

ENVIRONET: ON-LINE INFORMATION FOR LDEF

Michael Lauriente

NASA Goddard Space Flight Center

Code 420

Greenbelt, MD 20771-0001

Phone: 301/286-5690, Fax: 301/286-5198

ABSTRACT

EnviroNET is an on-line, free-form database intended to provide a centralized repository for a wide range of technical information on environmentally induced interactions of use to Space Shuttle customers and spacecraft designers. It provides a user-friendly, menu-driven format on networks that are connected globally and is available twenty-four hours a day — every day. The information, updated regularly, includes expository text, tabular numerical data, charts and graphs, and models. The system pools space data collected over the years by NASA, USAF, other government research facilities, industry, universities, and the European Space Agency. The models accept parameter input from the user, then calculate and display the derived values corresponding to that input. In addition to the archive, interactive graphics programs are also available on space debris, the neutral atmosphere, radiation, magnetic fields, and the ionosphere. A user-friendly, informative interface is standard for all the models and includes a pop-up help window with information on inputs, outputs and caveats. The system will eventually simplify mission analysis with analytical tools and deliver solutions for computationally intense graphical applications to do "What if..." scenarios. A proposed plan for developing a repository of information from the Long Duration Exposure Facility (LDEF) for a user group concludes the presentation.

INTRODUCTION

LDEF is an example of a highly cost effective experiment whose results will provide a major contribution to the design of spacecraft operating in Low Earth Orbits (LEO). Knowledge of the operating environments is important to the prevention of anomalies in the operation of spacecraft. After all the results have been analyzed and verified, EnviroNET would like to be considered as a centralized repository for technical information on environmentally induced interactions likely to be encountered in the LDEF orbit. These results will enhance the value of text that is presently available on other orbits. Features such as a user-friendly, menu-driven format on networks connected globally, available twenty-four hours a day will assist engineers and scientists in the retrieval and acquisition of this valuable information. This data will supplement the data

collected over the years by NASA, USAF, other government research facilities, industry, universities, and the European Space Agency. This information, updated regularly, contains text, tables, and over one hundred high resolution figures and graphs based on empirical data.

The topics, shown in Figure 1, act like files containing information on the space environment. Topic titles evolved from the Space Shuttle's concerns. Information emerging from LDEF should fit neatly into these topics. Text on space debris/meteoroids is considered a natural environment subject, as is text on the ionizing radiation environment. Finding specific information, however, is not solely dependent on knowing under which topic it has been filed. Searches of the entire database are possible using a key word search function.

- **Introduction**
- **Thermal and Humidity**
- **Vibration and Acoustics**
- **Electromagnetic Interference**
- **Loads and Low Frequency Dynamics**
- **Microbial and Toxic Contaminants**
- **Molecular Contamination**
- **Natural Environment**
- **Orbiter Motion**
- **Particulate Environment**
- **Surface Interactions**
- **Interactive Graphics Facility**

Figure 1. Current Topics.

A Working Group, Figure 2, is proposed to handle the task of developing the results of LDEF suitable for insertion into the EnviroNET library. A good deal of the groundwork has already been done. The User Panel has yet to be organized, but the Information Management Panel is provided by the staff of EnviroNET.

Figure 3 is a chart of the Natural and Induced Environments Panel. The Natural Environment Panel would include space debris/meteoroids and ionizing radiation. For LDEF it may be desirable to make modifications to the types of sub-panels. The purpose of the panel is to make assessments of reliability and traceability of data.

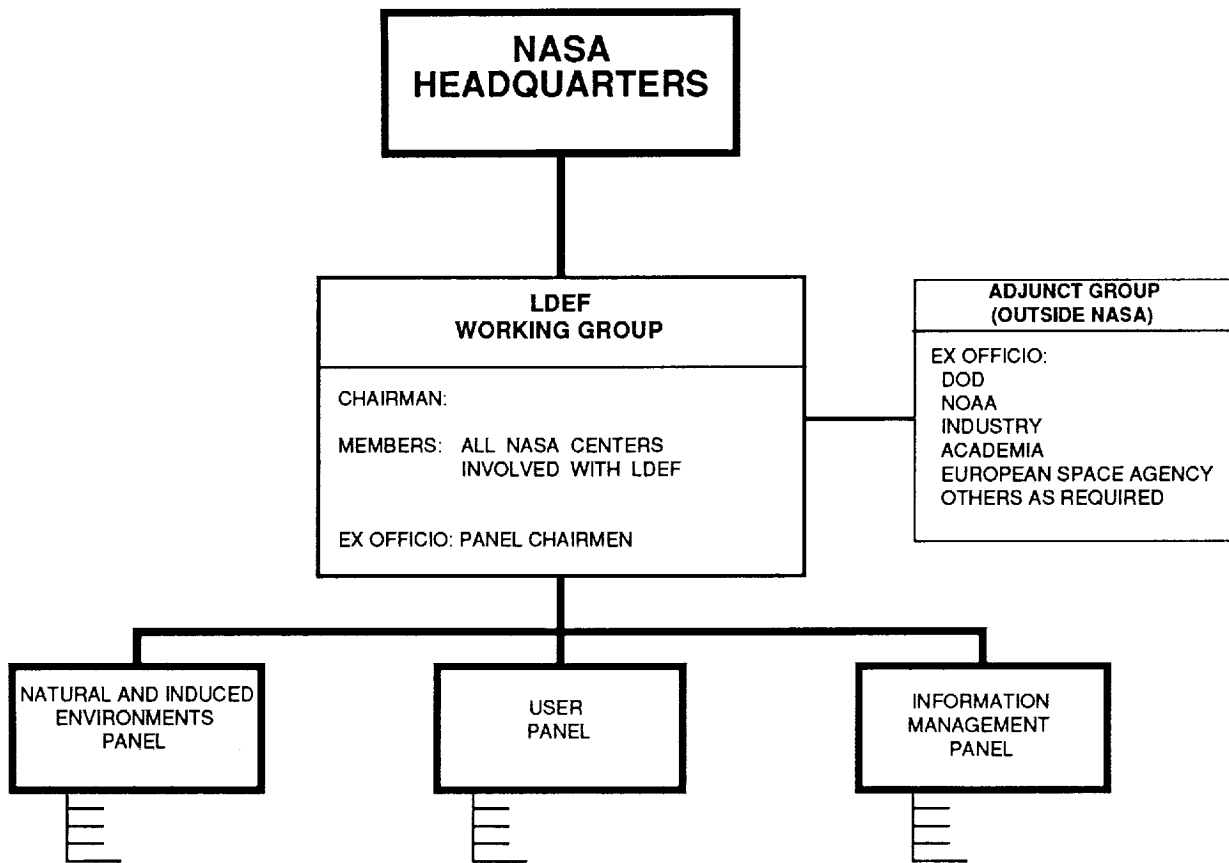


Figure 2. LDEF Working Group.

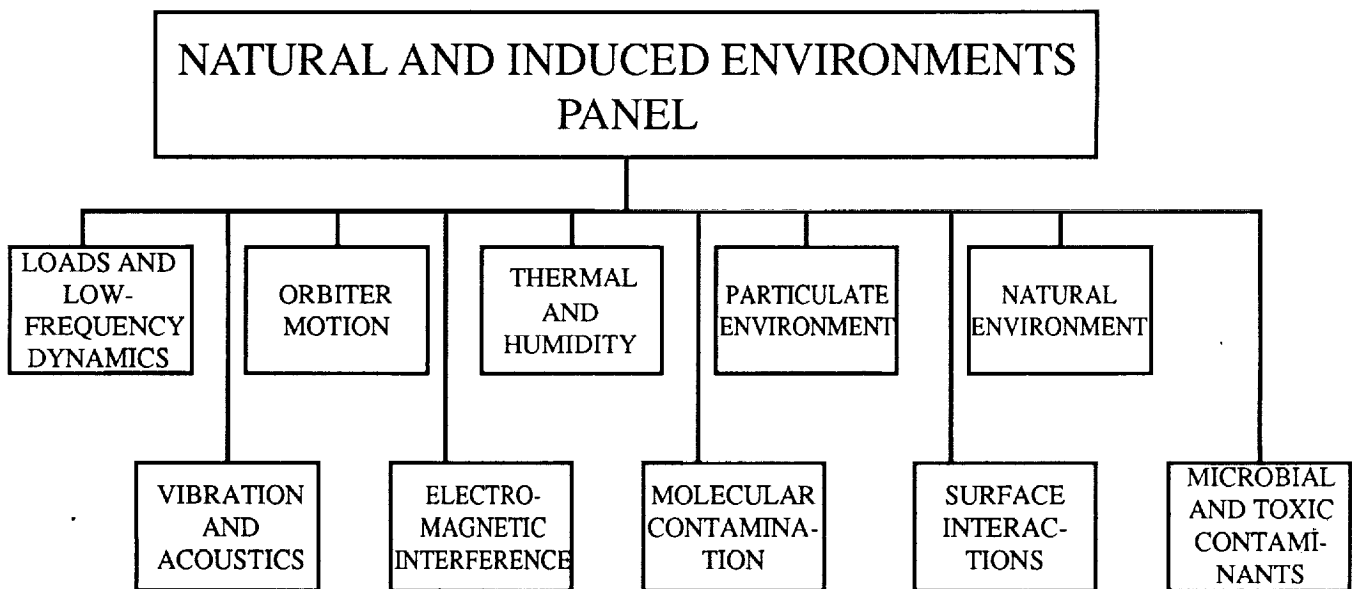


Figure 3. Natural and Induced Environments Panel.

ENVIRONET'S INTERACTIVE GRAPHICS AND MODELING

The implementation of on-line, simplified computational models in the EnviroNET database was strongly recommended by many EnviroNET users. A review of published prediction models indicated that selective computational models could be sufficiently simplified to meet the user-friendly requirement of the EnviroNET database. The scope of the interactive models is shown in Figure 4.

EnviroNET models provide a readily accessible method to do quick accurate calculations. These models encompass many important environments for engineers. A user-friendly informative interface is standard and all models have a pop-up help window which gives more information on inputs, outputs and caveats. Figure 5 is an example of a model help window for the International Geomagnetic Reference Field (IGRF) model¹. These models, based on data from satellites which orbit the earth in the thermospheric and exospheric regions of the atmosphere, will benefit from the LDEF data.

Use of the models has been simplified by providing outputs in a tabular form which can be viewed directly on the user's screen. In addition the data is available in file format for downloading or for plotting using EnviroNET's interactive graphics feature. Orbit dosage programs are designed to allow the user to analyze the radiation dosage for a given orbital configuration or to predict densities and temperatures encountered along a given orbit.

Figure 6 is an example of a user-friendly model for space debris². The Orbital Debris Model provides essential data needed for risk assessment; it is widely used to predict current and future debris environments. A provision to make order-of-magnitude estimates of collision probabilities is being developed. The input parameters are on the left and input ranges on the right. After the computer is asked to run the model, the output appears in a pop-up window.

- **Mass Spectrometer Incoherent Scatter Model (MSIS-86)**
- **MSIS-E (Altitude Extended version of MSIS)**
- **Marshall Engineering Thermosphere Model (MET)**
- **International Reference Ionosphere Model (IRI)**
- **International Geomagnetic Reference Field Model (IGRF)**
- **Radbelt Model**
- **Energetic Particles Model**
- **Cosmic Ray Effects on Microelectronics Model (CREME)**
- **Orbital Debris Model**
- **Meteoroid Model**
- **Orbital Decay Model**
- **Thermal Analysis Tool**
- **F10.7 Solar Flux Model**
- **Mars Neutral Atmosphere Model**

Figure 4. Scope of Interactive Models.

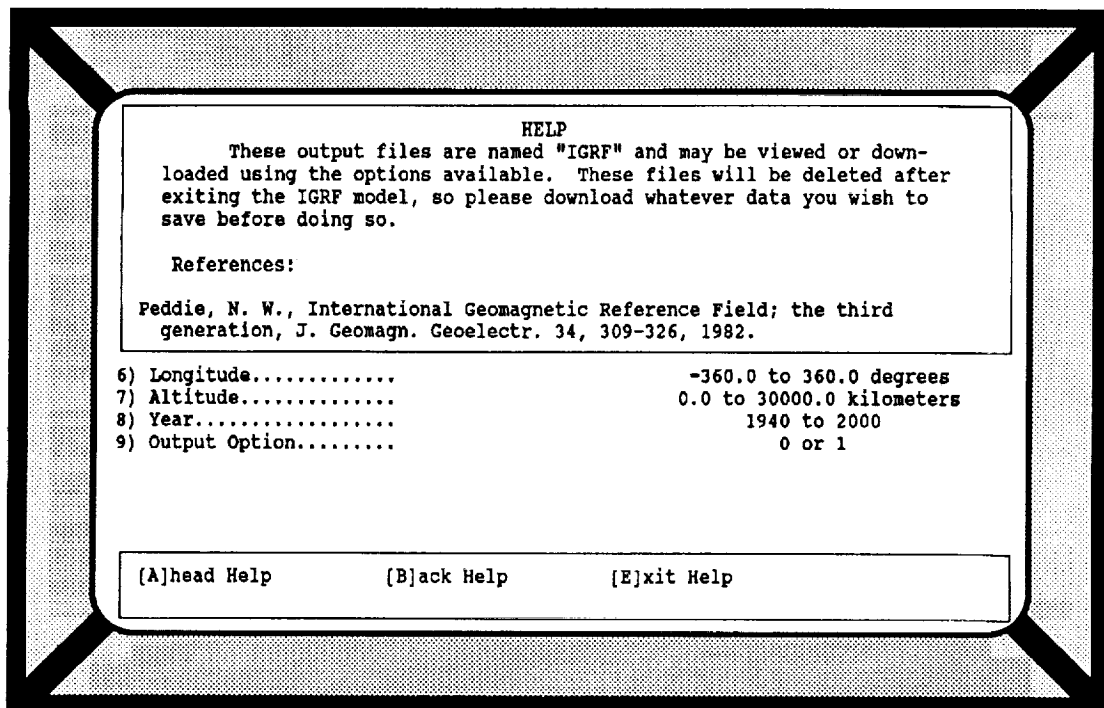


Figure 5. Help Window from the IGRF Model.

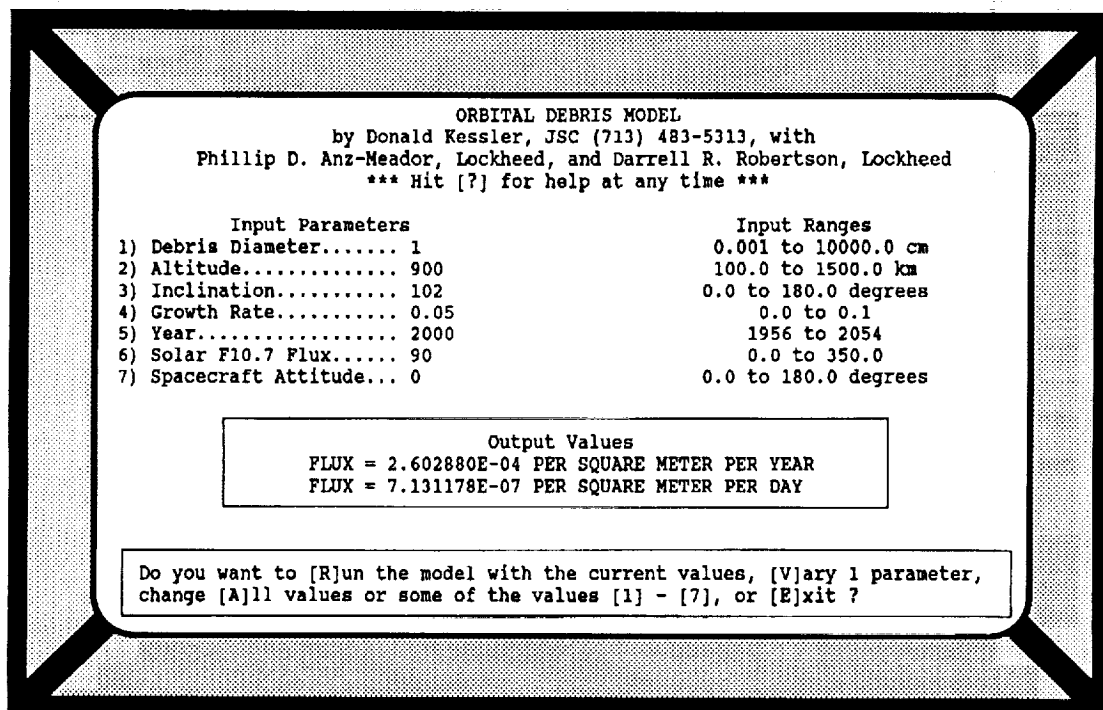


Figure 6. User-friendly Orbital Debris Model.

The system allows plotting of output versus any input parameter. By varying parameters within a model, "What if..." scenarios, as shown in Figure 7, can be graphically depicted on a remote user's computer screen. Graphs are generated using Interactive Data Language (IDL), a commonly used commercial package, which can be viewed on any terminal using Tektronix emulation.

Figure 8 is an example of a user-friendly interface for the Mass Spectrometer Incoherent Scatter (MSIS-86) Model³. MSIS is the standard empirical neutral atmosphere model. Output of temperatures and densities of atmospheric constituents, including atomic oxygen, are displayed in a clear, concise format on the screen. As shown below, by integrating over a specified orbit, mission fluences are easily calculated. Such information would be valuable for drag calculations or for calculating erosion due to atomic oxygen.

Environmental scientists can even map the atmosphere in spatial dimensions. Affordable tools now make it feasible to provide graphical representation to the scientific data. C programming is used to deliver computationally intense graphical representations. Figure 9 is an example of a surface plot superimposed over a topographic plot from the output of the MSIS-86 model. Day of the year is along the x-axis, latitude along the y-axis, and density along the z-axis.

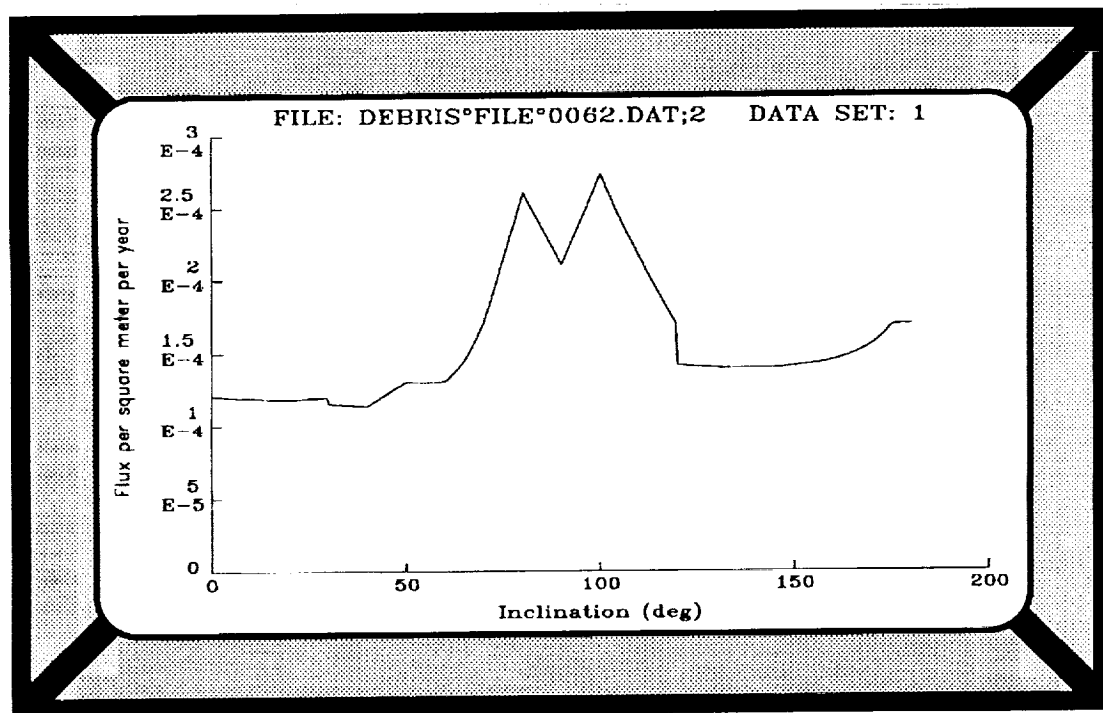


Figure 7. Plot from the Orbital Debris Model.

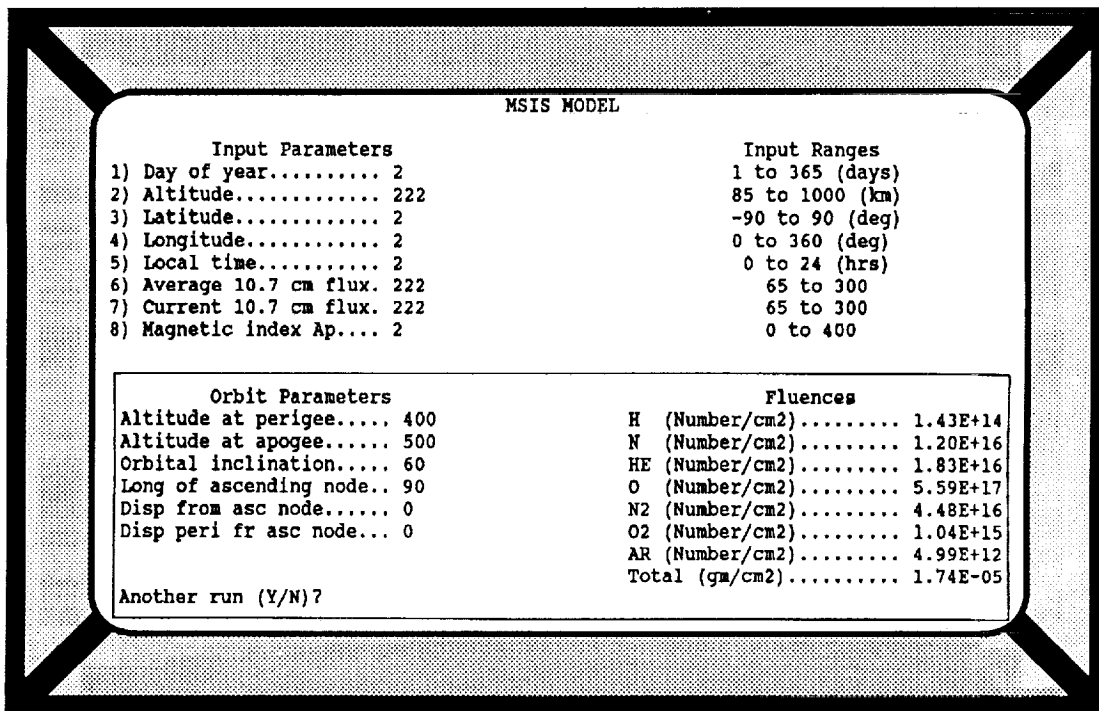


Figure 8. MSIS Model output showing orbital fluence of species.

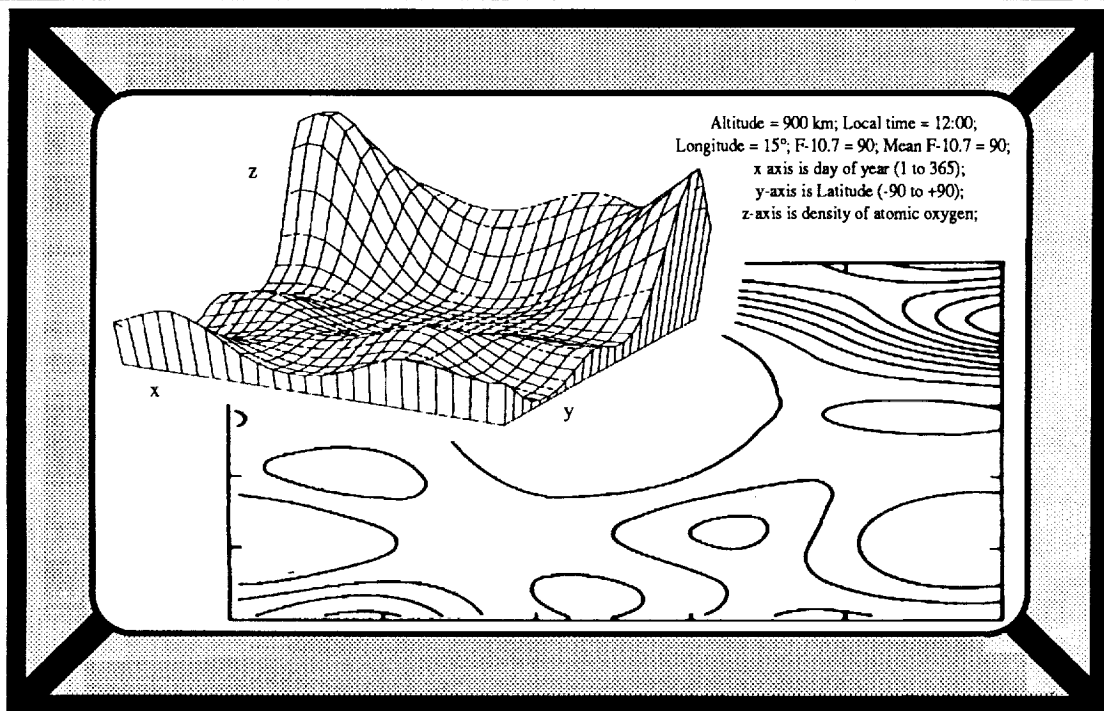


Figure 9. Sample output graphic from MSIS Model.

Figure 10 is an example of the Cosmic Ray Effects on Microelectronics (CREME) model. A prime use of the model is the calculation of the linear energy transfer (LET) spectra for a number of elements and range of densities for any orbit. This information, when used in conjunction with electronic part information, can be used to calculate the single-event upset (SEU) rate of the component. The model includes effects of solar flares, geomagnetic cutoff, and trapped protons.

Figure 11 is a review of EnviroNET's main menu. The aforementioned models fall under the Interactive Modeling Function. The Browse text retrieval system allows the user to literally "browse" through the textual library of EnviroNET. All written information is transportable, including graphics. The mail system, one of EnviroNET's sources of user feedback, has played a major role in improvements that have been implemented. Other features are the modeling function, message service, and bulletin notices. The systems manager, upon request, can establish an exclusive account for LDEF so that its constituents can have their own e-mail service.

Figure 12 shows the text as it is displayed on the screen by the Browse system. The window on the bottom gives the menu for performing actions within Browse such as paging forward and backward, dog-earing pages, searching the text topically by key word, or switching to the table of contents or index. The text often includes references to graphics which are separated into separate files in order to shorten the time required for downloading the text. Figure 13 is a sample screen presentation of the bit map graphics.

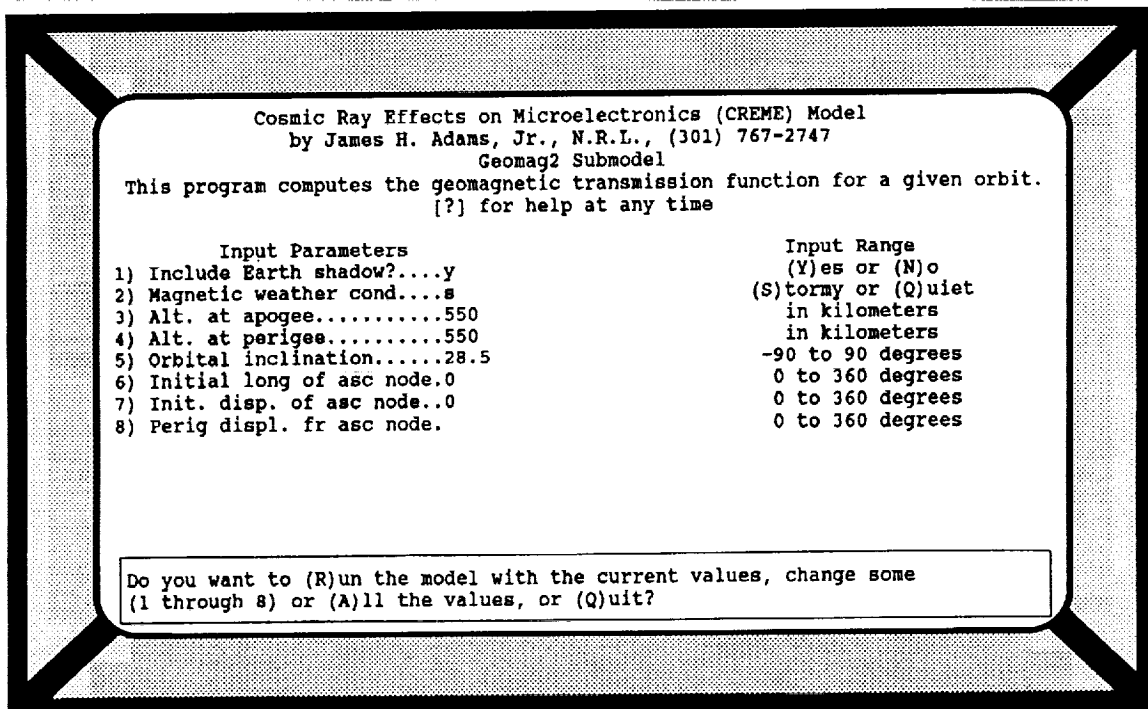


Figure 10. CREME Model.

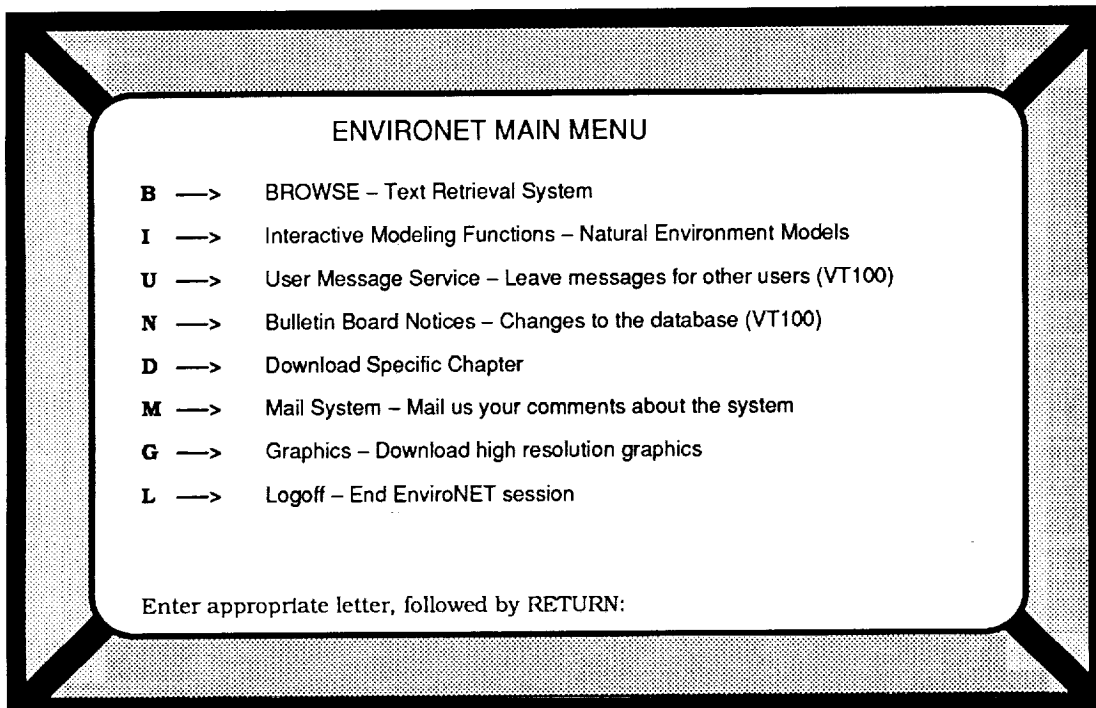


Figure 11. EnviroNET main menu.

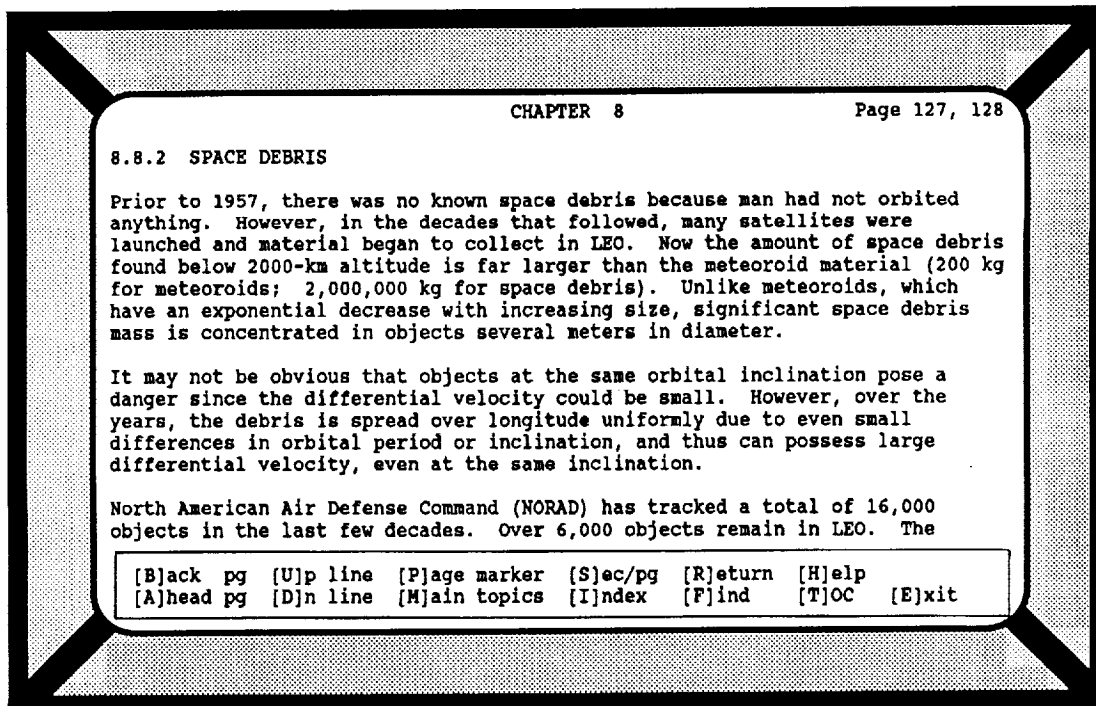


Figure 12. Browse text retrieval sub-system.

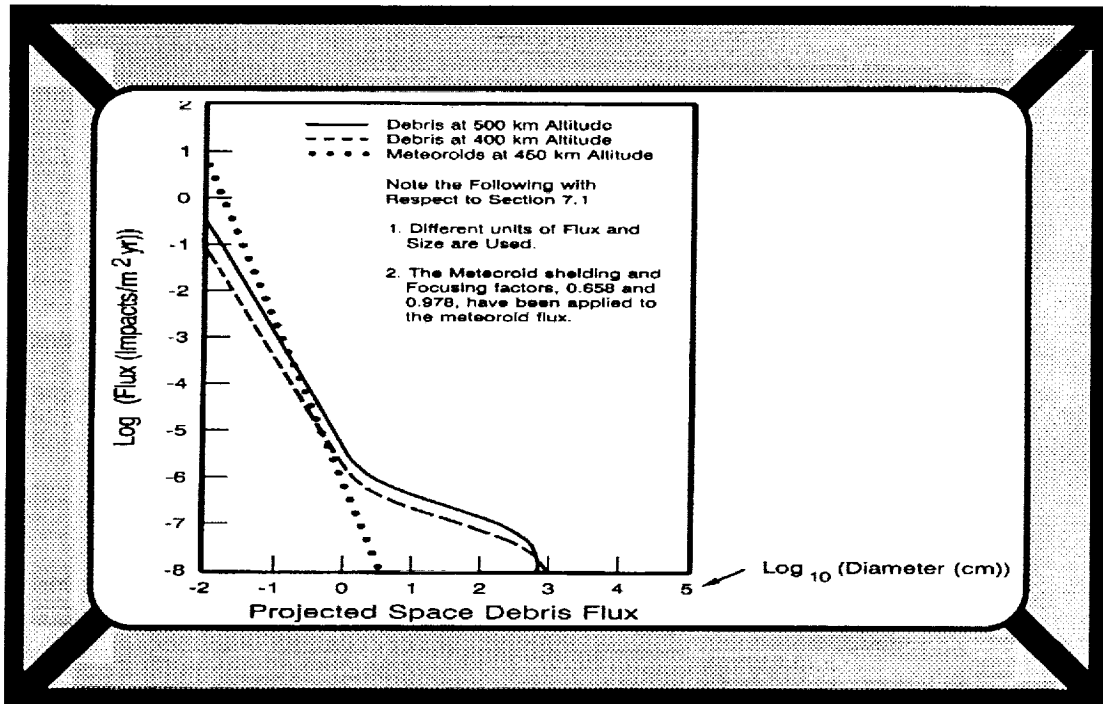


Figure 13. High resolution graphic.

CHAPTER 8 Page 168, 169

8.17 APPENDIX 8A: INTERAGENCY REPORT ON SPACE DEBRIS FOR THE NATIONAL SECURITY COUNCIL

 This appendix comprises the complete text of the Interagency Group (Space) "Report on Orbital Debris" prepared for the National Security Council, with minor editorial changes to correct typographical errors and to accommodate ASCII/EnviroNET format/style.

REPORT ON ORBITAL DEBRIS
 by INTERAGENCY GROUP (SPACE)
 NATIONAL SECURITY COUNCIL
 Washington, D.C.
 FEBRUARY 1989

[B]ack pg [U]p line [P]age marker [S]ec/pg [R]eturn [H]elp
 [A]head pg [D]n line [M]ain topics [I]ndex [F]ind [T]OC [E]xit

Figure 14. Interagency Report on Orbital Debris.

As a rule, full text of reports is not included in EnviroNET. Exceptions have been made for reports which were considered of strategic importance and not readily available to the community. The Interagency Report on Orbital Debris⁴ is one such report. It was added as an appendix to the section covering the natural environment (Figure 14). A copy of the report was forwarded directly to EnviroNET as a text file on floppy disk. This "electronic transfer" of information saved much labor and time by allowing the report to be included with minimal formatting. The other document included in its entirety is the Spacecraft Anomalies Handbook⁵.

Figure 15 is a schematic of the suggested data management and flow plan. The concept for a central data network is shown in Figure 16. The various access opportunities are shown at the bottom.

Figure 17 shows the model access and organization that is in use. Environmental models, written in either FORTRAN or C language are transparent to the user. The user works with a friendly input/output screen presentation. Other options available include reviewing data tables and viewing interactive graphics using C and Interactive Data Language (IDL).

DATA MANAGEMENT AND FLOW PLAN

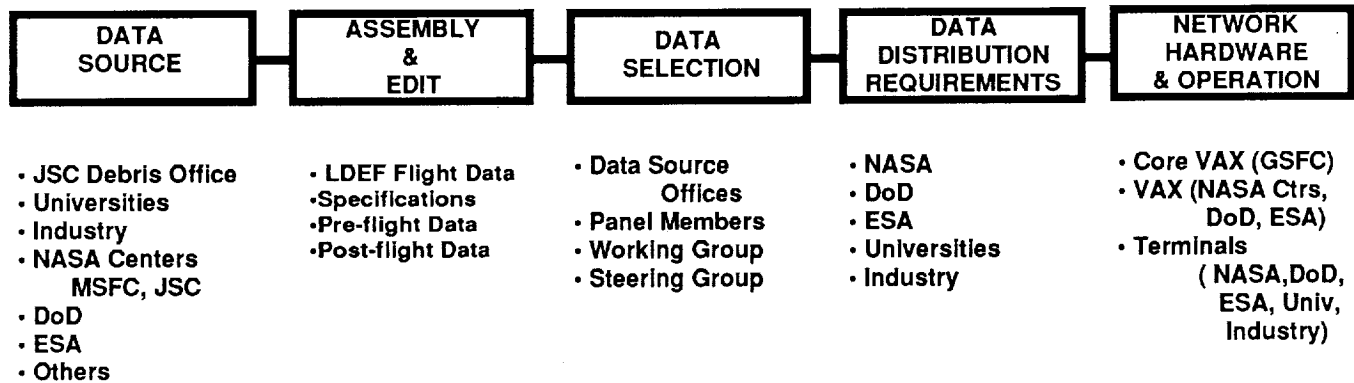


Figure 15. Data management and flow plan.

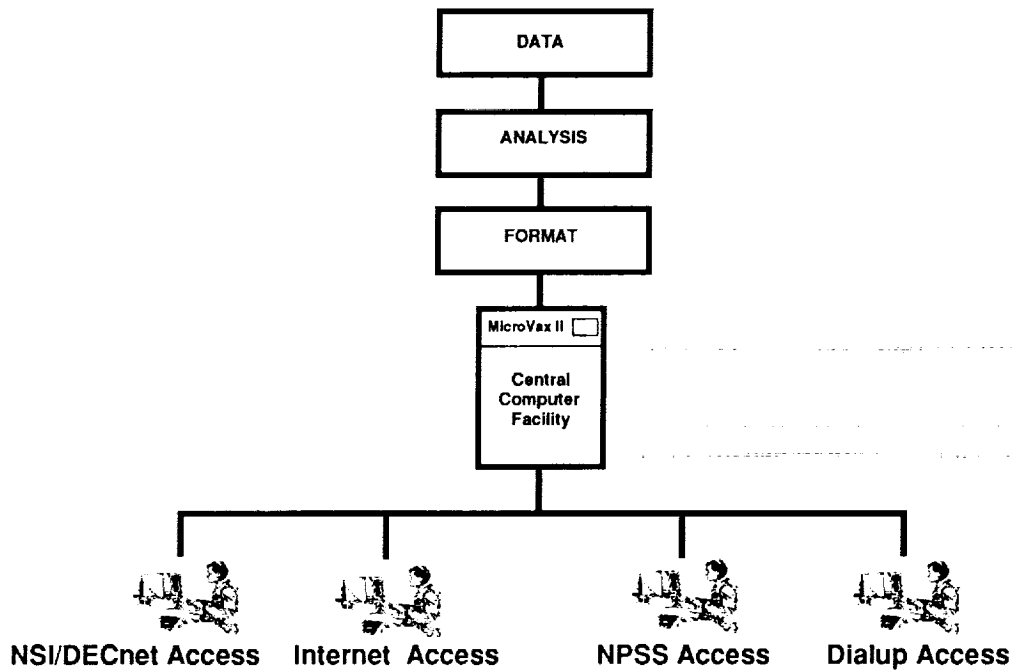


Figure 16. Central data network.

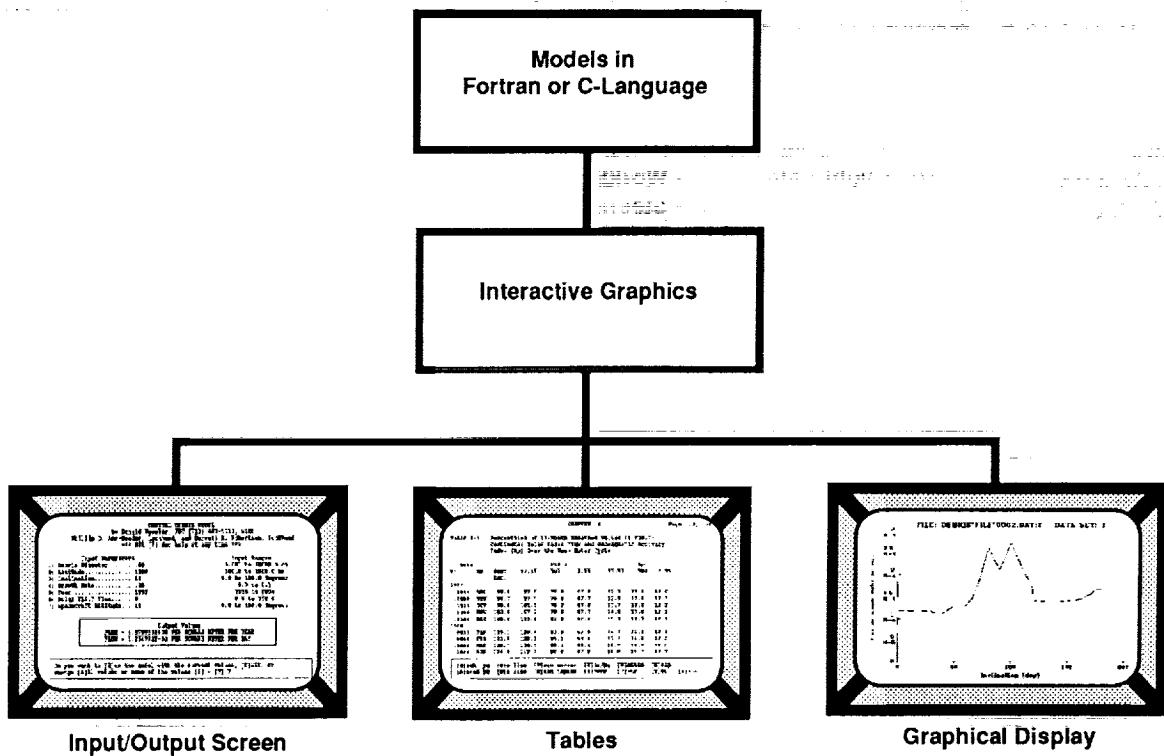


Figure 17. Model access exchange.

SPACECRAFT ANOMALIES EXPERT SYSTEM

Through the years, a host of information related to spacecraft anomalies has been accumulated. This information is principally located in EnviroNET's sections dealing with the natural environment and surface interactions. We are coordinating with all the agencies working in this area to help us develop an on-line facility to diagnose anomalies. In this category, Harry Koons and David Gorney of the Aerospace Corporation, who have been working on an expert system to address anomalies due to surface charging, bulk charging, single event upsets and total radiation dosage, have agreed to share their experience with us. We also have the assistance of NASA which publishes an annual report of anomalies on its own satellites. Lastly, there is NOAA, with its on-line reporting system. Expert systems provide an effective method for saving corporate knowledge, the experiences of researchers and engineers. They also allow computers to sift through large amounts of data and pinpoint significant parts. Figure 18 shows the expert system interface. Heuristics are used for predictions instead of algorithms. Approximate reasoning and inference are used to attack problems not rigidly defined.

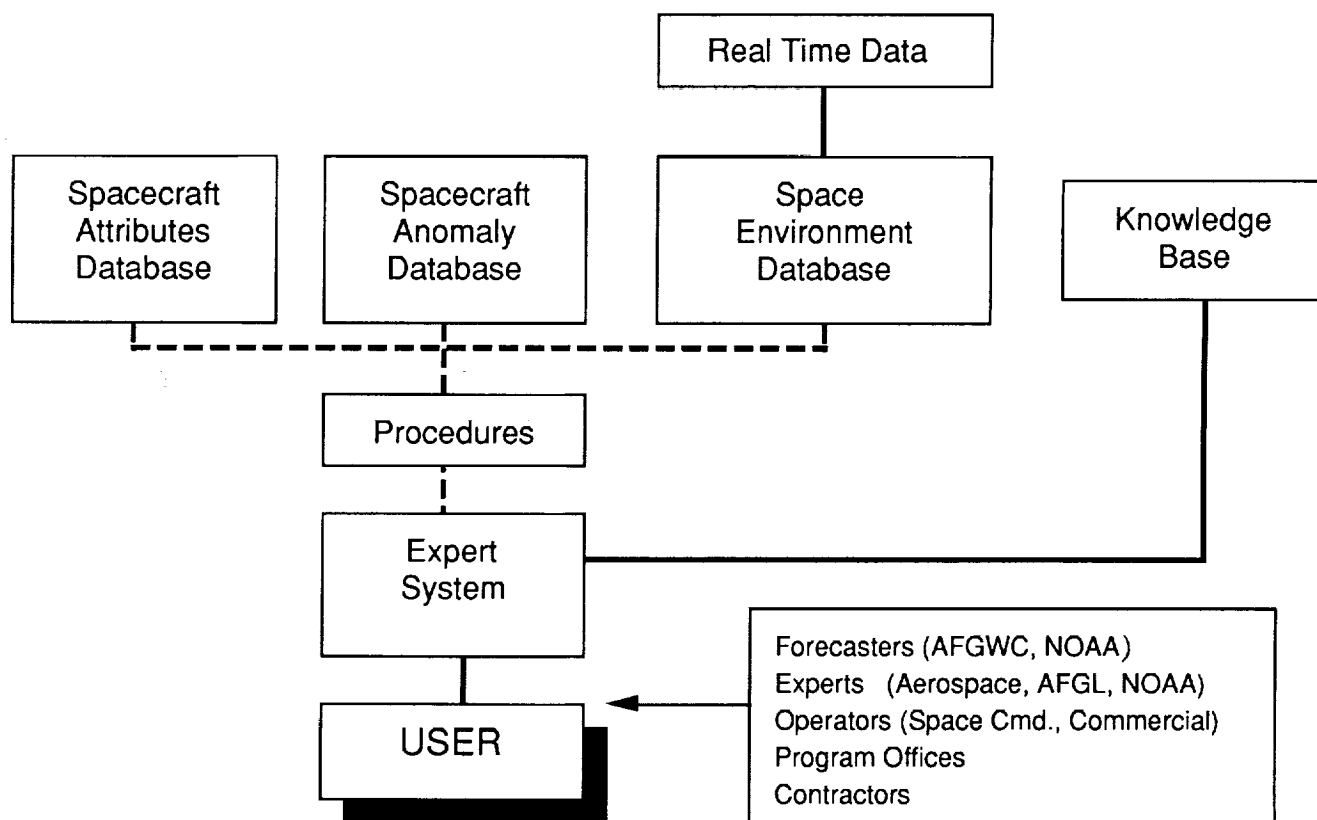
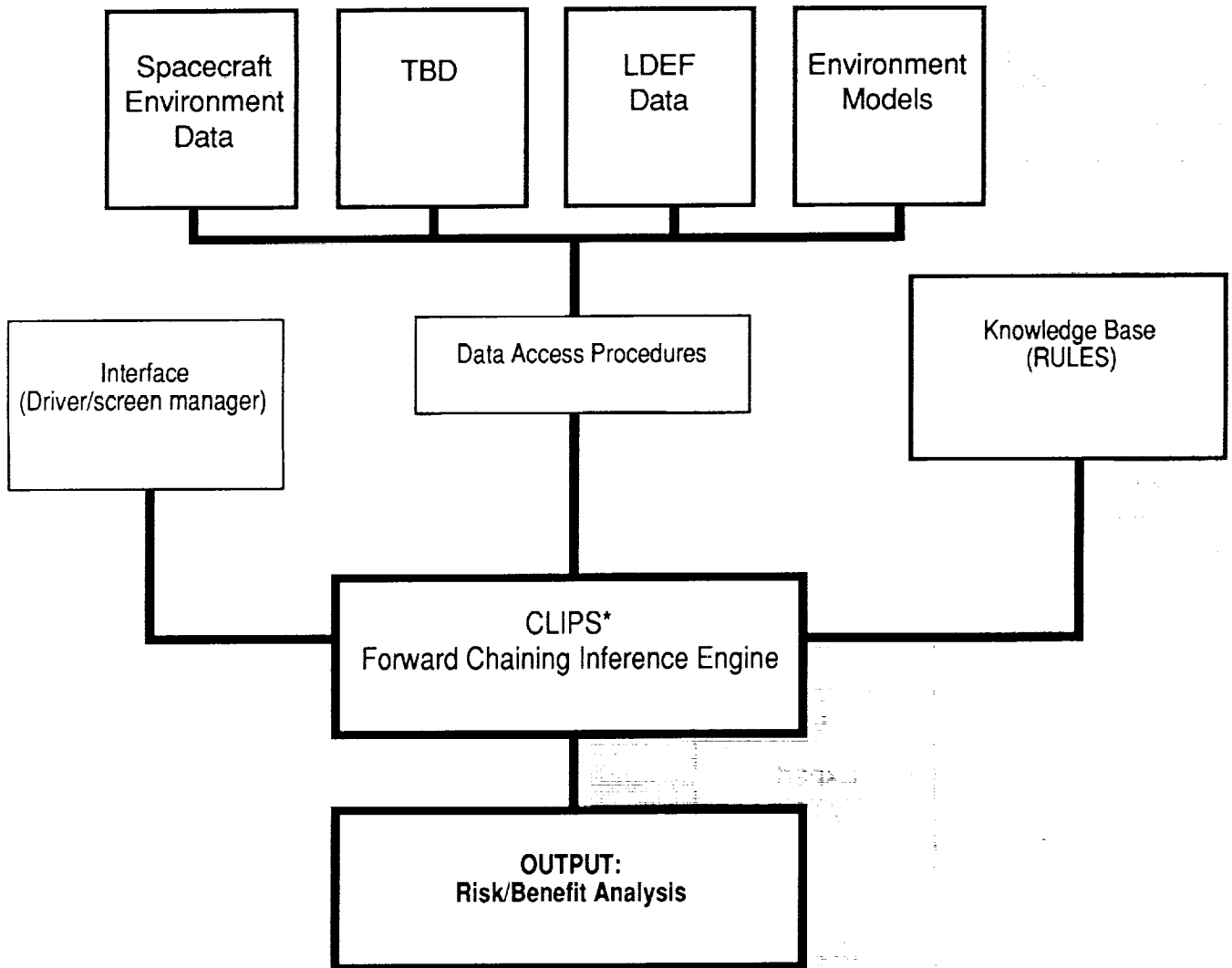


Figure 18. The Expert System Interface.

The Spacecraft Anomalies Expert System is a tool to diagnose causes of environmentally induced anomalies. It is also effective as a learning tool on environments. Modular systems allow easy expansion of satellite, technology, and past environmental conditions databases. The rules and facts generated by LDEF data can easily be formatted into the environment database.

Figure 19 is an adoption of the previous system which could be designed for LDEF. The software for the interface engine is reusable.



*C-Language Integrated Production System (NASA/JSC)

Figure 19. Proposed Expert System for LDEF.

TELESCIENCE TESTBED

EnviroNET is ideally suited for investigators to cooperate with their colleagues from their "remote" home laboratories and computers by computer networking. This is an expansion of the concept which started with the Atmosphere Explorer and Dynamics Explorer programs where many scientists were connected over dedicated phone lines to a central "remote" computer site containing their data and programs.

EnviroNET has always drawn on the NASA centers, other government laboratories, industry, and universities for help. It welcomes the opportunity to draw on the LDEF community.

CONCLUSION

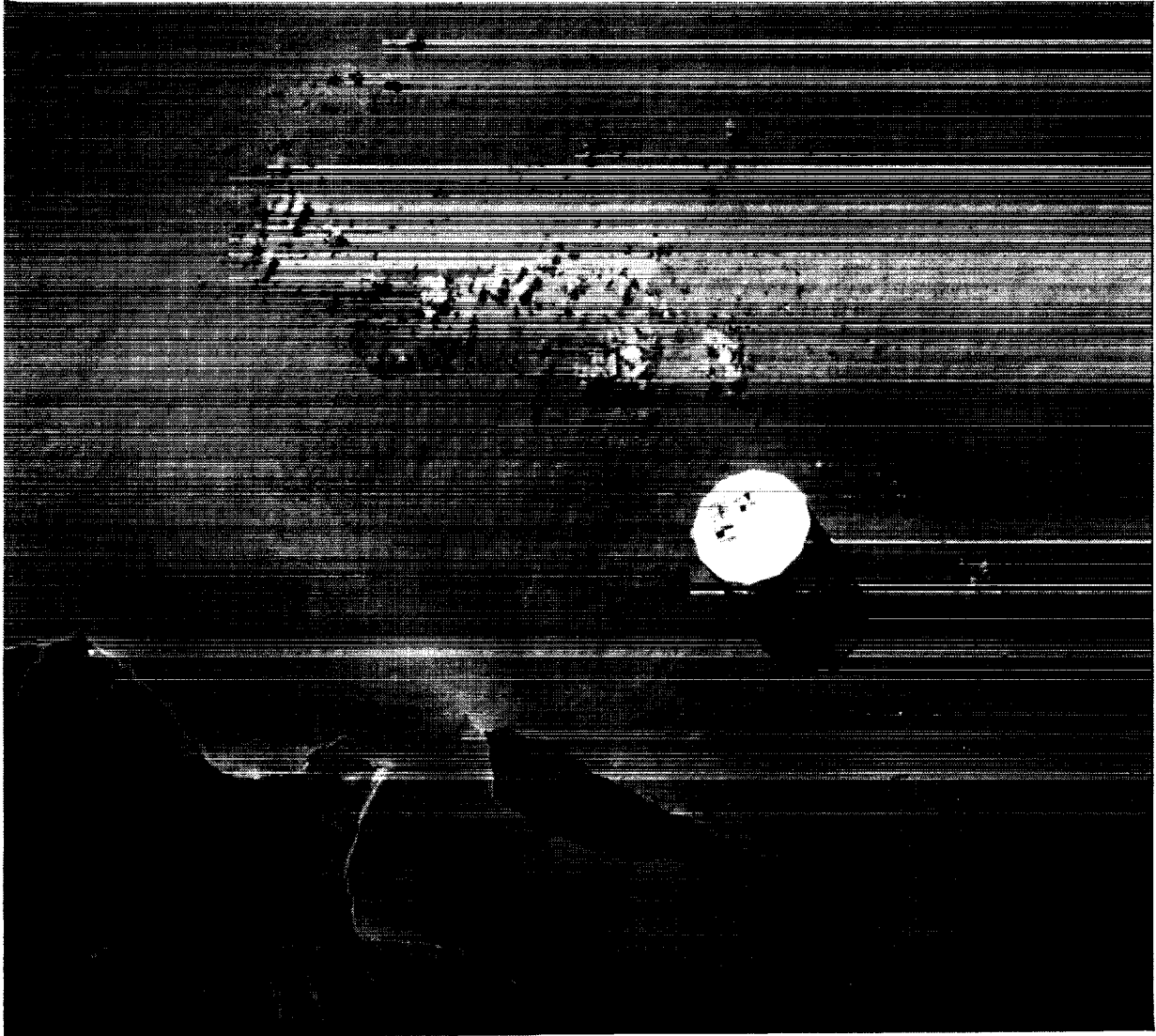
EnviroNET is an operational system available to the scientists, engineers, satellite operators and users concerned with space environments who have access to a terminal or dial-up port. It is a logical host for LDEF data to be used for extending the life of satellites and providing safety for manned missions.

REFERENCES

1. Peddie, N. W., International Geomagnetic Reference Field; the third generation, *Journal Geomagn. Geoelectr.*, vol. 34, 1982, pp. 309-326.
2. Kessler, D. J., Phillip D. Anz-Meador, and Robert C. Reynolds, Orbital Debris Environment for Spacecraft Designed to Operate in Low Earth Orbit, NASA TM-100471, 1989.
3. Hedin, Alan E., The MSIS-86 Thermospheric Model, *Journal Geophysical Research*, vol. 92, 1987, pp. 4648-4662.
4. Report on Orbital Debris by Interagency Group (SPACE) for National Security Council, Washington, D.C., February, 1989.
5. Robinson, Paul A., Spacecraft Environmental Anomalies Handbook, NTIS, August 1, 1989.

SPACE ENVIRONMENTS

IONIZING RADIATION



L-84-4313

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH PRECEDING PAGE BLANK NOT FILMED

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in financial reporting.

2. The second part of the document outlines the various methods and techniques used to collect and analyze data. It includes a detailed description of the experimental procedures and the statistical tools employed.

3. The third part of the document presents the results of the study, including a comparison of the different methods and a discussion of the implications of the findings. It also includes a section on the limitations of the study and suggestions for future research.

4. The fourth part of the document provides a comprehensive overview of the current state of the field and identifies key areas for further investigation. It also includes a list of references and a bibliography of the works cited in the document.

5. The fifth part of the document contains a detailed appendix of the data and calculations used in the study. It includes a table of the experimental results and a series of graphs and charts illustrating the trends and patterns observed.

6. The sixth part of the document is a concluding section that summarizes the main findings of the study and reiterates the importance of the research. It also includes a final statement on the author's contributions and a list of acknowledgments.

7. The seventh part of the document is a list of the authors' contact information and a statement of their affiliations. It also includes a list of the institutions and organizations that supported the research.

8. The eighth part of the document is a list of the authors' previous works and a list of the works of other researchers in the field. It also includes a list of the authors' current projects and a list of their future plans.

COMPTON ELECTRONIC COMPANY
1000 UNIVERSITY AVENUE
SUNNYVALE, CALIFORNIA 94088
TEL: (415) 961-1000

1980