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FINAL REPORT

VOLUME II

DEVELOPMENT OF USER GUIDELINES FOR ECAS DISPLAY DESIGN

TASK 9 AND TASK 10

Contract NAS8-32991

Prepared For:

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FOREWORD

This report describes the results of a six month study performed by the Essex Corporation to develop user guidelines for Spacelab Experiment Computer Application Software (ECAS) display design and command usage.

The final report is submitted in two parts: Volume I describes the activities associated with the development of the Spacelab ECAS Display Design and Command Usage Guidelines Document, and Volume II discusses the tasks associated with the development of Spacelab capability descriptions and the development of written matter relevant to specific science fields. Technical direction for the effort was provided by Mr. Paul T. Artis (EL15), Mr. Ronald Schlagheck (EL12), Mr. Leon B. Weaver (JA21), and Dr. Richard Chappell (ES53).

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1.0 INTRODUCTION

1.1 BACKGROUND

NASA's prime directive to expand knowledge of space and the atmosphere includes an implied obligation to communicate progress in this area to the public. It has often been said that the work is not done until the public has the results, and this involves more than printing highly technical data and making it available to the slim population who can understand it in that form and who would know enough to request it. Indeed, some of the greatest benefits of space research have resulted from the technological and theoretical science spinoffs that have filtered down from their orbital and often esoteric beginnings to the everyday life of the average citizen. The public needs what NASA can learn from space, and NASA needs the understanding and at least tacit support of the public in order to continue to provide the benefits accruing from space studies. For example, new discoveries in solar-terrestrial and magnetospheric physics are pointing the way toward breakthroughs in predicting short- and long-term global weather changes and climate shifts. With such a capability, people all over the world would be better able to determine how much rain to expect in a given year and, consequently, what crops would be likely to do well. They would be able to make more accurate advance estimates of how much energy would be needed to heat their homes and businesses in a given year or perhaps even over a given decade. It is the public, not NASA, who will benefit most and longest from such new knowledge, and NASA needs the public's (and their elected representative's) recognition of the utility of its efforts if it is to continue to receive the funding necessary for the work to progress.

Marshall Space Flight Center (MSFC) is sensitive to the criticality of public understanding and a public sense of involvement or "stake" in the outcome of NASA space-based research. This is especially true for research employing the Space Transportation System (STS), since the long-range success of the STS will depend on its acceptance by the public as a bona fide research tool to which they have access or from which they will reap fairly tangible rewards. Therefore, toward fulfilling its educational responsibilities, NASA/MSFC directed the addition of two tasks (Task 9 and Task 10) to the ongoing work of Contract NAS8-32991. Task 9 was designed to develop a flexible information package describing, in simple-to-understand terms, the general capabilities of the Space Shuttle and Spacelab and the potential public benefits of research utilizing the Space Transportation System. Task 10 was outlined to develop educational materials acquainting the general public with the usefulness of research specifically in the field of solar-terrestrial physics.

1.2 SCOPE

The 1978 effort was of modest scale, utilizing existing materials (where possible), as springboards from which to develop new materials tailored to the general public. Printed matter (periodical articles, booklets, press materials) and several pattern scripts were written. In addition, for Task 10, a network for distributing the prepared materials was set up and activated.

2.0 TASK 9 - DEVELOPMENT OF SPACELAB CAPABILITY AND EXPERIMENT DESCRIPTIONS

The Task 9 activities revolved chiefly around two major assignments: (1) creation of a comprehensive press kit pertaining to MSFC's part in the Spacelab 1 preparations, and (2) generation of a set of speakers aids about the Spacelab 1 experiments. These are discussed in Sections 2.1 and 2.2, below.

2.1 PRESS KIT MATERIALS FOR SPACELAB 1

In this assignment, Essex cooperated with MSFC in preparation of a substantial set of background data about Spacelab 1 by writing five of nine sections ultimately completed and incorporated into the final draft press kit. The sections prepared by Essex included:

- Section 4 - Spacelab Mission Management
- Section 5 - Spacelab Payload Selection
- Section 6 - Spacelab Payload Integration and Checkout
- Section 7 - Payload Operations Control Center
- Section 8 - Payload Specialist Selection and Training.

In collecting information for these sections, considerable literature research and personal interviews were required for each area to assure that written material would be technically accurate and would competently portray MSFC's Spacelab 1 activities and responsibilities. In addition to the COR for Task 9, Mr. Leon B. Weaver (JA21), who offered particularly helpful suggestions in the area of Spacelab Payload Selection, the individuals interviewed in the process of data collection were: Mr. Joe Cremin (JA22) for Mission Management, Mr. Tony O'Neil and Mr. G. Huffman (JA41) for Spacelab Payload Integration and Checkout, Mr. Clark Owen (EL14) for the Payload Operations Control Center, and Mr. Robert McBrayer (JA71) for Payload Specialist Selection and Training. The verbal and written materials supplied by each of these persons constituted the data base from which all Essex-generated sections were derived. The sections were prepared in sequence, usually with one or two undergoing technical review while the next was being written.

The main requirement for the kit was that all the materials be written in a manner that would be informative and meaningful to news media personnel outside of NASA. The "target" recipients for the kit were newspaper science writers and editors. In other words, some familiarity with the Space Transportation System (Shuttle and Spacelab) was assumed, though every attempt was made to provide ample facts and explanatory material to illuminate the STS concept still further and to detail Marshall Space Flight Center's involvement in preparations for launch of the first Spacelab Mission.

The completed draft press kit was a convenient, comprehensive, one-source document about Marshall's work on Spacelab 1. The kit marked the first time MSFC's Spacelab 1 activities, encompassing a diverse range of planning, assembly, and test functions, had been condensed into a single document written from an "external-to-NASA" point of view. It was, however, designed to be a flexible piece, with each section capable of standing alone whenever an upcoming specific news item to be released by the MSFC Public Affairs Office required only a part (or parts) of the overall kit to be provided to the media for general subject orientation and background detail.

The entire kit contains over a hundred pages of narrative information and illustrations in the five sections prepared by Essex and in the MSFC-generated sections on the Space Transportation System (Section 2), Spacelab (Section 3), the Spacelab 1 Payload (Section 9), and the Spacelab and Payload Program Officials (Section 12). The information was written with an eye toward long-term validity and broad applicability. It was current as of late summer 1978 and, except for certain administrative changes enacted since then (e.g., the relocation of payload integration and checkout activities from MSFC to KSC), it still provides useful background data and perspective on Spacelab as a whole and on Marshall Space Flight Center's Spacelab involvement in particular.

In addition to providing important factual information to news reporters, the kit supplies a convenient means for persons immersed in one area of MSFC Spacelab work (or those new to MSFC) to become at least generally familiar with the work going on in other associated areas of the Marshall facility. It is available upon request from Mr. Leon Weaver (JA21) or Mr. Richard Marmann (JA71) of the Mission Planning and Operations Management Office or in single copies (providing that specific approval is obtained from MSFC) from Essex Corporation in Huntsville, Alabama.

2.2 SPEAKERS AIDS FOR SPACELAB 1 EXPERIMENTS

The second major assignment under Task 9 was the preparation of narrative materials and ideas for accompanying viewgraphs that, taken together, would constitute a set of speakers aids useful in helping MSFC personnel who were invited to speak before audiences unfamiliar with the space sciences with simple, interesting descriptions of the experiments to be included in the first Spacelab payload. These materials were designed to complement extensive, already existing experiment equipment descriptions which had been previously prepared for MSFC by Brown Engineering. While the equipment-oriented materials accurately described the complex components to be flown as experimental equipment on Spacelab 1, they did not explain in terms a nonscientific audience could grasp, what the experiments themselves were supposed to do, why those particular experiments were selected for this specific mission payload, nor how the results of the experiments might benefit not only future space endeavors but also the public generally. It was felt by MSFC that many of the speaking engagements undertaken by Marshall personnel might benefit from a more rounded presentation of experiment objectives, activities, and potential benefits, in addition to discussion of the items of equipment to be used. Furthermore, the advance preparation of such broadly explanatory information would be a significant time-saver for speakers whose primary MSFC duties left little time for writing original speeches for every occasion that might arise.

To fill the need for lay-level explanatory materials about the Spacelab 1 experiments, Essex created five pattern talks, along with specific suggestions for accompanying viewgraph illustrations. The five talks correspond with the five major areas of investigation included in the Spacelab 1 payload. These are:

Area 1 - Atomspheric Physics and Earth Observations
Area 2 - Space Plasma Physics
Area 3 - Material Sciences and Technology
Area 4 - Astronomy and Solar Physics
Area 5 - Life Sciences.

To secure the documentation essential for synthesizing experiment descriptions comprehensible to lay-level audiences, a sizable literature collection and review effort was necessary. The information required was found to be widely dispersed (where it existed at all) and was written for the most part in highly technical language in documents never intended for public use. Extensive reading, research and personal interviews were performed by Essex to collect information of sufficient breadth to interpret--for general public consumption--complicated and difficult existing experiment descriptive materials and, further, to relocate the original rationale and long-term justification for the selection of each of the experiments included in the Spacelab 1 payload.

Within the five areas of investigation, the specific experiments to be flown were grouped by similarity of subject and purpose, e.g., Area 4 - Astronomy and Solar Physics experiments were subdivided into (a) ultraviolet and x-ray astronomy experiments and (b) solar constant and the parts of the solar system experiments. Explanations of the experiments were then written in language suitable for verbal presentation (that is, spoken English as opposed to more formal "technical report" type English). Simple examples and analogies were included to translate rather complicated experimental activities and terminology into a form which would be understood and better retained by nonscientific audiences. Care was exercised to connect the experiments with everyday events meaningful to the general public while still maintaining the requisite technical accuracy in describing them. Two examples of the narrative materials are provided in Appendix A of this volume. The first example (taken from Area 3) pertains to materials processing and the utility of "containerless melting" in the orbital environment. The second example (from Area 4) explains why our scientists need precise measurements of the sun's radiant output and why these measurements can best be made from space.

As with the press kit materials discussed in Section 2.1, the experiment descriptions were designed for flexibility of use. Each of the five experiment areas is written as a stand-alone talk, but within each talk, specific examples (and future accompanying viewgraph illustrations) can be pulled to augment other talks/presentations given by MSFC. The discussions of the experiments' goals and potential benefits are provided as source materials to be drawn upon to whatever extent an individual speaker may desire or need.

This collection of speakers aids is available through the same sources as the press kit--Mr. Leon Weaver (JA21) or Mr. Richard Marmann (JA71) of the MSFC Mission Planning and Operations Management Office, or (with MSFC approval) from Essex Corporation, Huntsville, Alabama.

2.3 RECOMMENDATIONS

While no additional funding is presently available for contracted materials preparation such as in the Task 9 effort, Essex strongly recommends that MSFC internally pursue generation of the viewgraphs to go along with the five talks. As the November 9, 1979, tentative launch date for the first mission draws nearer, demand for information about the experiments will (and should) increase. The public will desire more detail about the work to be performed aboard that flight, and, consequently, more speaking invitations will be extended to MSFC personnel. The existence of basic "spoken-English" explanations and illustrative viewgraphs pertaining to the experiments will facilitate response to these invitations without requiring undue redundant research and preparation time on the part of the speakers--at a time when their regular responsibilities connected with the mission are likely to be especially heavy. Use of part or parts of the completed, approved set of materials will also help assure that a reasonably consistent representation of the experiments is presented to the public.

3.0 TASK 10 - DEVELOPMENT OF WRITTEN MATERIALS RELEVANT TO SPECIFIC SCIENCE FIELDS

The Task 10 effort for 1978 focused on the preparation and distribution of educational materials concerning solar-terrestrial physics in general and, more specifically, the NASA/MSFC-related activities associated with this important field of space research. The work involved in creating the materials and the various means employed for informing the general public about the availability of these materials are discussed in Sections 3.1 and 3.2, below.

3.1 WRITTEN MATTER CONCERNING SOLAR-TERRESTRIAL RESEARCH

In performance of this assignment, Essex activities can be divided into five areas: (1) conduct of an extensive literature survey, (2) creating an article for publication in the National Space Institute (NSI) Newsletter, (3) cooperation with MSFC personnel in drafting and assembling a booklet about the Earth's Magnetosphere, (4) creation of "pattern" speakers materials about the Magnetosphere, and (5) initiating contacts with selected periodical publications.

3.1.1 Literature Survey

Upon initiation of the Task 10 work, Essex began an extensive study of existing literature pertaining not only to solar-terrestrial physics but also to related fields, such as atmospheric physics, space plasma physics, astrophysics, etc. This was complemented by further efforts to acquire basic Space Transportation System orientation and a primary acquaintance with the MSFC Magnetospheric Physics Branch. Documentation and verbal information were provided by Dr. Richard Chappell, COR for Task 10, obtained through the Redstone Scientific Information Center and other libraries in the Huntsville area, and collected via interview with MSFC personnel. Several weeks were expended by Essex in researching and reading in the solar-terrestrial field, in preparation for performance of the Task 10 writing assignments.

3.1.2 Article for NSI Newsletter

Dr. Chappell indicated an interest in contacting the National Space Institute, an organization of individuals largely outside the space sciences but very interested in advancing space work. Essex communicated with the organization to offer an article about solar-terrestrial physics research for publication in their monthly newsletter. Upon request from Mr. Courtney Stadd, editor of the newsletter, a feature article was prepared, submitted to Dr. Chappell for approval, and mailed to Mr. Stadd. The article, "Solar Wind: Magnetic Lines That Could Aid Weathermen," appeared in the June 1978 issue, and Mr. Stadd called Essex to commend the quality of the piece and the prompt response to his request. A copy of the article is provided as Appendix B to this report.

3.1.3 Magnetosphere Booklet

Generated as part of the Task 10 work was a fourteen-page, illustrated booklet describing the basic components and functions of the Earth's Magnetosphere, as well as Marshall Space Flight Center's ongoing research into this important region surrounding our planet. This booklet, entitled "Earthspace: The Magnetosphere", was synthesized from material collected by Essex during drafting of the NSI Newsletter article and two draft articles prepared prior to the initiation of Task 10 by Mr. Jim Horwitz (ES53) of the MSFC Magnetospheric Physics Branch. These three sources were condensed and combined by Essex into a simple-to-understand text which was reviewed and approved by Dr. Chappell and Mr. Horwitz and submitted to MSFC Public Affairs for typesetting and publication. In response to a request by the Public Affairs Office (PAO), Essex also worked through the Magnetospheric Physics staff to help secure illustrations suitable for the booklet.

When galley proofs of the booklet were made available by the PAO, it was evident that several editing and reorganization changes had been performed on the COR/Essex-approved version of the text, detracting somewhat from the information's technical accuracy and logical sequence of presentation. A reworking of the material was undertaken by Essex in cooperation with Public Affairs Office personnel to arrive at a mutually acceptable and accurate wording of the text. Dr. Chappell reviewed the revisions, and the text was then typeset and published as NASA/MSFC Booklet 1M 978.

The booklet was ready for distribution in December 1978. Copies are available in the lobby of MSFC Building 4200 (as part of the materials set out for visitors to the facility) and may be requested in quantity through the Public Affairs Office.

3.1.4 Speakers Materials on the Magnetosphere

During 1978, Dr. Chappell received and accepted several invitations to speak on the topic of solar-terrestrial physics and the Earth's Magnetosphere. The occasions brought him in contact with audiences of such diverse educational and professional backgrounds as members of official meetings of the Spacelab International Working Group (IWG), university professors and graduate students, public school students, educational television viewers, and members of a local astronomical society.

At each talk, Dr. Chappell relied on several, unmatched slides to help illustrate the physical concepts he was describing. As part of the Task 10 effort, therefore, Dr. Chappell requested that Essex develop a pattern program of slides, building up, step-by-step, a visual image of the Earth's Magnetosphere in a sequence that would be understandable to audiences unfamiliar with the region. This set of slides could be used in part or in whole by him when addressing various groups, and it would also be available to others who might be asked to speak on the subject.

In addition to Essex' submission of ideas for slides, which would be implemented by Mr. Dean Cagle (ET01), Dr. Chappell also requested that a pattern talk be written--a piece that could be used as it was or modified (i.e., made more technical or made simpler) to suit a particular audience. This script would also be made available, along with the slides, to interested persons, thereby making it more convenient for them to accept outside speaking invitations without taking too much time away from their regular daily duties.

This assignment proved to be rather larger than Essex or MSFC had anticipated, and during the 1978 Task 10 work, only the slide outline was completed, after several revisions. At the end of the contract, the script was still in progress and is tentatively scheduled for completion as a first assignment upon approval of the 1979 continuation of Task 10.

Projecting from their present condition, the slides and script together will present a simple narrative and "visual" explanation of what is actually a complex, invisible, and highly influential area around the Earth. It will acquaint audiences with physical phenomena most have never heard of and will help them understand the long-term, public-oriented advantages of pursuing space-based research into solar-terrestrial and magnetospheric physics.

3.1.5 Contact with Periodical Publications

During the latter part of the 1978 Task 10 work, initial inquiries were sent to selected periodicals to determine the proper format and channels for submission of articles on solar-terrestrial physics. Publication of articles in respected popular and professional periodicals was seen as one desirable means for getting information about sun-earth electromagnetic interactions out to a broad segment of the public. Upon approval of the 1979 Task 10 work, these inquiries will be followed up and the entire effort considerably expanded. The content of the articles will be geared toward the interests and education of each publication's customary readership.

3.2 EDUCATIONAL MATERIALS DISSEMINATION NETWORK

Early in the Task 10 effort, the need for a methodical approach to distributing the existing and future solar-terrestrial educational materials was discussed. It was recognized that creation of the materials did not insure that they would reach the people they were intended to inform. For example, a fine film about solar-terrestrial research had been prepared under Dr. Chappell's direction prior to Task 10. The film had been available for public distribution on a free-loan basis for some time, but due to the lack of an aggressive dissemination network, news of its availability had not reached the proper people. To help alleviate this situation, Essex took a two-pronged approach involving: (1) performance of a library survey of regional educational institutions, and (2) verbal and written communications with these institutions.

It was Dr. Chappell's original intent to have Essex work in informal cooperation with Ms. Pace Walker who was involved in creating educational materials relating to solar-terrestrial physics for the University of Texas at San Antonio (UTSA). The materials generated at the two locations would be distinct and separate, but, as the intended recipients of the materials were similar (i.e., the general public), it was felt that it would be economical for both MSFC (through Essex) and UTSA to work together in setting up a nation-wide dissemination network. In response to Dr. Chappell's suggestion, Essex conferred with Ms. Walker and worked out a plan by which each would make the appropriate contacts in specific states and then combine this information into a set of names and addresses that would cover the whole nation. The states were divided, with Essex taking responsibility for the Southern, Eastern and North Central states and Ms. Walker working on the Southwest, Western and South Central states. It was decided to contact educational institutions first.

During the contract period of performance, Essex used library references to accumulate the addresses of public and private school systems and universities in the assigned states. Several of these groups were contacted by telephone to identify the name(s) of the individual(s) responsible for informing the institutions about the availability of new educational materials. Following these telephone inquiries, letters were sent to provide specific information about the "Earthspace" film to the film library/audiovisual resource centers of the institutions. In the case of public secondary school systems, information for the teachers' newsletters was forwarded, so that the science faculty of the different schools would be made specifically aware of the materials (rather than simply listing the film, etc., in the schools' film catalogs to be "discovered" only by chance).

Verbal interest in the film and other materials, as expressed by the film resource coordinators of the public schools, has been gratifyingly enthusiastic. The Atlanta public school system, for example, asked for and received permission to duplicate the film so it could receive wider circulation among that system's 140 schools than would be possible with only one copy on loan from NASA.

This enthusiasm, while rather intangible, is taken as a positive indication of the effort's success. It is difficult to gauge response in terms of film requests, as these must be addressed to the Public Affairs Offices at the various NASA sites providing film loan services to the contacted states (e.g., MSFC PAO for Alabama, JSC PAO for Oklahoma, LSC PAO for Georgia, etc.).

In communicating with universities, the heads of the physics and astronomy departments were contacted, as well as public affairs and audiovisual resources personnel. These contacts resulted in an invitation extended to Dr. Chappell by the head of the physics department at the University of Alabama at Tuscaloosa to come and conduct a colloquium on space plasma physics. The colloquium was well attended by the physics faculty and members of the graduate school.

Essex' initial telephone and written communications also paved the way for the recent extension of an invitation for Dr. Chappell to speak on solar-terrestrial research before the physics department of Vanderbilt University in Nashville, Tennessee.

The cooperative setup of a nationwide educational materials dissemination network did not materialize during the 1978 work due to the relocation of Ms. Pace Walker, Essex' contact with UTSA. Upon approval of the 1979 effort, therefore, Essex will assume responsibility for the states formerly assigned to Ms. Walker and will manage the broadening and maintenance of the network from a single point. As new materials are made available, points in the network already contacted can be advised of the additional resources by means of a simple update service.

3.3 RECOMMENDATIONS

For communicating solar-terrestrial physics news to the largest number of people, Essex concurs with MSFC on the advisability of expanding contacts with popular national periodicals. One published article could reach not merely dozens or even hundreds but literally thousands or tens of thousands of people--and in a manner ultimately more economical for the government and probably more enthusiastically welcomed by the recipients than any other method of news distribution that could be employed. Furthermore, circulation of the magazines to regular subscribers and to purchasers of the magazines at newsstands could, in many instances, allow a solar-terrestrial physics article to reach a nationwide general-public readership. Written in an interesting, lay-oriented, journalistic style and well illustrated, the articles could be instrumental in promoting broader public familiarity and understanding of the sun-earth electromagnetic processes under investigation. Essex, therefore, recommends future emphasis on this avenue for establishing an effective educational communications link between the NASA researchers and the final benefactors of the research--the public.

In this same vein, Essex suggests expanding contacts with the visual and printed news media. Short film clips on the television news and articles published in the science and "Sunday supplement" sections of newspapers would also reach an extremely broad cross section of public readers.

Continued exercise and expansion of the educational materials dissemination network is also recommended by Essex, as this approach can reach a significant student population.

Continued acceptance of public speaking invitations is recommended because of the long-lasting positive public impression such personal contact establishes. Future talks (possibly using the prepared Magnetosphere slides and script to save time) could be delivered by Dr. Chappell or by other persons designated by him.

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4.0 SUMMARY

Spacelab/STS background information, designed primarily for the press, and talks describing the Spacelab 1 experiment goals, written primarily for nonscientific audiences, were prepared by Essex under Task 9 during 1978. Educational materials about solar-terrestrial physics and its potential public benefits were written under the Task 10 effort. In addition, Task 10 included development of a basic network for distributing audiovisual and printed materials to regional secondary schools and universities.

The assignments completed under these two tasks have resulted in the creation and availability of informative, lay-oriented speakers aids, articles, a booklet, and a press kit. All of these items are either already in use or stand ready to help MSFC fulfill its information obligations to the general public.

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APPENDIX A

EXAMPLES OF TASK 9 SPEAKERS MATERIALS

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EXAMPLES OF TASK 9 SPEAKERS MATERIALS

The following pages are taken from the notebook of speakers materials prepared under Task 9. Two examples from that notebook are provided. Example 1 is taken from Area 3 - Materials Science and Technology. Example 2 is taken from Area 4 - Astronomy and Solar Physics.

III. MATERIALS SCIENCES AND TECHNOLOGY (Cont.)

When we say "processing", we're not talking about stirring up some styrofoam and stamping out egg cartons. Materials processing relates to the very micro-scale physical interactions of matter and energy--cellular, molecular and atomic-level interactions. The experiments to be performed involve micro-processes--extremely small interactions which most people would never even think about but which can make a big difference in the quality of the product.

For example, if we drop some crystalline material into a test tube, we consider the two to be separate from each other. But when we heat the test tube to melt the powdered crystals into liquid form, the atoms of the tube itself can interact with the atoms of the melt, contaminating it. ("Contamination" in this sense means the introduction of any impurity.) While this may seem far-fetched and "contamination" with its more vernacular connotations of "ruining" may sound rather severe, if you think about it in a more everyday setting for a moment, you'll see that it is not. If a housewife heats water in an aluminum saucepan, she gets traces of aluminum in the water. The pan won't seem different when she's through and the water will look the same, but some scientists believe enough aluminum cooks out of the pan and into the food prepared in it to affect human health and well-being. Aluminum in the bloodstream is believed to do bad things to the brain cells. So here is an example of a heated liquid "contaminated" by its container.* The fact is, there are no real edges in the universe--only atomic structures which more or less tend to stick together, and only under certain circumstances. Change the circumstances (add heat, for example) and the tendencies can be altered.

(See Viewgraph III-3.)

*Another possible example, not quite the same, might be super-hot coffee served in a styrofoam cup. The container interacts with the liquid a little, causing it to taste a little like plastic. This changed flavor is not noticed when drinking coffee from a ceramic cup, because it takes far more heat to dissolve glass. It doesn't take much heat to dissolve part of the plastic; the coffee itself is hot enough to cause a slight interaction.

Well, now we have a melt which has been made less pure because of contamination by the container it was heated in. We take away the heat source, which has been keeping all this material churning around--not very evenly I might add--and which has been further contaminating it with bubbles of gas from the atmosphere, and what happens? On earth, right away, the heavier components start sinking to the bottom of the container and the lighter ones start moving to the top. So here we are in our spotless, earth-bound laboratory and our white jackets, holding a tube full of contaminated, inhomogeneously layered stuff, which is not at all the pure, evenly mixed specimen we were trying for. If this hypothetical specimen is now used, say, in the manufacture of tiny pieces of electronics gear for a highly sophisticated and expensive computer, the chances of that computer working up to its potential are not good. It's like building a $150,000 home with bricks that turn to powder at the first loud clap of thunder. No matter how carefully a thing is built, if the materials in it aren't right to start with, neither is the finished product.

(See Viewgraph III-4.)

III. MATERIALS SCIENCES AND TECHNOLOGY (Cont.)

The unavoidable presence of gravity on earth is the main cause of these and other materials processing problems. In the weightless or "free fall" conditions aboard an orbiting Spacecraft, however, the gravitational influence is no longer a factor. Spacelab experimenters will, in effect, "turn off" the earth's gravity for the length of time of the flight and study the already complicated interactions of various materials in its absence.

(See Viewgraph III-5.)

III. MATERIALS SCIENCES AND TECHNOLOGY (Cont.)

For example, in space, glass can be melted without having to have a container to catch the melted material. Some scientists refer to a "tubeless test tube". Because the material is weightless, it doesn't "fall down" or spread out when melted. It just floats, rather like the water droplets floated in the shower stall on Skylab. The astronauts practically had to grab the globs of water and rub them on their bodies in order to bathe. And when they were through, they had to vacuum it up, or water balls would have drifted out all over the Skylab interior.

(See Viewgraph III-6.)

III. MATERIALS SCIENCES AND TECHNOLOGY (Cont.)

So-called "containerless" melting will allow the creation of glass of a purity not reproducible by earth-based techniques. Glass for lenses of unparalleled optical properties might be made this way.

(See Viewgraph III-7.)

EXAMPLE 2

IV. ASTRONOMY AND SOLAR PHYSICS (Cont.)

B. Solar Constant and Parts of the Solar Spectrum

Our Sun's power staggers the imagination. While only an average-sized, ordinary type "yellow dwarf", in one second, this star of ours radiates more energy than man has used since the beginning of civilization. Naturally, the Sun's radiant energy streams out into space in all directions at all times, but just the portion that reaches us (about one two-billionths of the total output) would, in three days, deliver as much heat and light as would be produced by burning the earth's entire oil and coal resources and all of its forests. Its core is incredibly dense and hot--16,000,000°C. It has been estimated* that a piece of material the size of a pinhead at that temperature would kill a man a hundred miles away.

(See Viewgraph IV-16.)

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*by Sir James Jean, in his book The Universe Around Us.

The corona (which means "crown") is the name given to the Sun's atmosphere. It is considerably cooler than the core, but is still so hot that it continuously streams out into space, as though the Sun's churning, gaseous surface were completely covered with rocket nozzles, all going off at once. The highly ionized gas and the magnetic field lines that constitute the Sun's expanding atmosphere are what we call "solar wind", and this wind blasts by our planet at almost a million miles per hour.

(See Viewgraph IV-17.)

IV. ASTRONOMY AND SOLAR PHYSICS (B.) (Cont.)

For many years, people thought the sun's radiant output never changed. The term "solar constant" was coined to express this continuous, even radiation. In recent years, however, we have found out that the Sun's radiation does vary with changes in activity on the face of the Sun and, apparently, in consonance with its own 11- and 22-year magnetic cycles. This changing irradiance is of some concern to us.

(See Viewgraph IV-18.)

IV. ASTRONOMY AND SOLAR PHYSICS (B.) (Cont.)

A large body of data has been amassed showing how the incidence of flares on the Sun, for example, correspond to the subsequent incidence of monumental magnetic disturbances on earth, sometimes completely blacking out radio communications so vital to air and marine navigation safety, not to mention jamming standard radio and television broadcasts. Checking records clear back into the 1800's, the occurrence of severe drought in our High Plains area after every other 11-year solar magnetic (sunspot) cycle and the fact that such extensive droughts have not occurred at any <u>other</u> times in between seems more than just coincidence.

(See Viewgraph IV-19.)

Going still further back, people have observed "spots" on the sun for 2000 years that we know of. During the 65 year period between 1645 and 1710, however, there were almost no spots to be seen. For that same period of time, the earth was also unusually cold--it's been called the "Little Ice Age." When the sunspots resumed, the temperature on earth went back up.

(See Viewgraph IV-20.)

IV. ASTRONOMY AND SOLAR PHYSICS (B.) (Cont.)

So, variations in solar activity, conveyed to us over 93,000,000 miles, appear to have important effects on earth weather and climate. Changes in solar irradiance of a fraction of a percent could bring about responses on earth. A drop of one percent could cause a corresponding drop of 6°C in mean global temperature. One climate model predicts that if the sun's irradiance dropped by as much as six percent, the earth and all the oceans would be covered with ice. A drift of approximately <u>one-half</u> percent per <u>century</u> would suffice to explain the Little Ice Age.

(See Viewgraph IV-21.)

Solar physicists have long recognized the importance of knowing what the total solar irradiance _is_. Getting instruments above the atmosphere has been a tremendous boon in this respect.

Measurements made from the ground have not been precise enough. Our atmosphere blocks the Sun's radiation in many parts of the spectrum--ultraviolet and X-ray in particular. When measurements are made from the ground, "fudge factors" have to be thrown in to account for this atmospheric attenuation, and this leaves the precision of the measurements themselves no more accurate than ±1%. Now, that may sound pretty good, but as we have said, variations in solar radiation of _less_ than one percent can make a difference here on earth.

We can't know if the Sun's irradiance varies in the future unless we know exactly what it is _now_. We believe our instruments are sensitive enough to make precise measurements, but we must get them above the atmosphere--the same instruments, calibrated the same, flown many times and for long periods of time over about a ten-year period--to collect the information necessary to establish a mean total irradiance figure from which to base future comparisons. And that's where Spacelab comes in.

(See Viewgraph IV-22.)

IV. ASTRONOMY AND SOLAR PHYSICS (B.) (Cont.)

Two solar experiments planned for Spacelab 1 will measure the irradiance of the Sun from far ultraviolet through visible light to far infrared. In future reflights of the same equipment, the measurements will be repeated to check for subtle changes and trends.

A third solar experiment on Spacelab 1 will determine in which wavelengths of the solar spectrum changes occur. Variability in the wavelengths below 300 nanometers* affects mostly the dissociation of ozone and the chemical equilibrium of the stratosphere (the second atmospheric layer above the earth). Variability in the part of the spectrum above 700 nanometers would mostly affect water vapor and carbon dioxide absorption in the thermosphere (the first and closest layer of our atmosphere).

So, to make predictions about changes in the earth's atmosphere, we need to know not only what differences may occur in the Sun's total output but also in what parts of the spectrum these changes occur. Certain activities on the Sun could cause increases or decreases in ultraviolet output, or infrared, or X-ray, and these would influence what sort of responses we could expect by our terrestrial atmosphere.

(See Viewgraph IV-23.)

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*A nanometer is one-billionth of a meter.

ESSEX

APPENDIX B

ARTICLE FOR NSI NEWSLETTER

Solar Wind: *Magnetic Lines That Could Aid Weatherman*

Dateline 1980, Earth Orbit— , Scientists aboard Spacelab have begun experiments to observe the effects of tiny supersonic solar particles that have traveled 93 million miles from the sun in only two days.

"Particles from the sun affecting the weather . . ." Sound outlandish? Not so, says Dr. Rick Chappell of NASA's Marshall Space Flight Center in Huntsville, Ala. According to the Spacelab I mission specialist, electrically charged particles are continuously accelerating away from the sun's seething surface, dragging the solar magnetic field lines along with them. They pull and travel along these solar highways until they encounter the earth's magnetic field. Then, the particles and both the solar and earth magnetic field lines undergo complex interactions which more and more scientists speculate may influence widespread weather changes and even long-term shifts in climate.

Solar Wind Connection

We are only beginning to understand this remarkable sun-earth interaction. With space age technology, we were able to confirm that the earth lies not only in the path of visible light and other, invisible forms of radiation from the sun but also in the way of streaming, ionized particles, or "plasma." These particles and the interplanetary solar magnetic lines they follow are what we call "solar wind."

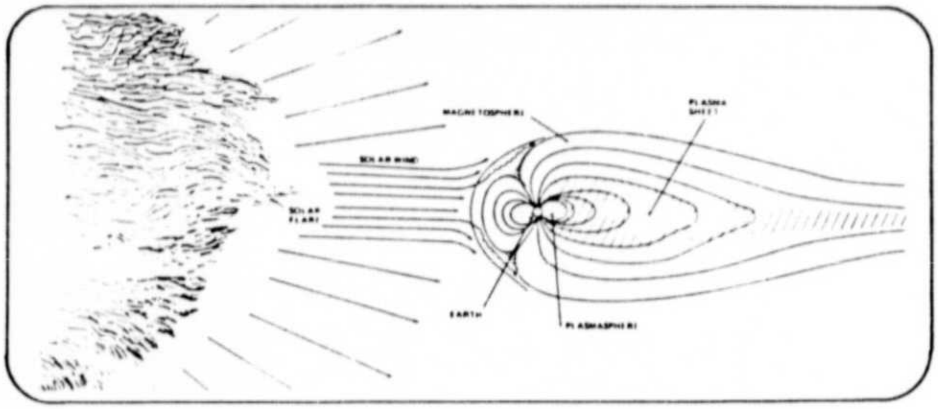
The sun's overall magnetic field is always in effect and solar emissions are occurring all the time. Nevertheless, special magnetic disturbances on the sun—things like sunspots and so-called "holes" in the sun's corona—cause measurable increases in the speed of solar particles reaching earth. The greater the solar magnetic and particular disturbance of our magnetosphere, the greater the changes in our weather, but how this happens remains obscure.

It's a Start

Basically, this is what we know. Solar wind streams radially out into space as if the sun were covered with rocket nozzles all going off at once. The particles and field lines that come toward the earth cause some strange changes in the shape of our own magnetic field, or "magnetosphere."

Because of the earth's molten metal core, strong magnetic lines stretch out near the south pole and curve back in near the north pole. Under ideal conditions, the earth's magnetosphere should, therefore, look like a giant doughnut, but the ram pressure of the solar wind causes its shape to be more like a comet—hemispherical on the sunward side and swept out into a long tail on the nightside.

The charged particles in solar wind push against the sunside of the magnetosphere but they can't easily enter it there (see illustration). In the elongated tail, however, a significant quantity of solar plasma does enter and become trapped along the field lines. There it remains until the plasma sheet that separates the upper and lower halves of the tail is thrown out of balance by sudden changes in the solar wind.



When this happens, the earth's field lines are squeezed together momentarily allowing them to link and snap back toward the earth, carrying along the trapped plasma particles. This surprising "back door" injection causes brilliant auroral displays an massive magnetic storms.

By some subtle, trigger-like interaction, changes in the solar wind also appear to influence our weather, though this relationship is far from proven. If we assume for a moment that it does exist, there are still a lot of questions. The most immediate stumper is the mechanism responsible for the interaction. Scientists haven't figured out how solar magnetic particles which penetrate our magnetosphere only as close as about 100 kilometers from the earth can impact our lower atmosphere, which extends upward only to about 10 kilometers. It is in this lower region where the events we commonly associate with "weather" occur, yet the solar magnetic field lines and particles do not reach this area and their energy seems too small to set off a chain reaction. It's a mystery.

We have discovered about all we can about this elusive but very important phenomenon from a terrestrial point of view. The major breakthroughs during the last twenty years have occurred because our space program has offered the opportunity to employ both manned spacecraft and high-orbiting automated satellites to reach positions of observation outside the obscuring effects of our lower atmosphere. By the mid-70's, for example, we had discovered coronal holes, realized that these invisible solar regions were causing changes in the solar wind, and that solar wind, in turn, was affecting the earth's magnetosphere.

The experiments planned for Spacelab present a chance to discover important new clues to the mystery.

With the special research capability of the Shuttle and Spacelab, scientists will be able to fly experiments that can take simultaneous measurements of both solar changes and the resulting fluctuations in the earth's magnetosphere and atmosphere over a period of days. Another type of study will involve using Spacelab to inject artificially ionized particles into the magnetosphre and then record what occurs in this miniature imitation of auroral particles (i.e., the beams of electrons that are the magnetospheric remains of the solar wind).

The Payoff of Finding Out

We know that there is a connection between solar magnetic activity and solar wind and fluctuations in the earth's magnetic field. If we determine that these fluctuations do indeed result in weather changes, we will have developed an invaluable prediction tool. The subsequent ability to make accurate, long-term weather and climate predictions could benefit virtually every person on earth.

The technology to resolve the mystery of the effect of the solar wind on our weather exists through the space program. As Dr. Chappell points out, to reap the tremendous possible benefits, the next step is to go and find out.