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B69 06077

SUBJECT: Radiation Protection for Apollo Missions - Case 340

DATE: June 25, 1969

FROM: R. H. Hilberg

ABSTRACT

The Space Physics Division at MSC has generated plans for the protection of astronauts from space radiation. Observations of particle storms occurring on the sun enable the SPD to give several hours warning on the dose exposure for the astronauts. These dose estimates have an uncertainty of less than an order of magnitude and decrease as particle data become available during an event. Some calculational techniques may warrant improvement however.

An emergency caused by man's increasing the particle fluxes trapped in the earth's magnetic field with a high altitude nuclear detonation has also been studied. However, one expects that the possibility of the occurrence of such an event is small.

If the projected dose approaches the Maximum Operational Dose, the relevant facts are sent to the flight surgeon. If this dose exceeds the MOD and the energetic particles causing the dose have been detected, the flight controller may institute a mission modification if one exists that can reduce the exposure significantly.

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MEMORANDUM FOR FILE

Introduction

The Space Physics Division (SPD) at the Manned Spacecraft Center supports the mission controllers of manned flights by advising them of the current and projected radiation situation. Since the systems used in gathering information have evolved considerably since the Mercury flights, I have reviewed the plans for SPD support for future Apollo missions, in particular those for the first lunar landing mission.

Information was gathered primarily through recent discussions with SPD personnel. The plans are described in Reference 1, and a more detailed description is given in Reference 2, which is not readily available. Background information on solar forecasting is given in Reference 3.

The dose that can be expected under normal conditions is calculated before the mission. Significant deviations from the nominal dose can cause undue risk to the crew. The purpose of the Space Environment Console staff is to warn mission controllers of danger in case they can modify the mission to reduce the dose exposure. The SEC is the focus of the data handling operationally and will be the focus in this memorandum.

Sources of Data

The radiation instruments on board the spacecraft provide the data with highest priority. In order to enable one to project dose rates, the observed dose rates are supplemented by extensive data dealing with solar activity and high altitude nuclear bursts. The data sources are described in Reference 1 and 2.

The spacecraft radiation detectors consist of the Nuclear Particle Detection System, the Van Allen Belt Dosimeter, three Personal Radiation Dosimeters, and a portable Radiation Survey Meter. Each astronaut also carries four (4) passive packages which can be read out after return to earth.

Some of the characteristics of the detectors and their data are shown in Table 1. The NPDS and VABD data are

telemetered to the ground and are available almost continually. PRD and RSM data are available when read out by the astronauts, normally twice a day.

MSC operates Solar Particle Alert Network stations at Houston, Texas; Carnarvon, Australia; and Canary Islands. Each station monitors solar emissions of 1495 MH_z, 2695 MH_z, and 4995 MH_z radio noise and 6562.79 Angstron (Hα) optical flares.

The SPD has shown that a strong correlation exists between radio noise bursts, in the range measured, and the total number of protons emitted in a solar storm (Reference 3). Specifically, acceptable regression fits of the form log (Total number of protons) = a + b log (Radio energy) have been made. Similar fits have been made with peak radio flux instead of total radio energy with greater uncertainty.

The optical parameters observed, plage area and brightness, and flare area and duration, are used for background information as they improve estimates of event size only slightly (Reference 3).

The Environmental Sciences Services Administration provides three types of support to MSC. They operate Hα telescopes at Boulder, Colorado, and Culgoora, Australia, reporting data to MSC directly. They operate the Solar Proton Monitoring System which observes effects produced by energetic particles in the polar regions. They supply the reports from their Space Disturbance Forecast Center to MSC including optical data similar to that recorded on SPAN and some additional activity analysis.

The Unites States Air Force's Air Weather Service provides reports of solar conditions and forecasts of activity similar in nature to the data provided by SDFC. The AWS also has agreed to operate Hα telescopes at Hawaii and Teheran, Iran. However, in the two years since they received the telescope, they have not yet installed the station in Hawaii.

The SPD has also arranged to receive particle flux data from the Vela Hotel satellites, as well as the Pioneer 7, 8, and 9 spacecraft. These data will be obtained as required rather than on a regular basis. They consist of particle flux measurements near earth and at various positions around the sun.

The Joint Atomic Energy Intelligence Center warns the SEC staff if there is a high altitude nuclear detonation. The location and size of the event should be available for SPD analysis. MSC also operates two low latitude riometer stations

to provide data on augmentation of the trapped radiation belts. Since this system duplicates DOD data which should be available through JAEIC, they may not be needed.

Operational Use of the Data

The SEC receives three status reports per day from each SPAN station. The SDFC and SFC also send regular forecasts and status reports.

If a SPAN station observes rf noise or an optical flare larger than established thresholds, reports are sent to the SEC by telephone and teletype. If the event seems significant, the SEC can request a paper tape containing the rf burst profile. Activity reports from SDFC and SFC will also advise the SEC staff of exceptional solar activity.

In the event of an important solar storm, the peak radio intensity yields a rough estimate of the total event size. If any danger seems possible, more complete data from the paper tape is compared with the events of the 19th solar cycle by means of a regression analysis. The data available (radio, optical and particulate) are used sequentially to predict total event dose and the associated standard deviation. The details of these calculations are under study since considering additional parameters does not necessarily improve the accuracy of the estimates.

The radio frequency data are available about an hour after the burst and computation results from the Auxiliary Computer Facility about an hour later. By this time, particle data from the spacecraft or one of the reporting satellites are available, and there is no significant false alarm problem. Rough dose estimates can be obtained more quickly with a leased computer arrangement if the ACF is tied up or by means of a slide-rule system.

The other cause for concern is filling magnetic field lines surrounding Earth with energetic charged particles by means of a high altitude nuclear detonation. The information supplied by the JAEIC should enable the SPD to calculate rough dose projections for specified mission profiles.

The calculations based on all relevant available data will be treated in one of two ways. If the expected dose is a significant fraction of the dose limits,* the SEC operator

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*The dose limits are described in Reference 4 and were derived on the basis of protection against specific short-term effects.

will report the available facts to the flight surgeon. If not, no warning will be given.

In the event that such a warning is given, a mission modification will be ordered only if certain criteria are met:

1. The expected dose will exceed the Maximum Operational Dose limit. This limit is permitted to change with the phase of the mission so that the controller has some freedom for judgement.

2. The energetic particles producing the dose must be observed directly, preferably by the onboard instrumentation.

3. A mission modification is available which will reduce the dose exposure. For example, the lunar stay, during which there is little shielding for the astronauts, may be cut short by returning astronauts to the protection of the command module.

Conclusions

The information on space radiation available at the SEC is as complete as the state-of-the-art permits.

The treatment of the optical and rf SPAN parameters by regression analysis may require further refinement. Ideally, using more parameters should improve the answer, but in practice this is not always the case.

The overall system is working very much as planned. However, the USAF-AWS support that was expected in return for two solar telescopes has not been forthcoming. The lack of mission support from the Hawaii Observatory leaves a significant gap in the SPAN coverage of the sun.

Acknowledgements

I would like to thank the personnel of the Space Physics Division for their help in providing much of the information contained in this memorandum.

Robert H Hilberg

1011-RHH-dly R. H. Hilberg

Attachment
References
Table I

REFERENCES

1. "Space Environment Operations Plan," FC043, 10-1-68; prepared by FOD/MSC.

2. "Space Environment Console Handbook," FC035, 9-23-68; prepared by FCD/MSC.

3. Gonzalez and Divita, "Solar Proton Forecast System and Procedures Used During the Mariner V Mission," JPL Technical Report 32-1303, 10-1-68.

4. Memorandum DD to FA "Radiation Levels for Apollo Crew Members AS-503", 3-1-67.

TABLE I

SYSTEM	READOUT	DATA
NPDS	Telemetered to MSC	Proton and alpha particle fluxes in 4 proton energy channels and 3 alpha particle energy chanels [number/cm^2-s in energy interval] Displayed on Console
VABD	Telemetered to MSC	Dose Rate [rad/hr] Displayed on Console
PRD	Visual Readout by Astronaut	Dose [rad]
RSM	Visual Readout by Astronaut	Dose Rate [rad/hr]

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