SECTION 24. CONCLUSIONS

The effects of space radiation on electronic devices, especially those on LSI devices and optics, provide the engineer with a complex problem. This document is a manual which specifically addresses the engineering problem and some of its management aspects. Summary graphs, tables and calculation methods are presented which are intended to help spacecraft designers to gauge the significance of the space radiation problem from their particular point of view and then to communicate this problem to management.

Descriptions of the environment, effects and possible solutions have been couched, as far as possible, in simple language. Much of the graphical material is original to ESA and gives comparisons of data from several publications or unpublished data. In all areas, improvements in analytical methods have been sought. Some difficult questions of transmission of electrons and protons into electronic boxes have been clarified and approximate methods for calculating dose-depth curves are given. The method is useful for preliminary investigations, but computer approaches are recommended for detailed equipment design.

"Dose-depth" curves for orbits of importance ("reference missions") are compared. A simple example of a geometrical sector analysis for one mission is given. In view of the importance of its use in telecommunications, the geostationary Earth orbit (GEO), is given special attention. Because of the development of manned space stations, low Earth orbits (LEO) are also of increasing interest.

The problem of predicting the responses of advanced electronic devices to radiation is a challenging one because the device physics involved is complex and the field is in continual development. During the preparation of this handbook, existing methods have been reviewed and new ones developed, e.g. the Simple Engineering Model for MOS devices. The designer must have the design tools that allow him the choice of circuit alteration, added shielding or the premium cost on hardened devices. By force of circumstances, designers will have to use many devices that are probably only available in "unhardened form". Thus, the sections on procurement, radiation test procedures and project aspects will be useful to system engineers and management.

Looking forward, a more formal interaction with projects is sought. Considering the rapid developments in aerospace and semiconductor technology, ESA is encouraging forward-looking research in this field.

New trends in space include the use of space stations, increased use of on-board data processing and sensors and the great increase in complexity of integrated circuits. It is hoped that by outlining the present state of radiation effects analysis techniques and the provision of guidelines, this handbook will lead to enhancement of the efficiency of European and international space project systems.