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ENVIRONET: AN ONLINE ENVIRONMENTAL INTERACTIONS RESOURCE

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ABSTRACT

EnviroNET is a centralized depository for technical information on environmentally induced interactions likely to be encountered by spacecraft in both low-altitude and high-altitude (including geosynchronous) orbits. 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 service pools space 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. These graphics can be accessed while still in the chapters, making it easy to flip from text to graphics and back. Interactive graphics programs are also available on space debris, the neutral atmosphere, magnetic field, and ionosphere. EnviroNET can help designers meet tough environmental flight criteria before committing to flight hardware built for experiments, instrumentation, or payloads to the launch site. A test bed for developing an expert system for diagnosing environmentally induced anomalies for spacecraft has been in progress in cooperation with the USAF. An agreement has also been made with the USAF to use EnviroNET as a test bed for proposed standard atmosphere models by the AIAA Atmospheric Standards Committee.

BACKGROUND

EnviroNET was initiated at the request of NASA headquarters to provide a centralized depository of design guidelines for use by the space community with access capability. This action was prompted by the need for a detailed description of the environmental interactions with Shuttle and its payloads. The extreme complexity and size of the Shuttle made it very difficult to characterize these environments by direct computation

In the fall of 1982, NASA conducted its first Shuttle Environment Workshop to determine what had been learned from these measurements[1]. This led to environmental concerns voiced and a need for up-to-date information, on a continuing basis. To address the issues, NASA's Office of Space Science and Applications (OSSA) requested that a focal point be established for this environmental information, and that the activity be coordinated with other NASA centers, government agencies, and the user community. Goddard Space Flight Center (GSFC) was asked to lead this Agency-wide effort. It also suggested that the data obtained from this activity be put into an electronic database which could be accessed by any interested user from its work place. A second workshop was held where the concept for the current EnviroNET information resource was organized[2].

What has evolved is a user-friendly; menu-driven space environment information service[3]. Utilizing the global network of the Space Physics Analysis Network (SPAN)[4] this service is available to the space community, nationwide, as well as internationally. It is also useful to designers of equipment for low and high altitude satellites—including geosynchronous spacecraft. It is available twenty-four hours a day..every day. The system incorporates a combination of expository text and numerical tables amounting to about 2 million characters (bytes), plus Fortran programs that model several natural environments.

BROWSE

The main-menu system, which controls the EnviroNET activity on the MicroVAX II, allows one to run BROWSE, the principal retrieval program. With BROWSE, data files can be accessed, graphics and text downloaded, mail sent to the system manager, bulletin board notices read, the models run, or the system exited. Simple command choices allow one to page through the EnviroNET database sequentially, or jump to points of interest. BROWSE does require a VT100-compatible terminal or emulation. Three menus are available: Main Topics, Data and Table of Contents/Index. One can move among the three menus to any part of the database, or back to the EnviroNET main menu with a single keystroke. As you BROWSE about the database and change menus, the information on the terminal screen will change, but the basic layout of the screen will remain the same. The text is under continuous review by technical subpanels (each corresponding to the subject areas of the database) of experts who correct and augment the database to keep it accurate and current.

A partial list of the current topics contained in EnviroNET is shown in Fig. 1. The topics of primary interest to this session are the chapters on the Natural Environment and Surface Interactions, and the interactive graphics facility. The chairman of the subpanel on Surface Interactions Henry Garrett gave two papers at the SOAR '89. They were on the environmental interactions on space robotics and the Space Station[5,6].

- **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**

Fig. 1 Current Topics

ENVIRONET'S INTERACTIVE GRAPHICS AND MODELING

Use of models have been simplified by to providing tabular outputs to the screen or to files and for plotting the resultant models. 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. Computer models are being expanded beyond the current models (thermosphere, ionosphere, energetic particles, magnetic field) to include gravity, radiation, meteoroids, the increasingly important space debris, and spacecraft anomalies.

The scope of the interactive models is shown in Fig. 2. The models include neutral atmosphere density and temperature, ionosphere, electron temperature and density, the magnetic field vector, and energetic particle or radiation flux. These models are based on data from satellites which orbit the earth in the thermospheric and exospheric regions of the atmosphere.

The implementation of on-line simplified computational models in the EnviroNET database has been strongly recommended by many EnviroNET users. A review of published prediction models indicates that selective computational models can be sufficiently simplified to meet the user-friendly requirement of the EnviroNET database user. 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 on all models. All models have a pop-up help window which give more information on inputs, outputs and caveats. Fig. 3 is an example of a model help window for the International Geomagnetic Reference Field model[7].

Mass Sprectrometer Incoherent Scatter (MSIS)*
Marshall Engineering Thermosphere (MET)*
International Reference Ionosphere (IRI)*
Cosmic Ray Effects on Microelectronics (CREME)
Energetic Particles*
Radiation Belts
Solar Flux
International Geomagnetic Reference Field (IGRF)*
Orbital Debris*
Marsgram*

***Suitable for orbit integration**

Fig. 2 Scope of Interactive Models

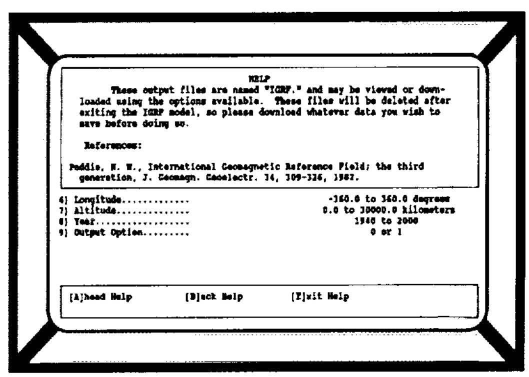

Fig. 3 Help window from the IRI model

The orbital debris model provides essential data needed for risk assessment. The model is a widely used one of the current and future debris environment. The model permits order-of-magnitude estimates of collision probabilities. Fig. 4 is an example of a user friendly model for space debris[8]. The input parameters are on the left and input ranges on the right. After the computer is asked to run the model with keyed in values, the output then appears on the split screen on the bottom.

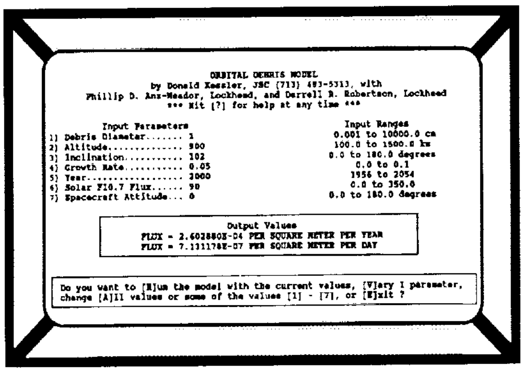

Fig. 4 User-friendly space debris model

The interactive graphics system permits plotting from common graphics terminals and emulators (Tektronics). The system allows plotting of output versus any input parameter. Graphs are generated using interactive data language (IDL), a commonly used commercial package as shown in Fig. 5. The real time graphing can do "What if...." scenarios.

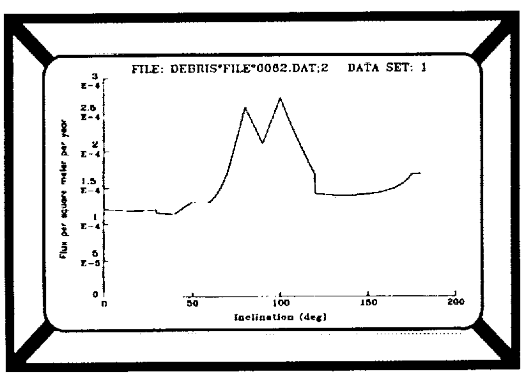

Fig. 5 Plot from the output of space debris model

Fig. 6 is an example of a user-friendly model for the 1986 Mass Spectrometer Incoherent Scatter (MSIS)-86 Model[9]. It is a standard empirical neutral atmosphere model. User-friendly output of temperatures and densities of atmosphere components including atomic oxygen are possible. As shown below, calculations of mission fluences of atmospheric species when integrated over an orbit model are easy. Such information would be valuable for drag calculations or calculating oxygen erosion.

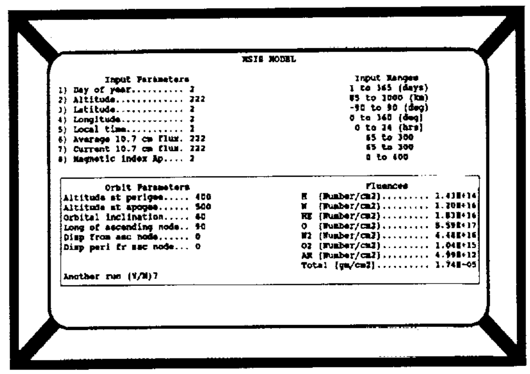

Fig. 6 MSIS model output showing orbital fluence of species

Environmental scientists may now map space atmospheres in spatial dimensions. Affordable tools now make it feasible to gain access to the scientific data which we have expressed in FORTRAN-compiled information. The CISC and VMS combination of c programming are used to deliver solutions to computational intense graphical applications. Fig. 7 is an example of a surface plot superimposed over a topographic plot from the output of the MSIS-86 model. The F 107=90, F 107 average=90. Day of the year is along the x-axis, latitude along the y-axis, and density along the z-axis.

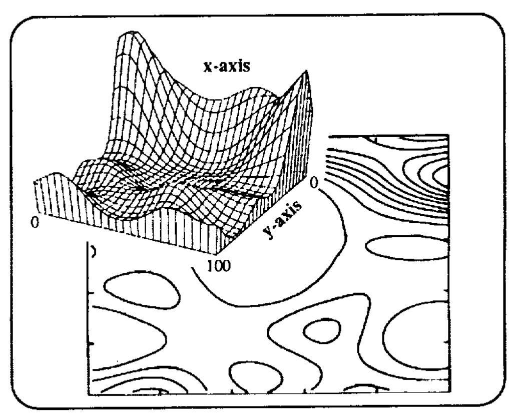

Fig. 7 Sample output plot produced from MSIS-86 model Altitude=900km; Local time =12:00; Longitude=15°; F107=90; Mean F107=90; x axis is day of year(1-365); Y-axis is Latitude(-90-90); z-axis is density of atomic oxygen;

SPACECRAFT ANOMALIES EXPERT SYSTEM

Through the years, a host of information related to spacecraft anomalies have been accumulated. This information is principally located in the chapters on the natural environment and surface interactions. We are coordinating with all the agencies working in this area to help us develop an online facility to diagnose anomalies. In this category, Koons and Gorney, who have been working on an expert system to address anomalies due to surface charging, bulk charging, single event effects and total radiation dosage have agreed to share their experience with us. We also have the assistance of NASA which publishes an annual anomalies report on its satellites. Lastly there is NOAA with its online reporting system. Expert systems provide an effective method of saving corporate knowledge. They also allow computers to sift through large amounts of data and pinpoint significant parts. Fig. 8 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.

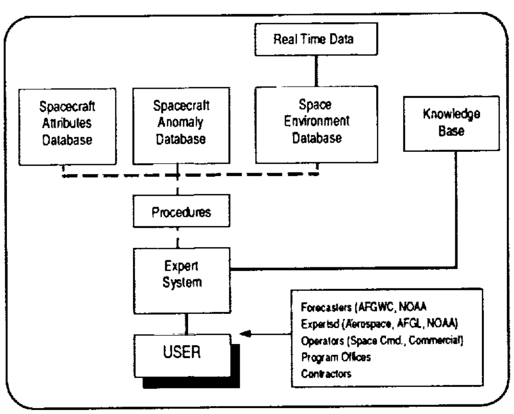

Fig. 8 Expert system interface

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 allows expansion of satellite, technology, and past environmental conditions databases. The prototype program was developed by Aerospace Corp.

SPACE ENVIRONMENT STANDARDS

This continuing effort is ideally suitable to link the scientific community with users. By presenting our developments at national meetings and participating in committee meetings on standards it is anticipated that a contribution to development of space environment standards will be achieved. At the invitation of Dr. Al Rubin, chairman of the AIAA Atmospheric Standards, a presentation was made on January 8, 1990. It was suggested that EnviroNET be used as a mechanism for proposed standards because of the linkage to the space community through the Space Physics Analysis Network.

TELESCIENCE TESTBED

EnviroNET is ideally suited for investigators to cooperate from their "remote" home laboratories and computers with their colleagues by computer networking. This is an expansion of the concept started with the Atmosphere Explorer and Dynamics Explorer programs when many scientists were connected over dedicated phone lines to a central "remote" computer site containing their data and computer programs. With the advent of SPAN, the remote Dynamics Explorer scientists can communicate with one another directly and offload calculations and data analysis to their home systems, thereby improving productivity with simultaneous analysis on remote, distributed computer systems. EnviroNET is being upgraded to permit the users to conduct teleanalysis, i.e., perform analyses using Space Shuttle/Space Station environment data and the models on computers at remote institutions. EnviroNET has always drawn on the NASA centers, other government laboratories, industry, and universities for help. The academic community is especially involved because it provides important opportunities for testing and evaluating new ideas, techniques and concepts before they have reached the state of maturity considered by contractors and project mangers suitable for implementation. A testbed program like EnviroNET provides a valuable way of training graduate students who represent the future scientists and engineers of the nation, and who need to be at the cutting edge of technology to ensure our economic survival.

UPDATING ENVIRONET

EnviroNET is a living document. One of the driving forces for having an "electronic handbook" was to compress the time for communicating important information. Although the National Security Council's Interagency Report On Orbital Debris[10] was issued a few weeks before the NASA/DOD Orbital Debris Conference[11], we were able to have the complete report online in time for the meeting. Robinson's Spacecraft Environmental Anomalies Handbook sponsored by the Air Force[12] will soon be online.

Workshops conducted periodically are issued as informal documents for the purpose of feedback of information essential to the improvement of the services to users. As an example, at the mini-workshop held by the Natural Environment Panel, recommendations were made to add models that will generate energetic electron and proton environment values for a point in space, calculate orbital integrations of particle fluence, provide magnetic field traces and calculate ionospheric parameters. Now featuring interactive graphics software, the system will eventually simplify space environment mission analysis.

Last year a mini-workshop was held on environmentally induced spacecraft anomalies. In addition to NASA, the meeting was supported by the National Oceanic and Atmospheric Administration, TRW Inc., U.S. Air Force Systems Command, Global Weather Central Environmental Technical Applications Center, and Air Weather Service. Koons and Gorney described a spacecraft anomaly expert system, Elsen reported on Goddard spacecraft anomalies, Robinson presented material on single-event upsets, Heckman and Allen reported NOAA spacecraft anomaly data, and Wilson and Scro reported on the Air Force spacecraft anomalies database. This meeting was followed by a special session on environmentally induced spacecraft anomalies chaired jointly by the Air Force and NASA at the AIAA January meeting in Reno[13]. The session was expanded to include a description of the Goddard's trapped radiation facility and a paper by Garrett and Whittlesey on Anomalies on TDRSS.

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 tail node on SPAN accessible directly or through the national networks via NPSS. The EnviroNET staff welcomes comments and suggestions for how to improve this service. To summarize, the benefits to using EnviroNET include:

1) Validated NASA environmental information and interactive space models

2) Facilitating analysis of the natural space environment for missions

ACKNOWLEDGMENTS

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REFERENCES

1. Proceedings: The Shuttle Environment Workshop. Prepared for NASA by Systematics Corp., Contract NAS5-27326, Feb. 1983.

2. Wilkerson, Thomas D., Michael Lauriente, and Gerald W. Sharp. Space Shuttle Environment. Library of Congress Catalog No.: 85-81606, ISB No-939204-28-2

3. The EnviroNET Users Guide. Code 410.1, NASA/GSFC, Greenbelt, MD 20770

4. Green, James L. The Space Physics Analysis Network. Computer Physics Communication 49, pp. 205-213, North-Holland, Amsterdam, 1988.

5. Henry B. Garrett, Space Environments And Their Effects On Space Automation And Robotics, SOAR 89.

6. G.B. Murphy, H.B. Garrett, Interactions Between The Space Station And The Environment , SOAR 89.

7. Peddie, N.W., International Geomagnetic Reference Field; the third generation, J. Geomagn. Geoelectr. 34, 309-326, 1982.

8. 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.

9. Hedin, Alan E. The MSIS-86 Thermospheric Model, J. Geophys. Res., vol. 92, pp. 4648-4662, 1987.

10. Report on Orbital Debris by Interagency Group (SPACE) for National Security Council, Washington, D.C. February 1989.

11. AIAA/NASA/DOD Orbital Debris Conference: Technical Issues & Future Directions, April 16-19, 1990, Baltimore, MD

12. Paul A. Robinson, Spacecraft Environmental Anomalies Handbook, August 1, 1989, NTIS.

13. 28th Aerospace Sciences Meeting, Reno, Nevada, January 8-11, 1990

A. Vampola, Tutorial on Spacecraft Environmental Interactions Anomalies, CP AIAA 90-0172.

D. Wilkinson, NOAA's Spacecraft Anomaly Data Base, CP AIAA 90-0173.

P. Robinson, Anomalies Due to Single-Event Upsets, CP AIAA 90-0174.

D. Gorney and H. Koons, Spacecraft Anomaly Expert System, CP AIAA 90-0175.

J. Gaffey and D. Bilitza, Trapped Radiation Model Facility, CP AIAA 90-0176.

H. Garrett and A. Whittlesey, Environmentally Induced Spacecraft Anomalies on TDRSS, CP AIAA 90-0178.