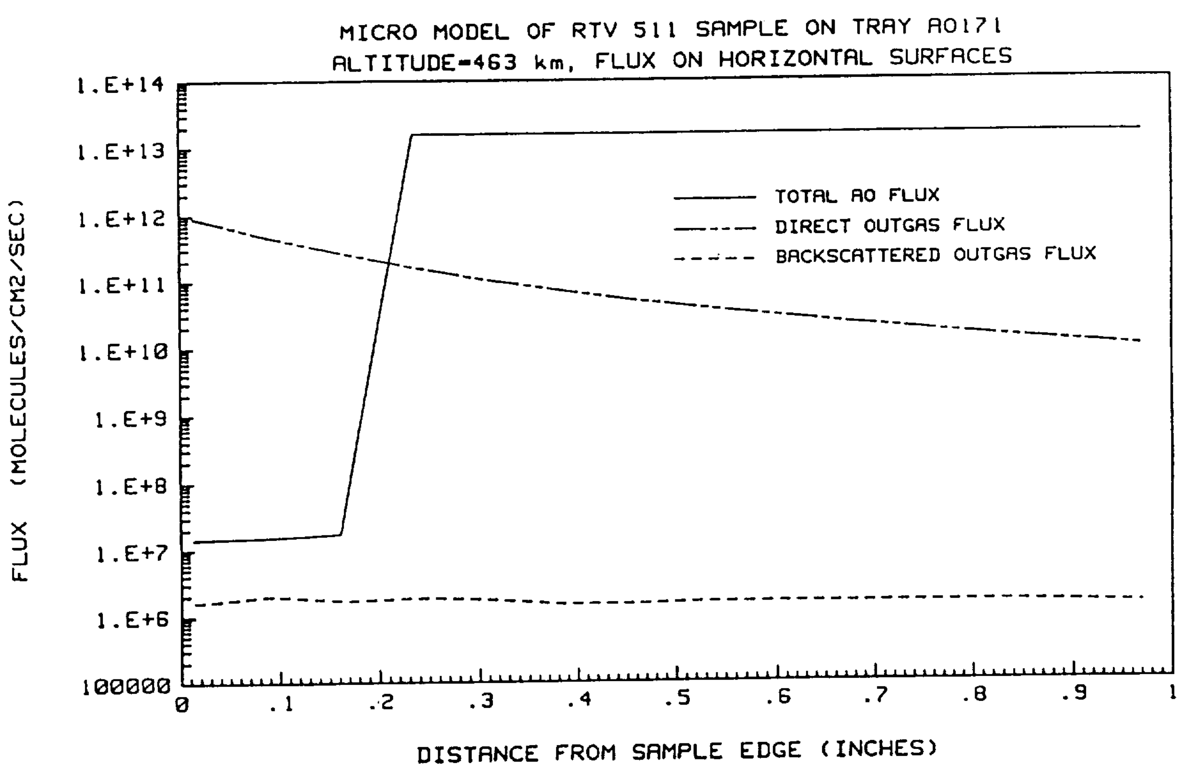

Figure 10. AO and Outgassing Flux

Because no large differences in deposition levels were predicted it is assumed that the pattern of discolorations observed on the experiment correspond to areas of high atomic oxygen flux that fixed the contaminants. Shadowing of the atomic oxygen flux, predicted by the models, corresponds to observations.

RECOMMENDATIONS

It is recommended that some additional modeling be performed to further determine the sources of contaminants. This would include modeling the openings to the interior at the corners of the tray and scattering them back to the surfaces on the tray. The scattering back to surfaces from the large gas cloud that surrounds LDEF can also be included in the tray model and the micro model. However, the flux direction from this large cloud should be very nearly the same as the flux direction of atomic oxygen since the oxygen is one of the prime scatterers of the contaminants.

REFERENCES

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2.Gordon, T.D., "Integrated Spacecraft Environments Model User's Guide. Version 5.1", Applied Science Technologies, AST 12.3B, April 1993.

3.Rantanen,R.O. and Gordon, T. D., "LDEF Contamination Modeling" Presented at LDEF Materials Workshop, 19 November 1991.

4.Rantanen, R.O. and Gordon, T. D., "LDEF Experiment AO171 Contamination Modeling", Final Report ROR-MSFC-1-93, 1 October 1993. Delivered to NASA, MSFC.