THE SHUTTLE GLOW:
A PROGRAM TO STUDY THE RAM-INDUCED PHENOMENA

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The ram-induced phenomena almost surely involve a number of different physical interactions whose study historically is of interest to different disciplines. At a minimum, aeronomy (or aerochemistry), surface physics and chemistry, and plasma physics are important, and to this one should probably add rarefied gas dynamics. Each of these specialties was represented at the second conference, although aeronomy predominated. The significance of several different mechanisms was evident to some investigators much earlier than this second conference in May 1985. Papadopoulos published hypotheses relating glow and observed plasma effects in 1983; Kofsky discussed both aerochemical and surface chemistry in the same year.

In January 1984, SAIC submitted a proposal to NASA Headquarters entitled "The Shuttle Glow: A Program to Determine the Physics of the Ram Induced Phenomena." This proposal was prepared by Papadopoulos, Kofsky, and Anderson, and included the following elements in a shuttle-based experiment:

- The use of a special flat generating surface >1 x 3 m on which the glow can be produced and observed. This surface will be maneuvered to vary the orientation of ram flow and of projected component of geomagnetic field.

- Remotely mounted optical instruments to view the glowing layer on the plate. By scanning, the variation of radiance as a function of wavelength and standoff distance from the plate will be observed looking parallel to the plate.

  - The optical instruments include a visible light photographic camera that has already been flown on shuttle and a scanning grating spectrometer in the visible. These might be supplemented by the Orbiter video system.

- In situ plasma diagnostic sensors mounted on and just above the plate to measure effects in the glowing layer and in the medium adjacent to it.

  - The plasma instruments include a neutral density gauge, a plasma density and temperature probe, an electric wave receiver, and an energetic electron detector to measure the flux striking the plate and moving in the volume just above it.

  - Three near-infrared photometers were included in this set of sensors looking normally outward from the plate.

- The preferred location of the generating plate and in situ diagnostics is on the end of the Remote Manipulator System (RMS) arm. We suggested that a three- or four-sided structure be used, carrying a different surface material on each side; aluminum, kapton, tiles, and other organics were suggested. Only one side would carry the in situ diagnostic suite. Portions of this one side could be electrically biased to alter plasma flow. In this configuration, the optical instruments would be mounted rigidly in the shuttle bay with all motion being accomplished by the RMS.

- An alternative configuration was suggested to avoid dependence on the RMS. The generating plate is hinged at one end to fold up out of the bay so that either of the two sides can be exposed to the ram flow. In this case, the optical instruments will be mounted on a pan-tilt head.

Subsequent to submission of this proposal the desirability of using the MSFC Hitchhiker was pointed out to us by NASA. A preliminary instrument layout was prepared in which the generating plate covers much of the top of the Hitchhiker structure, with the diagnostic sensors above and behind the plate and the optical sensors at the edge. The plate does not hinge, and so the shuttle must be maneuvered to vary ram flow. Increasing knowledge of the phenomena led us to enlarge the set of sensors as follows:

- Four UV photometers were added to cover wavelengths down to 1200 Å, including the O resonance lines that could be excited by electron impact.

- A cryogenic CVF infrared photometer was substituted for the infrared photometers, covering the wavelength range from 0.8 to 14 microns. This instrument will be provided by Carl Rice of the Aerospace Corporation.

- Energetic ion energy spectrometers were added complementing the electron sensors.

- The use of controlled gas releases was suggested as a way of determining the effect of varying the density and constituency of the local gas phase.

- A large carrousel was discussed to afford the capability of presenting four to six different samples to the ram flow.

Our objectives in carrying out this investigation are threefold:

- To observe the full range of ram-induced phenomena, bearing in mind those that are relevant to the Space Telescope and to other large systems. This includes not only photon emission, but the effects of bombarding dielectrics and other materials with energetic charged particles. Not only erosion, but charge implantation and microdischarges can result.

- To understand the full range of physical and chemical effects that result. It is likely that various mechanisms have different importance under different local conditions. For example, the plasma effects clearly occur. In some cases, they may dominate the production of glow. In other cases, they may be unimportant for glow but still significant for production of electrical noise, etc.

- To develop a predictive capability so that the magnitude of glow and the related effects can be calculated for any conditions. As a corollary, means to ameliorate the effects might be developed.

No formal response to our proposal has been received from NASA. Many of the experimental concepts that we suggested are now in general circulation. Their use is being planned in conjunction with existing NASA instrumentation. No dedicated instrument suite is being planned as yet. Now that NASA recognizes the interest and potential problem of the ram-induced phenomena, we look forward to participating in these investigations.