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SCIENCE INFORMATION SYSTEMS NEWSLETTER

April 1993
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NASA Forms Three Science Offices From OSSA

On March 11, 1993, NASA Administrator Dan Goldin announced the reorganization of the Office of Space Science and Applications (OSSA) into three new science program offices: the Office of Space Science (OSS, Code S), the Office of Mission to Planet Earth (Code Y), and the Office of Life and Microgravity Science and Applications (Code U).

The Office of Space Science is comprised of the following elements: the Astrophysics Division, the Solar System Exploration Division, the Space Physics Division, and the NASA Resident Office at the Jet Propulsion Laboratory (JPL). A Technology and Information Systems Office, a Launch Vehicle Office, and an Administration and Resources Division have also been formed. This new organization will also have institutional management responsibility for the JPL contract. OSS is headed by Wes Huntress, who succeeds Len

NASA

The recent reorganization of the Office of Space Science and Applications created three new science program offices—the Office of Space Science (OSS) managed by Wes Huntress (second from left), the Office of Life and Microgravity Science and Applications led by Harry Holloway (third left), and the Office of Mission to Planet Earth managed by Shelby Tilford (far right). The Information Systems Branch, directed by Joe Bredekamp (far left), was transferred to the newly established Technology and Information Systems Office in OSS.

The purpose of the INFORMATION SYSTEMS NEWSLETTER is to inform the space science and applications research community about information systems development and to promote coordination and collaboration by providing a forum for communication. This quarterly publication focuses on programs sponsored by the Information Systems Branch in support of NASA's Office of Space Science. Articles of interest for other programs and agencies are presented as well.

Fisk, currently the NASA chief scientist. Later this summer Fisk will join the faculty at the University of Michigan in Ann Arbor. Al Diaz has been named deputy associate administrator for OSS and Katy Schmoll will act as the assistant associate administrator for management.

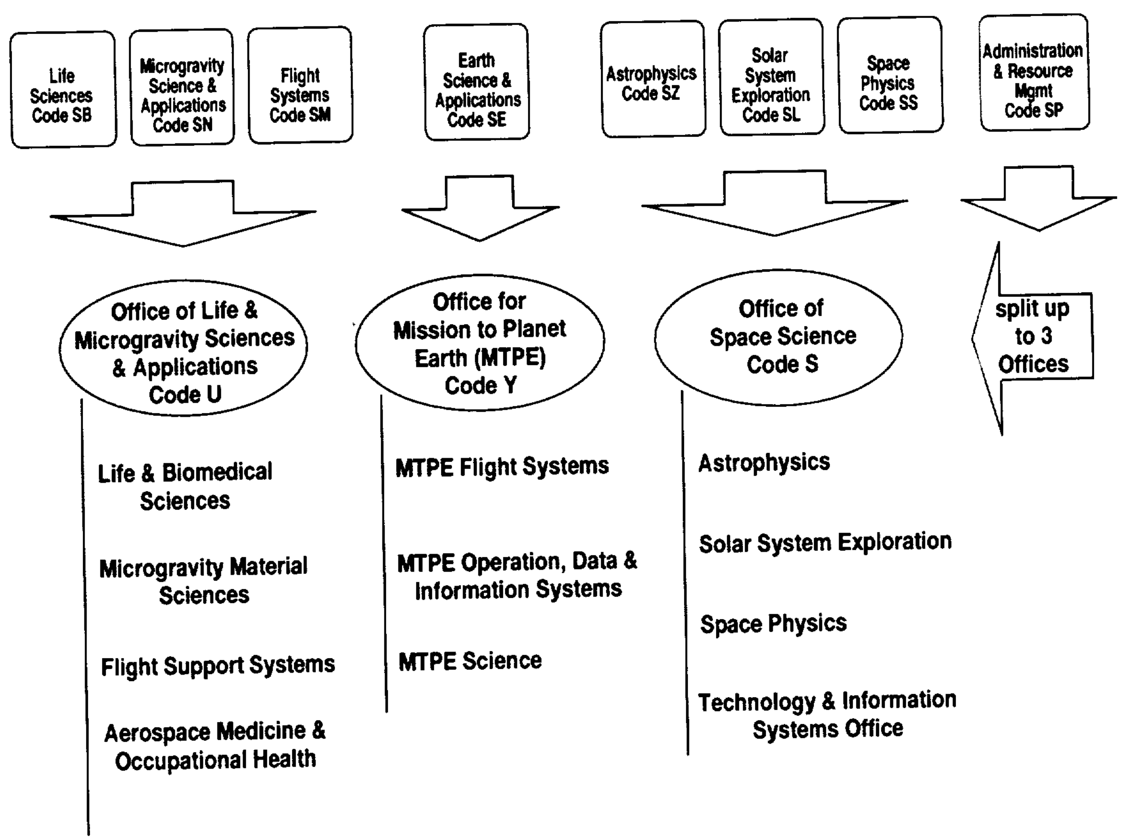
Shelby Tilford, as acting associate administrator, will lead the Office of Mission to Planet Earth (MTPE). The components of this office are: the MTPE Flight Systems Division, the MTPE Operation, Data, and Information Systems Division, and the MTPE Science Division. An Institutional Management Office, a resource Management Office, a Policy Coordination Office, and a Technology Innovation and Advanced Planning Office will also be formed. This new organization will also have institutional management responsibility for the Goddard Space Flight Center.

The Office of Life and Microgravity Science and Applications, led by Harry Holloway, is made up of: the Life and Biomedical Sciences Division, the Microgravity Material Sciences Division, the Flight Support Systems Division, and the Aerospace Medicine and Occupational Health Division. Assisting Holloway in the formation of the office is former astronaut Bonnie Dunbar. The Deputy Associate Administrator for the space flight activities of this office is Arnauld Nicogossian.

In the reorganization, the Information Systems Branch (former Code SMI) was transferred as a unit to the newly established Technology and Information Systems Office within OSS. "The intent is to preserve to the maximum extent possible the current functions of the Branch and continue to conduct them as a coherent, integrated whole, providing support to all three science programs (Codes S, U, and Y)," said Joe Bredekamp, chief of the Information Systems Branch.

The budget responsibility for the scientific computing portion of the program will be transferred to the Office for Mission to Planet Earth, based on the fact that this science program office is likely to have the most demanding requirements for computing. The Information Systems Branch will continue to serve all three science programs to coordinate the NASA High-Performance Computing and Communications Program with the Office of Aeronautics, Exploration and Technology (Code R).

The Information Systems Management Board will continue to play a key role in coordinating all information systems activities. The Board will be comprised of members from



OSSA reorganization

all three science program offices, and will be chaired by a senior-level manager from one of the three offices on a rotating basis. The Board is currently chaired by Joe Alexander, the former assistant associate administrator to OSSA. Alexander left NASA to become the associate director of Space Sciences (Code 600) at the Goddard Space Flight Center.

"The importance of this Board for resolving issues, setting policy, determining priorities, and assessing program performance will only increase in the future in dealing with issues that not only span science disciplines but program offices as well," said Bredekamp.

Final implementation of the reorganization of OSSA is expected to occur by June 1, 1993.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1994 BUDGET SUMMARY
(Millions of Dollars)

	FY 1993	FY 1994
RESEARCH AND DEVELOPMENT	7,089.3	7,712.3
SPACE STATION & NEW TECHNOLOGY INVESTMENTS	2,122.5	2,300.0 1/
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	649.2	649.2
Spacelab	114.4	139.9
Engineering & Technical Base	214.2	203.4
Payload Operations & Support Equipment	131.5	95.4
Tethered Satellite System	3.4	—
Advanced Propulsion Technology	10.0	—
Advanced Programs	32.9	60.7
Research Operations Support	142.8	149.8
SPACE SCIENCE	1,577.5	1,631.9 2/
PHYSICS & ASTRONOMY	1,103.8	1,074.7
Advanced X-Ray Astrophysics Facility	168.3	260.3
Global Geospace Science	72.6	13.3
Gravity Probe-B	1.9	40.0
Shuttle/Spacelab Payload Mission Management & Integration	94.1	(117.7)*
Payload & Instrument Development	99.3	53.4
Explorer Development	115.8	123.3
Mission Operations & Data Analysis	415.4	416.2
Research & Analysis	71.6	72.2
Suborbital Program	64.8	69.5
Information Systems	—	26.5*
PLANETARY EXPLORATION	473.7	557.2
Cassini	205.0	266.6
Mars '94	3.5	3.5
Mission Operations & Data Analysis	163.5	160.7
Research & Analysis	101.7	126.4*

1/ The President has directed NASA to undertake an intense effort to redesign the Space Station. Funding for the Space Station, activities which support utilization of the Space Station, and other initiatives to stimulate the development of new technology is included in the Space Station and New Technology Investments line. Details of these activities will be provided in June as part of the redesigned Space Station package.

2/ The Office of Space Science and Applications budget has been reorganized into three separate program offices — the Office of Space Science, the Office of Life and Microgravity Sciences and Applications, and the Office of Mission to Planet Earth. An accompanying crosswalk displays the restructured budget starting in FY 1994.

*See Space Science & Applications Budget Crosswalk next page

All articles and photographs without bylines were written and taken by the editor, Sandy Dueck. Editorial assistance was provided by Lynn Koert, Goddard Space Flight Center and Pat Kaspar, Ames Research Center.

Readers are invited to contribute articles to the INFORMATION SYSTEMS NEWSLETTER. *Contributions should be sent electronically to the editor— NASAmail- SDUECK; NSI DECnet- JPLPDS::SDUECK; Internet- sdueck@nasamail.jpl.nasa.gov*

Changes of address should be sent to—Sandy Dueck, Jet Propulsion Laboratory, 4800 Oak Grove Drive, M/S 168-514, Pasadena, CA 91109. For inquiries phone (818) 354-5073.

Newsletter layout—Robin Dumas, JPL Graphics.

	FY 1993	FY 1994
LIFE & MICROGRAVITY SCIENCES & APPLICATIONS	140.5	351.0
Research & Analysis	53.9	49.2
Flight Experiments	86.6	94.7
Subtotal Life Sciences	**140.5**	**143.9**
Research & Analysis	(17.9)	18.4*
Flight Experiments	(155.1)	71.0*
Shuttle/Spacelab Payload Mission Management & Integration	(94.0)	117.7*
Subtotal Microgravity Research, Transferred Programs	**267.0**	**207.1**
MISSION TO PLANET EARTH	1,148.0	1,074.9
Earth Observing System (EOS)	263.8	322.7
EOS Data Information System	130.7	182.7
Earth Probes	99.4	97.3
Payload & Instrument Development	35.4	22.9
Mission Operations & Data Analysis	147.6	160.8
Research & Analysis	166.2	181.5
Airborne Program	20.7	25.2
Space Communications	4.0	3.0
Information Systems	—	11.8
Research Operations Support	70.1	67.0
Subtotal Mission to Planet Earth	**937.9**	**1,074.9**
Materials Processing	172.9	(89.4)*
Information Systems	36.2	(26.5)*
Search & Rescue	1.0	(1.1)*
Subtotal, Transferred Programs	**210.1**	**(117.0)**

*See Space Science & Applications Budget Crosswalk

SPACE SCIENCE & APPLICATIONS

FY 1994 Congressional Budget Crosswalk (Millions of Dollars)

OLD STRUCTURE

	TOTALS	Physics & Astronomy	Planetary Exploration	Life Sciences	Space Applications
	3,058.9	1,165.9	546.7	154.4	1,191.9
NEW STRUCTURE	3,058.9				
SPACE SCIENCE	1,631.9				
Physics & Astronomy	1,074.7	1,048.2			26.5
Programs that did not change	1,048.2	1,048.2			
Information Systems	26.5				26.5
Planetary Exploration	557.2		546.7	10.5	
Programs that did not change	430.8		430.8		
Research & Analysis	126.4		115.9	10.5	
LIFE AND MICROGRAVITY SCIENCE AND APPLICATIONS	351.0	117.7		143.9	89.4
Shuttle/Spacelab Payload Msn. Mgmt.	117.7	117.7			
Life Sciences Research & Analysis	49.2			49.2	
Life Sciences Flight Experiments	94.7			94.7	
Microgravity Research & Analysis	18.4				18.4
Microgravity Flight Experiments	71.0				71.0
MISSION TO PLANET EARTH	1,074.9				1,074.9
Programs that did not change	1,074.9				1,074.9
USE OF SPACE	1.1				1.1
Rescue	1.1				1.1

New Changes to TAE Software

Elfrieda Harris, TAE Support Office, Goddard Space Flight Center

TAE Plus V5.2 became public from COSMIC in 1993, and the development team has been busy finishing up an assortment of ports to different UNIX platforms and beginning the port to the VAX/VMS environment. Also, as workstation vendors begin updating their software to X11R5 and Motif 1.2, we will begin porting to these environments. The first of this group is HP, whose latest operating system release (R9.0) includes Motif 1.2 and X11R5. By the time you receive this newsletter, we expect TAE Plus V5.2 will be operational in this new HP environment.

In addition to the new changes to the TAE software, the last few months have been a time of change for the TAE Project—first in the NASA project management and second, in the distribution of future TAE Plus software. In January, after nine years of managing the project, Marti Szczur accepted the position as head of the Software and Automation Systems Branch within Goddard's Data Systems Technology Division (Code 522) and Chris Rouff has become the new project manager. Chris has worked at Goddard since 1991. He graduated from the University of Southern California with a Ph.D. in computer science and for his dissertation he developed a user interface management system (Reduced Programming Prototyper) and a user interface specification called Interface Representation Graphs.

Prior to taking on the TAE project management, Chris was involved in developing a graphical user interface for a simulation tool and heading up a NASA special interest group on software engineering. The TAE team is extremely pleased that Chris will be leading the project and feels that he will bring a wealth of academic training and fresh ideas to the TAE Plus development effort.

The other big news involves the decision to grant exclusive distribution rights of future TAE Plus software (post V5.2) to the prime development contractor, Century Computing, Inc. The rationale for commercializing the TAE Plus software is directly related to its success as a user interface development tool. The popularity and demand for TAE Plus has led to an obvious increase in user support activities (e.g., maintenance, user support/training, upgrades, ports to new platforms). While we love the growth in our user community, it has been stretching our resources at Goddard. TAE Plus has become a robust, mature product, and upon careful evaluation, it appears the TAE user community will be better served by TAE Plus becoming a commercial product. How is that, you might ask? Well, as a COTS tool, users can anticipate more frequent releases, expanded support and training capability, commercial influence on features and quality, and improved reliability.

The first commercial release of TAE Plus will be TAE Plus V5.3, which is scheduled for release in the third quarter of 1993. This version will combine new features required by NASA users, as well as Century-developed enhancements derived from industry needs into a single release.

Century's philosophy is to maintain the NASA approach of offering a high-quality product at a reasonable cost. Century will also provide discounts to government and university users. Because of NASA's investment in TAE Plus for more than 10 years, the agreement with Century provides for Goddard to receive a copy of each commercial release of TAE Plus (subsequent to V5.2) free of charge, and Goddard has the perpetual right to distribute TAE Plus to any Goddard-funded project. For a period of up to 5 years following the Century release of V5.3, Goddard also retains the right to distribute the commercial version of TAE Plus to any NASA-funded project. The source for receiving this copy will be through the Goddard TAE Support Office.

Century Computing, Inc. will be providing support and training options for their customers. The bonus for the TAE Plus community is that with Century's experience in developing, implementing, maintaining and documenting TAE software over the past 10 years, you can be assured that your questions will continue to be answered promptly and accurately. Also, after the release of TAE Plus V5.3, Century will become the publisher of the *TAE Newslet-*

TAE

Transportable

Applications

Environment Plus

The Transportable Applications Environment (TAE) Project provides integrated software tools and executive services to support a variety of applications within the NASA community. TAE Plus is a portable software development environment designed to support rapid building, tailoring, and management of user interfaces for graphic-oriented applications. TAE "Classic" is an executive program that binds a system of application programs into a single, easily operated whole and supports user operation of programs.

Calendar

MAY

10-11	Workshop on the International Coordination of the Exploration of Mars, Wiesbaden, Germany; Telephone: 49-5556-1440; Fax: 49-5556-4709
10-12	National Geo-Data Policy Forum: Influencing U.S. Policies Governing Spatial Data, Washington, DC; Brenda Abrams: (301)929-3318
15-17	Workshop on the Analysis of Interplanetary Dust, Houston, TX; Program Services Dept.: (713) 486-2150
24-28	American Geophysical Union Spring Meeting & Special Session on Scientific Visualization, Baltimore, MD: (202) 462-6900

JUNE

01-03	Community-Wide Workshop on NASA's Space Physics Data System, Houston, TX; Rikhi Sharma: (202) 479-0750
14-17	Tenth TAE Users' Conference, Goddard Space Flight Center, Greenbelt, MD; TAE Support Office: (301) 286-6034
21-24	NASA's 1993 Space Station Freedom Utilization Conference, San Francisco, CA; Information: (202) 479-5242
27-9 July	Computer-Aided Analysis of Rigid and Flexible Mechanical Systems, Troia, Portugal; Manuel Seabra Pereira: (351) (1) 8473437, Internet—D1023@beta.ist.pt

AUGUST

01-06	SIGGRAPH 93, Anaheim, CA; (312) 321-6830
03-06	Applied Information Systems Research Program (AISRP) Workshop III, Boulder, CO; Glenn Mucklow: (202) 358-2235
24-26	Land Information From Space-Based Systems, Twelfth William T. Pecora Remote-Sensing Symposium, Sioux Falls, S. Dak.; Robert Haas: (605) 594-6007

ter and host of the TAE User Conferences. Goddard and NASA users will have the option of purchasing a support license directly with Century or utilizing the services of the Goddard TAE Support Office, which retains the right to support any NASA-funded projects.

The Advanced Technology Division at Goddard will continue to be involved in TAE Plus after Version 5.3 is commercially released. Because of the numerous NASA TAE user sites, we will still be developing new user interface development capabilities to be used in conjunction with the TAE Plus tool, and, when applicable, these functions could become available to the public (either as a part of the TAE Plus commercial release, on an anonymous FTP or as a software product available from COSMIC.) A TAE Advisory Board, made up of representatives from Century, NASA, industry, university and other government agencies is being established. This group will provide recommendations about future enhancements and oversee development efforts such that enhancements converge into a single TAE Plus product and not hybrid systems (e.g., UNIX a la Berkeley and AT&T System 5).

We also intend to investigate and explore new directions with future user interface technologies, which may or may not find their way into TAE Plus. For example, voice/speech/video technologies, intelligent user interface development tools, integration of User Interface Management System and CASE environments, and utilization of 3-D objects in space operation applications are all candidate domains of interest to us.

The TAE Project Office, the TAE Support Office and Century Computing are all available to respond to any questions, concerns or comments you might have. Also, at the TAE Users' Conference being held June 14-17, more details will be discussed and all of us will be available for answering questions. The Conference will be held at Goddard, thus enabling us to host the meeting for *no fee*. This informal conference will include panel sessions, tutorials, and demonstrations. For more details contact the TAE Support Office at: (301) 286-6034; Internet: taeso@postman.gsfc.nasa.gov

Evolution of a Scientific Visualization Studio

Carol Boquist, James Strong, and Dave Pape, Goddard Space Flight Center, Code 932, and Trisha Cunningham, HSTX

Scientific visualization enables scientists to observe data in a manner that allows them to perform insightful analysis and enhance understanding of observed phenomena. At the NASA Center for Computational Sciences (NCCS) Scientific Visualization Studio (SVS), scientists use leading-edge graphics techniques to generate animations of data to observe motion or changes.

The Space Data and Computing Division (SDCD) at Goddard began making movies of scientific data in the mid-1980s. These visualization capabilities proved to be useful to the scientific community, and so, in the late '80s, the SDCD created the visualization studio. As technology became more readily available, the studio became a resource as important to scientists as their own computational facilities.

Sequence animation

In the early '80s, visualization capabilities in the SDCD were limited to flickering and viewing stereo images with colored lens glasses. (Flickering is the process of sequencing two or three images in rapid succession.) These techniques provided a limited ability to observe depth, motion, or changes. The need to observe a long sequence of images was later met through the use of video recording in the mid-1980s.

Scientists obtain Earth and space science data in several observations over a period of time. A rapid display of data images in sequence, often referred to as animation, allows researchers to quickly observe and analyze phenomena involving changes or motion. The ability to visualize complex objects in motion enables researchers to discriminate and locate structures within an object. These structures might otherwise remain unnoticed. Animation can also expose processing problems that ordinarily would not be observed.

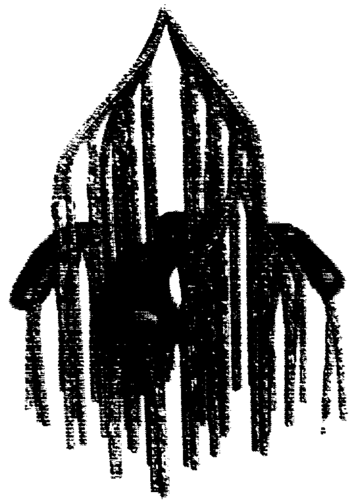
Visualizing the third dimension

In the late '80s, the NCCS's first foray into animating the third dimension was a "flyby" animation that takes the viewer on a three-dimensional journey through surface datasets. A flyby can provide valuable information about the relationship between elevations and the surface data. One of the first applications of this capability enabled researchers to evaluate the accuracy of elevation information derived from an automatic stereo image analysis program operating on a pair of synthetic aperture radar images of a region near Bangladesh.

In the early '90s, 3-D imaging subsequently became more sophisticated, including volumetric rendering with color, shading, and transparency. Volumetric rendering was first used to observe the shell of exploding particles from the Crab Nebula. Images of the nebula were taken in a sequence of spectral bands. The light from irradiating particles traveling toward Earth was shifted toward the blue end of the spectrum and appeared in the first images of the sequence. Light from particles traveling away from Earth was red-shifted and appeared in the last images. By "stacking" the image in three dimensions it was possible to observe the particles in the exploding shell.

SVS personnel developed software for viewing the spectral images as if they were stacked in layers forming a cube. The transparency of the data layer was controlled by the brightness of the pixels. This made it possible to see through low brightness data. Twenty-seven spectral images of the Crab Nebula were viewed using this graphics technique.

Each layer was assigned a color along the spectrum from red at the longest wavelength, to blue at the shortest wavelength. By adjusting



GSFC

Evolutionary Model: The evolution of the degree of two traits (horizontal plane) with respect to time (vertically downward) as mutations and survivability of the species are modeled.

the threshold brightness below which the pixels became transparent, the shell structure of the expanding particles became evident. With the movie-making capability of the SVS, the cube of data could be viewed while rotating, making the shape of the shell structure more obvious. The colors of the layers helped delineate front and back surfaces of the shell.

Recently, the SVS produced volume rendering of a 3-D particle model of solar-wind interaction with the magnetosphere. The data collected reflects the Earth's effect on the particle density in the solar wind. The flow patterns that develop can only be clearly recognized when the results are rendered in the form of a 3-D movie. The movie shows a high concentration of ions between the Earth and the Sun and a pocket of low ion density behind the Earth.

The SVS today

After establishing the movie-making facility, the SVS began providing interactive visualization tools. Interactive visualization is a particularly informative and useful method of data analysis. It takes advantage of the learning patterns of the human mind. People learn and conceptualize most effectively in an interactive environment. Workstations available in the SVS provide the opportunity for researchers to move and rotate visualized data. This can greatly enhance understanding of the information. For instance, when visualizing ozone in the atmosphere, using a mouse control, the scientist can travel around regions containing a certain percentage of ozone.

The SVS has produced hundreds of animated sequences, each featuring up to 3000 images for scientists since operations began. These sequences have spanned the research spectrum, including models, data, simulations, and comparisons of actual data to model predictions. Today, it is not unusual for scientists to do their modeling overnight and walk away with an animation of their results the next morning.

Sequences are generated by scientists at Goddard or other facilities, by SVS personnel, or by visiting scientists. Sequences generated at other facilities are transferred to the SVS via the network. SVS personnel record the images one frame at a time on an optical video disk. The sequences are then played back at rates up to 30 frames per second from the disk and recorded on videotape in VHS, S-VHS, U-matic, or BetaCam SP formats. Sound can be added to taped sequences by using dubbing hardware and software on the SVS's SGI Indigo workstation.

Today, under the auspices of the NCCS, the SVS provides services for the most varied visualization challenges in astronomy, atmospheres, climate evolution, and global change. High-resolution, full color, shading, interactivity, and 3-D perspective views all contribute to the high-quality visualizations. High-speed network connections to the NCCS Cray and mass storage enhance the ability of the SVS to provide visualization tools and products to users of the NCCS facilities.

SVS capabilities

The NCCS provides graphics workstations, interactive graphics software, and various output devices for scientists to use in analyzing and displaying datasets as well as creating animations. SVS personnel provide consultation and assistance to scientists who want to visualize data for maximum information content.

SVS personnel are ready to help scientists use the software and hardware resources and can produce polished, final animations. In cases where complex graphics are desired, a person knowledgeable in visualization techniques can be assigned to work one-on-one with a scientist to create the necessary imagery. For additional information contact the Scientific Visualization Studio at: (301) 286-4101.

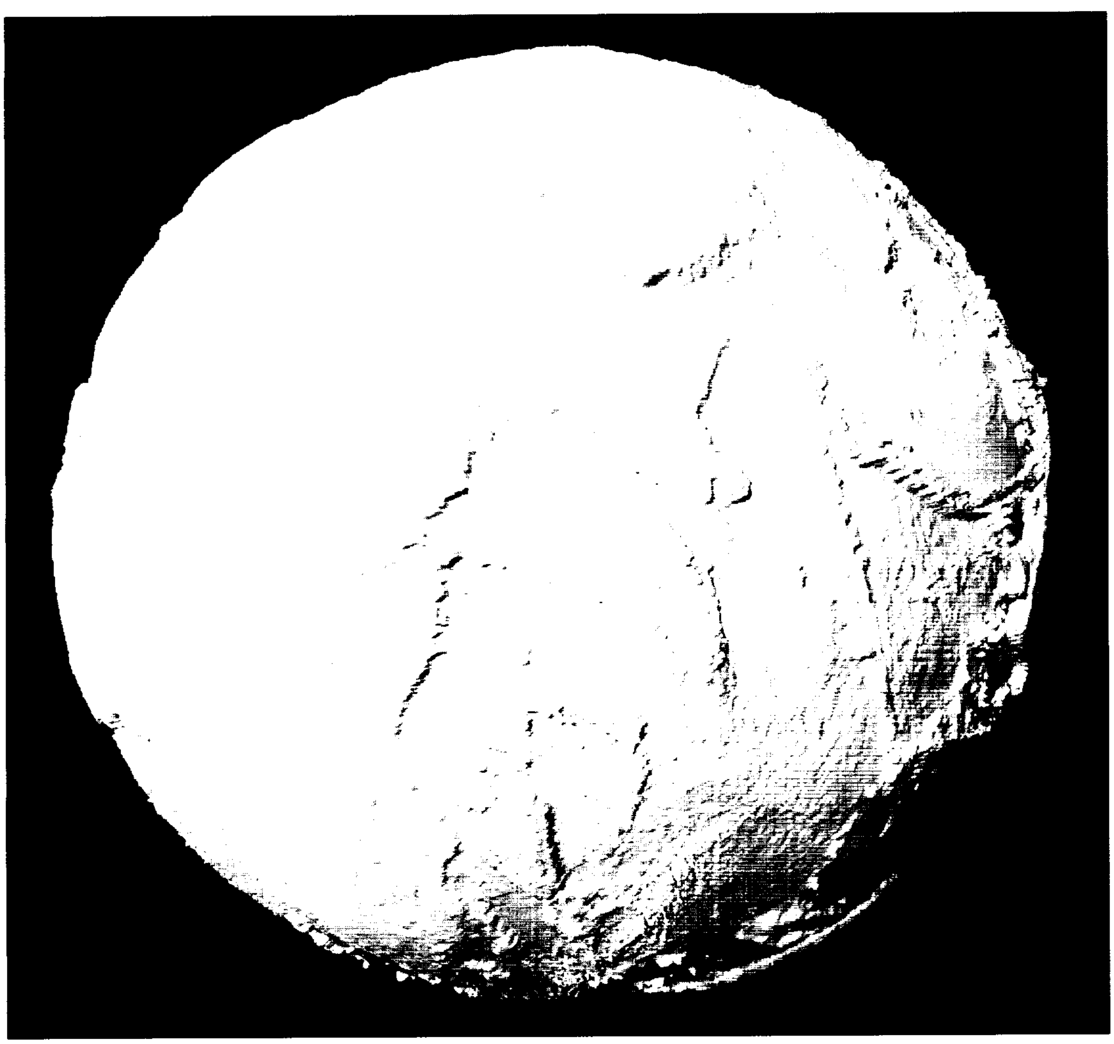
New SVS Opportunities

The SVS has recently received funding for two projects that will advance the utility of satellite data by making data more comprehensible to scientists, lay persons, and children alike.

The objective of the first project is to enhance the highly interactive visualization program FAST, by creating an illusionary "real world" environment for analysis of data and model output. To create the illusion, you wear a helmet or goggles that simulate immersion into a computer-generated environment that contains the 3-D dataset. This method allows you to interact with your model in the same way that you interact with the standard 3-D world—through binocular vision and physical movement. This addresses two deficiencies in standard displays: a 2-D model image may be obscure or confusing if the 3-D model is complex; and often, the more generalized and versatile the visualization tool, the harder it is to use. Binocular vision clarifies the complex model, while movement simplifies the user interface.

The goal of the second project is to develop, in house, a professional quality, clear, and engaging educational movie about the Earth's atmospheric circulation for use in junior high school curricula. Taking advantage of Goddard's Earth science datasets, SVS personnel will convert information and research results into a movie composed of topic modules, each of which will convey one piece of information about the Earth. The modules can be used as building blocks for other movies with different themes. Under this project, two or three modules will be created.

During this experience investigators will document what people, skills, data processing, computer graphics, and video techniques are needed to make a complete movie, and to help gauge realistic budgets for similar projects.



GSFC

Naked Earth: Without water, the oceanic ridges are easily seen. The upwelling of the Himalayas, Alps and Carpathian Mountains—a consequence of the movement of the Indian and African plates—is obvious in this image.

NSI

NASA Science Internet

The NASA Science Internet program develops and operates computer networks for NASA's space science and applications community to enable researchers worldwide to connect to science databases, computational resources, and to each other for collaboration.

NSI Establishes First Real-Time Video Link Between U.S. and Antarctica

Mark Leon, Ames Research Center

On November 24, 1992, NASA Science Internet (NSI) engineers implemented the world's first real-time video link between McMurdo Station in the Antarctic and the continental United States. This link was also the first real-time video transmission accomplished from such a low latitude.

The effort, which built upon NSI's existing Antarctic high-speed data communications infrastructure, was a response to last-minute requests from major television networks for live coverage of NASA's Mars analog experiments in Antarctica. Ames exobiology scientists are studying the sediments beneath the Antarctic's frozen lakes using telepresence technology as a precursor to exploration of Mars. Telepresence allows them to remotely operate a video camera mounted on a robot (a mini-submarine) beneath the Antarctic ice. Researchers at Ames Research Center wearing video headsets control the camera by their head movements.

To meet broadcast requirements for bidirectional video, NSI employed laser, microwave, and satellite communication links as well as a variety of video codexes and multiplexers. NSI implemented several different network configurations within a short period of time to accommodate requirements for both live broadcasts and scientific experimentation. The 764-Kbps link to McMurdo Station provides for Internet data, official and toll phones, and compressed full-motion video. NSI also provided technical assistance in setting up the local and wide area network allowing for long-term support for science. Because many NASA science disciplines have experiments in the Antarctic, this link will be a valuable tool in accomplishing their science goals.

NSI engineers indeed faced Mars-like problems, including a severe time constraint, lack of sleep, lack of resources, nonstandard

Carol Stoker (left), ARC, and Robert Wharton, Desert Research Institute, with the Remotely Operated Vehicle at Lake Hoare, Antarctica.

interfaces, and the harsh environment of Antarctica, which took its toll on both equipment and personnel. The success of the mission is attributed to the excellent teamwork and cooperation of staff both in the Antarctic and at home including that of the National Science Foundation, the Marshall Space Flight Center Program Support Communications Network, Ames Research Center, and NSI. The problems encountered and the solutions developed in establishing a communications network in a harsh and isolated environment provide valuable insights into the conditions space explorers will encounter in planetary exploration.

New Network Information Center Supports Advanced Applications

Elizabeth Feinler, NASA Science Internet, Ames Research Center

The new Network Applications and Information Center (NAIC) began operations on March 29 under the Advanced Network Applications Section (ANA) at Ames Research Center. This is the first step in enhancing NASA Science Internet network user support by evolving from a single Network Information Center toward a coordinated NASA-wide support system of distributed network information Center NICs (CNICs). Each CNIC will be colocated with the center's science users, and thus will be more familiar with those end-user's special environments, applications, and specific network usage problems.

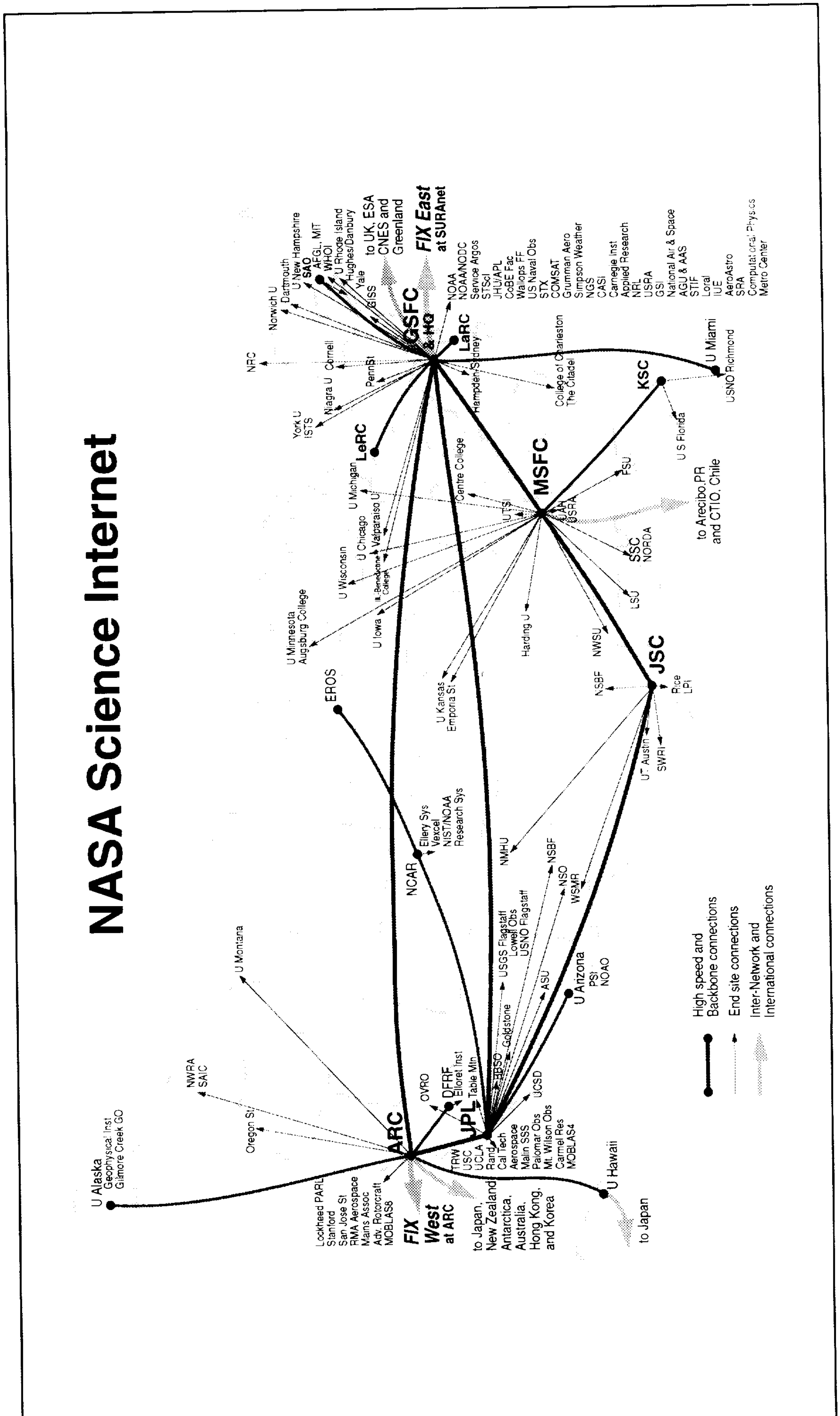
The NAIC expands upon the original successful NSI NIC function provided by Goddard Space Flight Center by merging it with several existing functions at Ames in the ANA Section. This merger enhances the overall NIC service by directly coupling it to advanced applications such as agency and interagency directory services and interoperable email gateway development.

NAIC will provide two basic services in support of the NASA science and research community. First, it will distribute basic user service and science applications toolkits to the CNICs and then it will work with the CNICs to plan and coordinate future activities for NASA's "network of NICs." Second, it will provide support for many of the advanced network applications now being developed and deployed by ANA; many of these new applications are driven by NASA science and research programs, but need further adaption. NAIC will also look outside NASA for relevant tools and applications, leveraging on its involvement with the Internet Engineering Task Force, various international technical groups, as well as from the commercial marketplace.

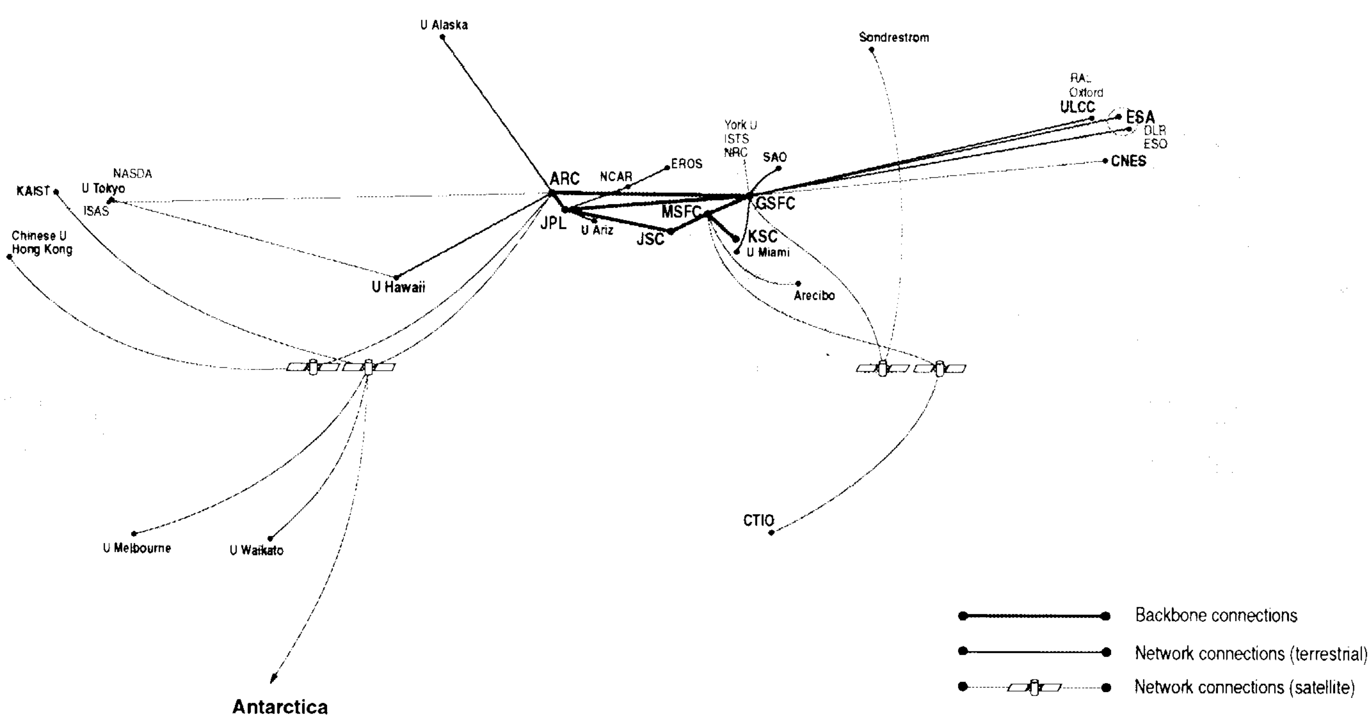
Having a network of NICs will directly benefit NASA science network users because their network information services will be located at the same centers as their research laboratories and computer facilities.

End users will find that their information needs can be met by their local CNIC, which best understands their institutional communications and local network needs. In addition, the development of a coordinated set of network tools and applications will make it possible for each CNIC to deliver more information services directly to the scientists' workplace. The scientist no longer needs to learn new procedures to access various network information services at remote locations. With NAIC's generic set of network tools, users and CNICs alike will benefit from dedicated local support, reduced duplication of effort, and improved ability to share resources. This approach embodies NASA's "cheaper, faster, better" paradigm.

When the new CNIC architecture is fully in place, each CNIC expects to handle most end-user questions. This will allow the NAIC at Ames to devote the bulk of its efforts to developing new procedures and guidelines for advanced network applications. The NAIC will also provide scientists with the latest versions, implementations, documentation, and even


NASA Science Internet
U Alaska
Geophysical Inst
Gilmore Creek GO
NWRA
SAIC
Oregon St
U Montana
ARC
FIX West at ARC
Lockheed PARL
Stanford
San Jose St
RMA Aerospace
Mains Assoc
Adv. Rotorcraft
MOBLAS8
to Japan, New Zealand Antarctica, Australia, Hong Kong, and Korea
U Hawaii
to Japan
OVRO
DFRF
Elloret Inst
Table Mtn
JPL
TRW
USC
UCLA
Rand
Cal Tech
Aerospace
Main SSS
Palomar Obs
Mt. Wilson Obs
Carmel Res
MOBLAS4
UCSD
BBSO
Goldstone
USGS Flagstaff
Lowell Obs
USNO Flagstaff
ASU
U Arizona
PSI
NOAO
NSO
WSMR
NSBF
NMHU
NCAR
Ellery Sys
Vexcel
NIST/NOAA
Research Sys
EROS
U Kansas
Emporia St
U Minnesota
Augsburg College
U Iowa
U Wisconsin
U Chicago
Valparaiso U
U Michigan
LeRC
York U
ISTS
Niagra U
Cornell
NRC
PennSt
Norwich U
Dartmouth
U New Hampshire
SAO
AFGL, MIT
WHOI
U Rhode Island
Hughes/Danbury
Yale
GISS
to UK, ESA CNES and Greenland
FIX East at SURAnet
GSFC & HQ
LaRC
Hampden/Sydney
NOAA
NOAA/NODC
Service Argos
STScI
JHU/APL
CoBE Fac
Wallops FF
US Naval Obs
STX
COMSAT
Grumman Aero
Simpson Weather
NGS
CASI
Carnegie Inst
Applied Research
NRL
USRA
GSI
National Air & Space
AGU & AAS
STIF
Loral
IUE
AeroAstro
SRA
Computational Physics
Metro Center
College of Charleston
The Citadel
U Miami
USNO Richmond
KSC
U S Florida
Centre College
UTSI
MSFC
UAH
USRA
FSU
to Arecibo,PR and CTIO, Chile
SSC
NORDA
LSU
Harding U
NWSU
JSC
Rice
LPI
NSBF
UT Austin
SWRI
High speed and Backbone connections
End site connections
Inter-Network and International connections

NASA Science Internet International



The NASA Science Internet currently connects and monitors 167 nodes at 136 sites worldwide, extending from the Antarctic to Greenland, and to all major continents excluding Africa.

installation "folklore" for widely supported network applications.

Ames' NAIC is also planning to lead community outreach and seminars to train network users and implementers. ANA and NAIC will work closely with NASA's Inter-Center Council for Computer Networking, NASA wide area networks, NASA center communications facilities, the National Science Foundation's new federal InterNIC, and related network information activities in a coordinated effort to meet all the network information and applications needs of NASA science network users.

Currently, ANA is deploying X.500 "White Pages" Directory Services and associated User Agents at all the NASA centers. This includes ANA support for ISODE, QUIPU, PHBook, FINGER, PC PHBook, WHOIS, MaX.500, XTDUA, Mac PHBook, and SYBASE database reach-through. ANA also supports various electronic messaging services and online mail distribution services including: CE Quickmail, X.500 Reflector, HQ's NSIRELAY, Lotus cc:Mail, Microsoft Mail for PCs, networked FAX, ZMAIL, DEC's All-in-One, ASTROMAIL, AISRP, and HEAD mail. Future plans include development and support for multimedia mail, X.500 "Yellow Pages" Directory Service, online network conferencing, and electronic signature authentication.

Larry Gamble will be heading up the NAIC assisted by April Marine, Mary Stahl, Tony Quartuccio, Alex Deacon, and Mike Armstrong. The author is assisting with NIC architecture and planning. Cyrus Chow leads ANA's research and development activities. Both groups are under NASA Manager John Yin and Sterling Task Manager Laura Stark, and are part of the Ames Wide Area Networks and Services Branch (Code EDC).

For further information contact the NAIC at: (415) 604-0600; Internet: NAIC@nasa.gov; NSI/DECnet: EAST::"naic@nasa.gov"

Network Notes

Joanie Thompson, Ames Research Center

Eleven new sites were added to the NASA Science Internet:

- Applied Research Corporation, Landover, MD
- Centre National D'Etudes Spactiales, Toulouse Cedex, France
- Crustal Dynamics Satellite Laser Ranging Unit, Monument Peak, CA
- Crustal Dynamics Satellite Laser Ranging Unit, Quincy, CA
- Grumman Aerospace Corp., Bethpage, NY
- Hughes-Danbury Optical Systems, Inc., Danbury, CT
- Mains Associates, Berkeley, CA
- McMurdo Base Station, Antarctica
- National Scientific Balloon Facility, Palestine, TX
- National Solar Observatory, Sunspot, NM
- Niagara University, Niagara, NY

Network Link Created to Support Operation Restore Hope in Somalia

Bill Yurcik and Brian Lev, Computer Network Branch, HSTX/Goddard Space Flight Center

On December 15, 1992, Goddard's Fran Stetina contacted the Computer Network Branch for help in establishing network connectivity between Goddard and the U.S. Air Force Global Weather Central (GWC) to allow the transfer of satellite weather data in support of Operation Restore Hope in Somalia. The only connectivity information available at that time was that GWC was located at Offutt Air Force Base in Nebraska, which had a MILNET connection but was not normally reachable over the Internet.

After many hours of electronic sleuthing and discussions with USAF staff at Offutt AFB and Strategic Air Command Headquarters, Computer Network Branch staff discovered that a link could be established if a static route was entered into various packet switches that interfaced with the MILNET. In cooperation with Naval Research Laboratory (NRL) staff, a pilot indirect link was established between Goddard, an account on a system at NRL (which has local MILNET connectivity), and an account on a system at GWC, with the first successful file transfer tests taking place on December 18.

Once connectivity proved possible, staff members worked over the weekend coordinating with the NASA Science Internet (NSI) Network Operation Center at Ames Research Center and SURAnet staff in College Park, Md., to establish a direct link from Goddard to the GWC. The first successful file transfers over this direct link occurred on December 19. Although this direct link is appreciably faster, the original pilot indirect link through NRL is being maintained as a backup.

In addition to helping create the required network link, the staff coordinated and assisted with the rapid network registration and software configuration of a dedicated VAX on the Goddard LAN, and provided TCP/IP software and configuration information for a Macintosh Quadra that was being shipped to Offutt AFB to serve as a data acquisition and processing platform. On December 22, the transfer of satellite weather data between these two systems over the direct GSFC/GWC link was successfully demonstrated on-site at Offutt to Colonel Charles Holliday, chief of the GWCUs Product Improvement Branch, Technology Improvement Section, by Goddard's International Data Systems Office.

Successful establishment of this network connection required substantial cooperative contributions from many groups and several members of the Computer Network Branch, and we wish to thank everyone involved for their help in fulfilling the original request. We believe this effort is an excellent example of teamwork, network expertise, and the use of network resources.

Galileo Geometry & Graphics Software Modified for Cassini Observations

Karen E. Simmons, Joshua E. Colwell, Kirk D. Benell, Laboratory for Atmospheric and Space Physics, University of Colorado

The Cassini Geometry and Graphics Software, or CGGS, is an observation planning package being implemented by the Cassini Ultraviolet Imaging Spectrometer Team (UVIS) at the University of Colorado's Laboratory for Atmospheric and Space Physics.

CGGS is a descendent of the Galileo Geometry and Graphics Software (GGGS) developed by the Galileo UVS Team in Colorado. CGGS (pronounced C-Geez) is a window-based visualization tool that can be used by all Cassini instrument scientists to understand observation opportunities available during the orbital tour at Saturn, and to design observations based on those opportunities. The software currently shows fields of view (FOVs) for the UVIS and Hydrogen-Deuterium Absorption Cell and can be readily modified to include any instrument on Cassini. CGGS models spacecraft motion and orientation and will check spacecraft constraints. The user display shows the FOVs projected on the sky plane with selectable attributes including the coordinate system, rings, body features, satellites and their orbits, and the stellar background (Figure 1).

In addition to the interactive display, both CGGS and GGGS output a geometry file (similar to the classic Supplemental Experiment Data Record/footprint product) and a pointing file (SPICE C kernel). This ability of both programs to read and write pointing kernels allows for iterative design and review processing, an integral part of mission observation planning. This provides an advantage over the current (POINTER style) planning software in that designs can be distributed, reviewed, and changed if necessary, by the very science community for whom the instrument observations are to be made. For the first time then, a scientist can now see a graphic of the design, or even view an animation of the observation, without having to live where the designs are crafted.

An important new mission operations concept is the inherent ability of the mission planning group to use these designs to form the actual spacecraft command sequence. By incorporating SPICE kernel readers into the mission-level sequence generation software, considerable design time could be recaptured by using the designs input from the science community. Thorough constraint checking and fine-scale spacecraft operation characteristics could be used at this time by the mission software to qualify the designs for sequence inclusion.

GGGS began as a geometry package to visualize how data from science observations had been acquired. It was also used to reconstruct spacecraft pointing information by comparing UVS instrument data with spacecraft attitude data and pointing knowledge from images obtained by the Galileo Imaging Team. GGGS quickly became a Galileo observation planning tool when the NAIF Toolkit update provided a routine to write C kernels. At that time it became clear that GGGS could be a multimission visualization package by adapting it for the Cassini UVIS. As a proof-of-concept exercise, GGGS was converted and used to understand observations obtained from the Russian Phobos mission. GGGS is now being distributed in a significantly upgraded Version 1.0. CGGS is in beta testing; Version 1.0 is

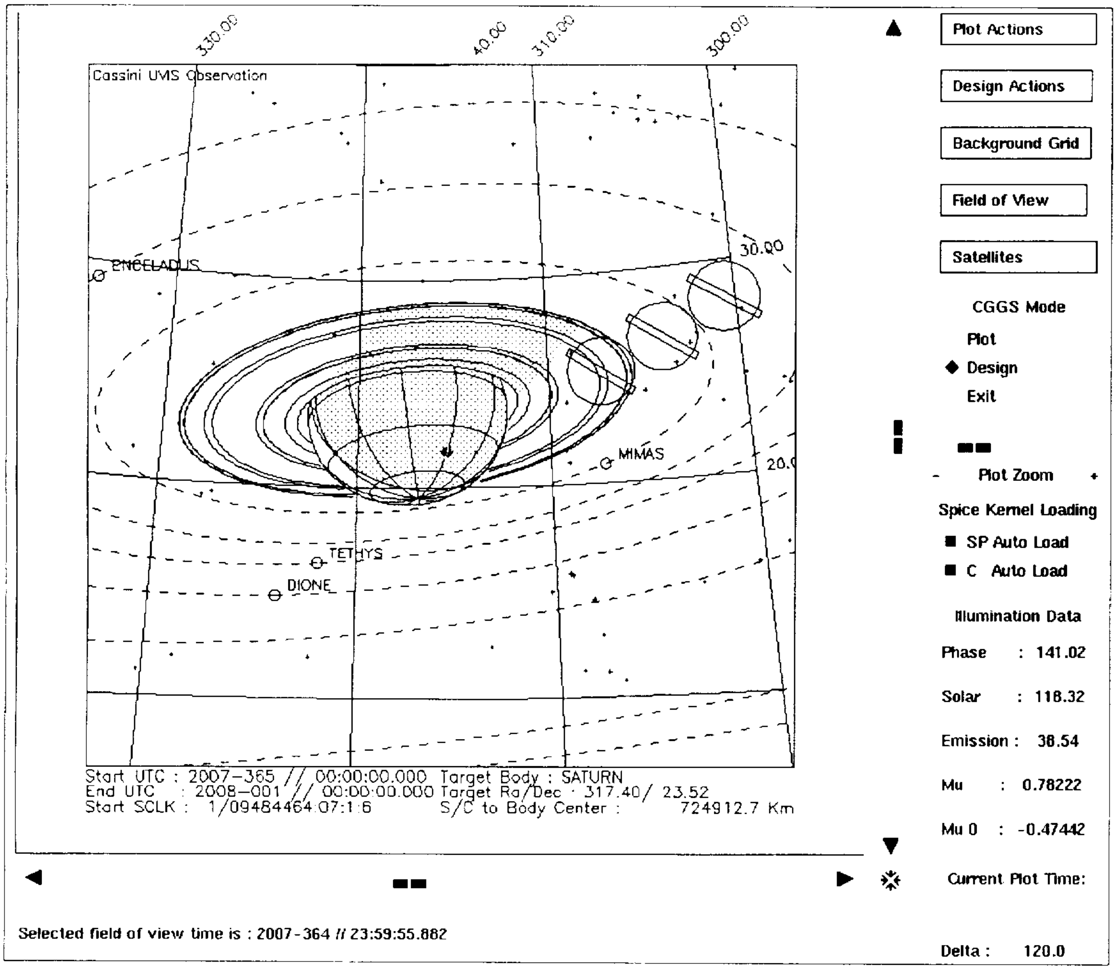


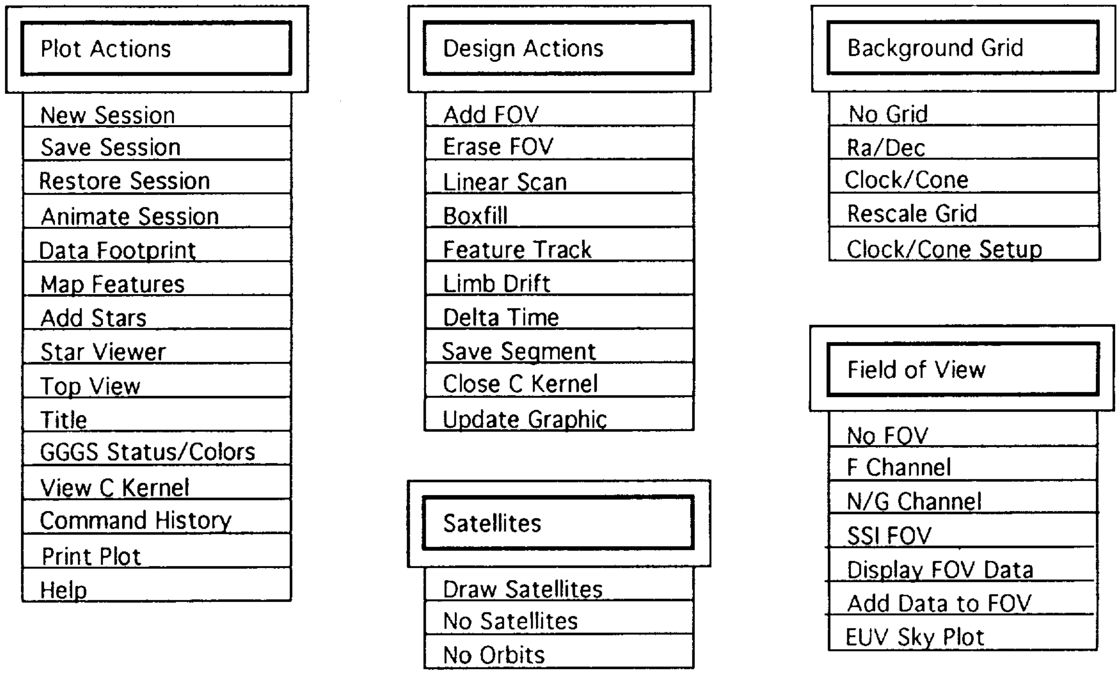
Figure 1: A CGGS display of Saturn and the rings for two Cassini Ultraviolet Imaging Spectrometer fields of view at a time near the end of the Cassini orbital tour. Shown are the 6 mrad slit and the field of view of the German-built Hydrogen-Deuterium Absorption Cell. SAO stars are shown; the star number and class label is deselected. Illumination data given at the right pertains to a moveable point shown here near the south pole.

scheduled for completion by August 1993. Both tools are written in Research Systems, Inc. Interactive Data Language (IDL) and have an interface to the Fortran SPICELIB Toolkit and SPICE kernels. IDL is available with minor differences in implementation for VMS and Unix systems. These data differences necessitate distinct versions of GGGS and CGGS for VMS and Unix.

Converting GGGS for the Cassini hardware configuration has provided a knowledge base for mission-to-mission conversion. We found the major changes were due to hardware differences that affect coordinate system definitions and operation modes. Cassini lacks a scan platform and is not a dual-spin spacecraft like Galileo. Adapting GGGS for Cassini required modification of about 10% of the GGGS subroutines. Instrument hardware changes, however, such as fields of view and mounting specifications, are well handled by the SPICE Instrument kernel and are easily changed by substituting new kernels. Besides pointing out the clear advantage for NASA missions to use the SPICE kernel system, it seems clear now that new versions of the Geometry and Graphics Software should be converted depending on the type of spacecraft: spinning vs. all-axis stabilized. Both models are now available.

The basic GGGS software was developed in one half work-year by physics student author Benell (some body orientation algorithms were also contributed by Doyle Hall of Johns Hopkins.) The Xwindows displays, beta testing and Version 1.0 upgrades have taken another half work-year. The Cassini mission conversion occurred at the same time as the conversion from VMS to Unix and took approximately one quarter work-year for the mission-specific changes. Major factors in keeping the development time down have been: the quality of the

Figure 2: Pull-down menu options allow you to manipulate display attributes, choose the axis reference system, select output actions, control kernel usage, pick fields of view and to activate plot, design and session functions.



SPICELIB Toolkit and its documentation, the excellent NAIF user support, and the simplicity of IDL window programing and Fortran interfacing.

Future upgrades include an interface to physical models that will accept CGGS input and have their output displayed as part of the graphic. Thus, not only will scientists have the capability to visualize and design observations, but they will be able to simulate those observations by incorporating their own physical model, such as a brightness model in a given wavelength range. Another new option will be tour design, once the NAIF Toolkit includes the ability to modify conic element-based SP (Spacecraft and Planet ephemeris) kernels as well as read them. CGGS will use this SP write capability to investigate subtle orbit modifications and their effects on the quality of science observations. Again, with the ability to electronically distribute modified kernels, all Cassini teams will have the ability to judge the quality of these tour modifications.

Figure 2 indicates the menu options available on GGGS; CGGS offers new FOV options as well as spacecraft orientation control and expanded animation capabilities. Other interfaces include hardcopy to laser printer devices (or file), on-line help, and a Save-Restore session option. The current GGGS tool includes a Tektronix 4010/4014 driver that allows a non-window user to see a limited graphic and to write geometry files for use in data analysis. A user document is currently available in a postscript print file and a TAR backup file of the GGGS unix version is now available. A hands-on demonstration account is currently available for the GGGS VMS version and a TAR backup for CGGS will be available at beta release.

For further information on availability of any CGGS items contact Josh Colwell at: NSI/ DECnet: SARGON::COLWELL;
Internet: colwell@sargon.colorado.edu.
For GGGS products contact Karen Simmons at: BPER::SIMMONS;
simmons@pisces.colorado.edu

NAIF Delivers E-kernel Subsystem to Mars Observer & MARS 94/96

Chuck Acton, NAIF Task Manager, Jet Propulsion Laboratory

NASA's SPICE system is designed to provide scientists much of the ancillary information needed to plan and interpret space science observations. The principal components—called SPICE kernel files—contain ephemerides, instrument pointing, target body cartographic characteristics and similar celestial geometry and related information.

Also a principal SPICE component is the E-kernel, the home of Events pertaining to data-taking activities. JPL's Navigation and Ancillary Information Facility (NAIF) Group recently finished implementation and testing of the Version 1 E-kernel subsystem. The design specifications, software and documentation have been delivered to the Mars Observer and MARS 94/96 flight projects, and will shortly be delivered to Galileo as well. This article describes the E-kernel subsystem architecture and contents, and outlines expected use of the E-kernel components.

The determination of celestial geometry for observation planning or data analysis is the most mature and best known function of SPICE. Yet when the SPICE concept was conceived [in the early '80s] scientists realized that the careful recording of observation objectives, spacecraft and instrument commands, and notes about how the observations were carried out would be increasingly important as data volume, hardware complexity and interest in correlative data analysis grow. Interest in widely sharing data and in assuring that all information needed to reevaluate data in future years pointed to the need for a data product such as the E-kernel.

The E-kernel design process was arduous, reflecting the wide scope of functional requirements placed on it and the many design ideas offered by the science and engineering communities affected. The NAIF Version 1 E-kernel implementation attempts to accommodate these requirements within an adaptable and extensible architecture that can permit substantial evolution without obsolescing early E-kernel data products. (Planning for growth while retaining backward compatibility are important characteristics of the entire SPICE system design.) Only time will tell to what extent this design/implementation meets the needs of producers and users of EVENTS component information.

E-kernel functional requirements

The overarching requirement on the SPICE E-kernel (EK) is that it contain records of mission events—both planned and unexpected—that will, or might, help a scientist achieve a fuller understanding of the data returned from spacecraft instruments.

The scientist to be helped by the E-kernel could be a specialist for a particular instrument or an interdisciplinary scientist working with data from several instruments. This EK customer need not be someone directly associated with an active project—the information within E-kernels is also intended to help those scientists whose work may start years after the mission is completed. As an example, if Viking had generated SPICE kernels, including an E-kernel, these could have helped Mars Observer and MARS 94/96 science team members better prepare for their own mission operations. Similarly, had Voyager generated E-kernels these would help Galileo and Cassini scientists better understand precursor datasets for their Jupiter and Saturn in-orbit operations.

Additional primary requirements are as follows:

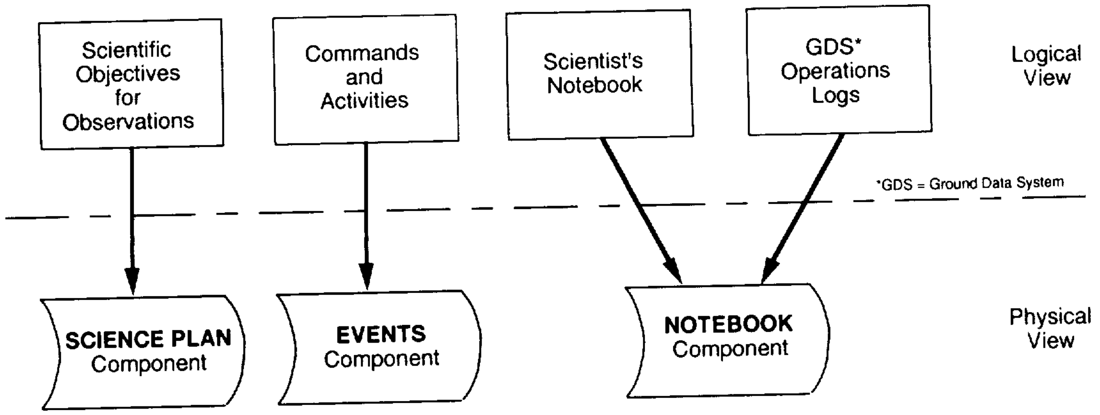
- Inputs must be easily assembled/produced
- Inputs for the NOTEBOOK component must be possible from all mission operations teams
- The contents must be in text format (or readily transformed to text format) for viewing on a terminal screen or in a printout, or for searching, using common text utilities such as UNIX's grep
- The contents must be accessible using NAIF Toolkit subroutines that are integrated into a user's own application program
- Provision must be made for clearly describing any mnemonics or codes used within the E-kernel in an associated glossary

NAIF

Navigation and Ancillary Information Facility

The goal of the Navigation and Ancillary Information Facility is to provide the planetary science community with datasets and transportable software tools appropriate for computing, archiving, accessing and distributing the ancillary viewing geometry needed to interpret observations of solar system bodies.

Figure 1. E-kernel components



- The E-kernel files and allied NAIF Toolkit software must be portable

E-kernel design

The E-kernel consists of four logical sub-elements, implemented in three distinct physical components, as shown in Figure 1. (This is unlike all other SPICE kernels, each of which is implemented as a single component.)

The types of information held in entries provided for these three components are noted below.

SCIENCE PLAN—entries contain broadly stated scientific objectives of the instrument observations scheduled over a stated period of time.

Figure 2. Template for a SCIENCE PLAN or NOTEBOOK entry

```
EK_PLAN_AND_NOTEBOOK_ENTRY_FORMAT_VERSION_1

\header

  TYPE              = <insert PLAN or
                       NOTEBOOK>
  SYSTEM_ID         = <SPICE numeric code>
  SYSTEM_NAME       = <short instrument or
                       subsystem name>
  UTC_START_TIME    = <event time, or event
                       start time>
  UTC_STOP_TIME     = <event stop time, if
                       appropriate>
  SCLK_START_TIME   = <optional spacecraft
                       clock start time>
  SCLK_STOP_TIME    = <optional spacecraft
                       clock stop time>
  ENTRY_TIME        = <date/time this entry was
                       prepared>
  AUTHOR            = <author name>
  INSTITUTION       = <author affiliation>

\text

< Insert text here containing the science plan or
notebook information >
```

EVENTS—entries are the instrument, spacecraft and ground data system commands (given in terse English) designed to carry out the scientific objectives of the SCIENCE PLAN as well as general spacecraft engineering functions.

NOTEBOOK—entries are notes recorded by scientists and engineers regarding any unexpected results (and suspected) of carrying out some set of commands.

The EK components are not intended to be garbage heaps where each and every sort of ancillary information that doesn't seem to belong elsewhere is placed. But deciding exactly what to put in the E-kernel is a question of pragmatism: It is difficult to know in advance what information may help solve a future science data analysis problem. Because the E-kernel contents may be quickly searched by NAIF Toolkit and operating system software it will probably be best to err by entering too much rather than too little information.

Science Plan and Notebook specifications

While their functions are quite different, the SCIENCE PLAN and NOTEBOOK components are implemented as text files using a single format. Each entry consists of a minimal set of formatted header information followed by an unlimited amount of nearly free-form text. Entries are made by filling out a template using any text editor or a word processor that has a "save as text" option. This template is shown in Figure 2.

Header items are given in KEYWORD = VALUE format. Entry_type identifies the input as either a SCIENCE PLAN or NOTEBOOK contribution. Subsystem_ID (numeric or text) identifies to which instrument or spacecraft or ground system element the entry pertains. Entry_time indicates when the template was filled out while start_time or the equivalent start_clock_count show the time during mission operations thought to be most relevant for the entry. The optional stop_time or stop_clock_count may be used to indicate an end to the relevance of a plan or notebook E-kernel entry.

SCIENCE PLAN entries are collected from each instrument team and are merged in a single file covering a given period—perhaps two weeks or a month. In the merge process the header data are validated and all entries are ordered according to either start_time (the default) or entry_time. NOTEBOOK entries are treated identically. Although they have the same format, SCIENCE PLAN and NOTEBOOK entries are kept in separate files since they serve quite different purposes.

Events specifications

The EVENTS component of the E-kernel has many characteristics of a flat file database. Information in the EVENTS component appears in a tabular structure, with individual entries appearing like rows and the data making up each entry organized in columns. Each "column" has a name and data type declaration—character, numeric or date/time, plus data size. A column may be indexed if searches on its contents are expected to occur. By default every EVENTS file has two columns automatically declared: these are subsystem_id and time. These allow EVENTS data to be correlated with entries in the SCIENCE PLAN and NOTEBOOK components, and with other SPICE data. One or more additional columns are declared to contain the actual command or event information.

The NAIF Toolkit contains the subroutines needed to enter data into an EVENTS component and to retrieve information from an EVENTS component. The Toolkit also includes complete programs—TEKST and INSPEKT—to accomplish the data entry and data retrieval functions.

As with the SCIENCE PLAN and NOTEBOOK components, EVENTS contributions can be merged into one or a few files covering a given period of time. Every merged EVENTS file includes a "comment area" where descriptive metadata may be placed. The metadata could include structured labels useful in creating catalog entries. Figure 3 is an example of such labels. Similar labels can be included in merged SCIENCE PLAN and NOTEBOOK files. EVENTS components are structured as FORTRAN direct access files to allow for fast information retrieval in response to a user query. You query the EVENTS component using syntax and semantics similar to those of the Structured Query Language used in many commercial database products. A simple example of an EK query that can be executed within the INSPEKT program is:

```
select * where command like "SPC*"
        and time GT 1995-01-15T11:10
        order by time;
```

Most of the relational operators associated with a flat file (single table) database have been implemented in the E-kernel software query functions.

```
spacecraft_name = mars94
MISSION_PHASE_NAME = ORBIT
PRODUCT_VERSION_TYPE = <type>
START_TIME = <yyyy-mm-ddThh:mm:ss.ttt>
STOP_TIME = <yyyy-mm-ddThh:mm:ss.ttt>
spacecraft_clock_start_count = <number>
spacecraft_clock_stop_count = <number>
TARGET_NAME = MARS
INSTRUMENT_NAME = <common name(s)>
producer_id = <name>
product_id = <unique ID for this file>
product_creation_time = <yyyy-mm-ddThh:mm:ss.ttt>
SOURCE_PRODUCT_ID = <name(s) of input files>
NOTE = <additional information>
```

Figure 3. Example of E-kernel labels

Using E-kernel components

The information contained in the three E-kernel components may be displayed on a terminal screen, printed, or processed by NAIF Toolkit software or your own operating system's utilities. Figures 4 and 5 illustrate the options available.

Figure 6 shows what a portion of the data in a made-up NOTEBOOK file might look like. Figure 7 shows data selected from a made-up EVENTS file, formatted in an INSPEKT report file.

Figure 4. Accessing data in a SCIENCE PLAN or NOTEBOOK E-kernel file

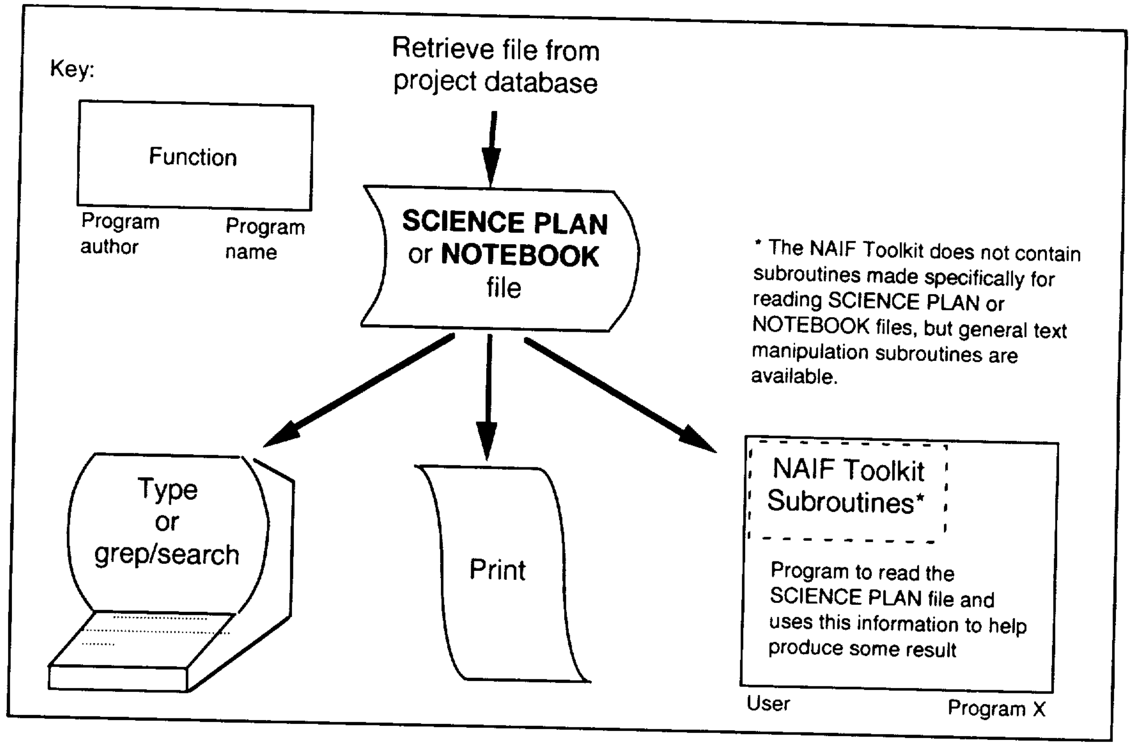
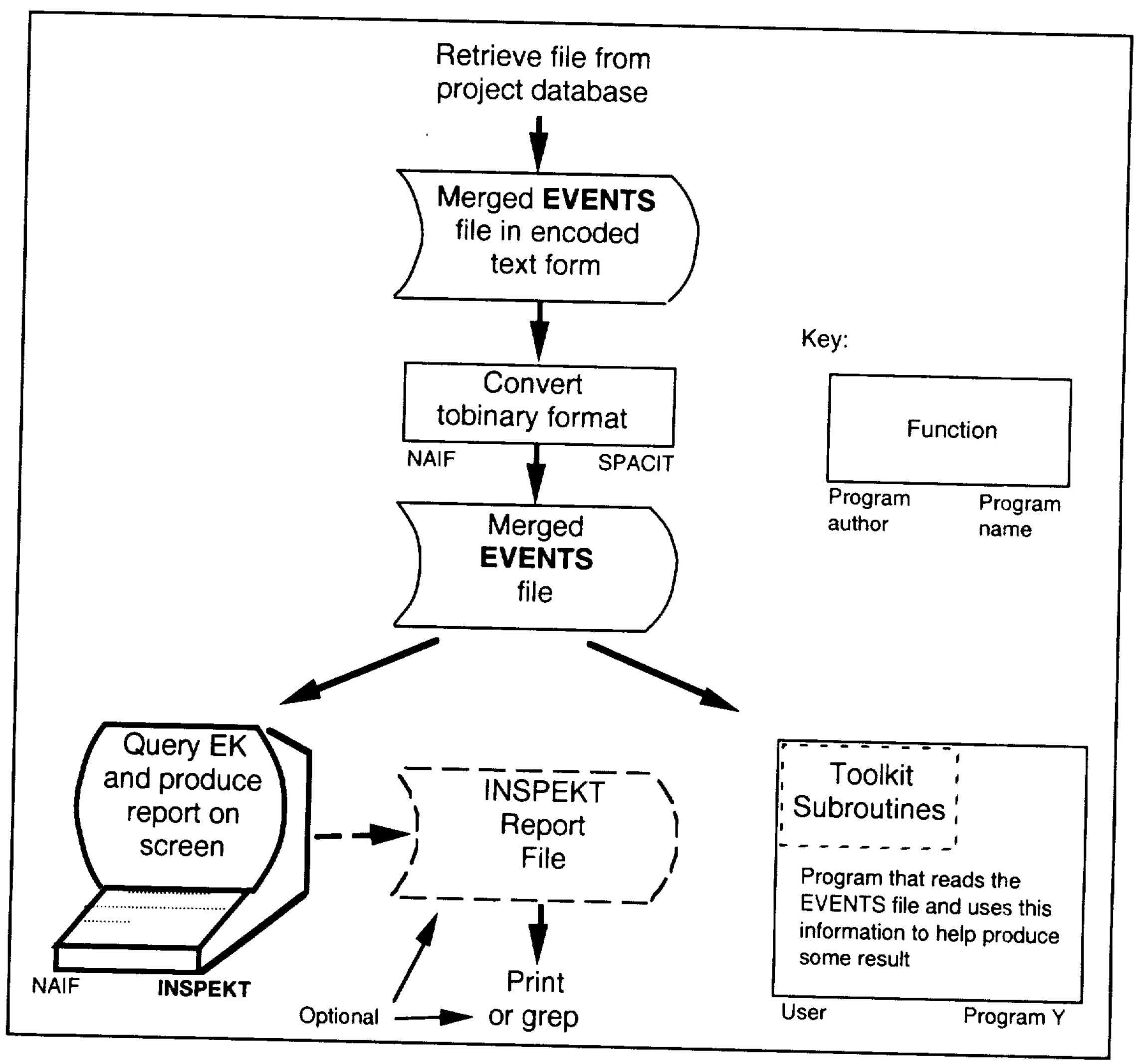


Figure 5. Accessing data in an EVENTS E-kernel file



```
EK_PLAN_AND_NOTEBOOK_ENTRY_FORMAT_VERSION_1

\header

  TYP = NOTEBOOK
  SYSTEM_ID = -15030
  SYSTEM_NAME = SPICAM
  UTC_START_TIME = 1995-01-16T02:03:00
  UTC_STOP_TIME = 1995-01-16T02:17:00
  SCLK_START_TIME =
  SCLK_STOP_TIME =
  ENTRY_TIME = 1995-01-24
  AUTHOR = Khavenson, Nicolas
  INSTITUTION = Space Research Institute, Moscow

\text

A lightning strike at the Evpetoria ground station caused
a brief power outage during playback of SPICAM image
data. After consultation with the PI it was decided not to
attempt a replay. Two full images and a portion of a third
were lost.
```

Figure 6. Example of a NOTEBOOK file

What lies ahead

Integration of the E-kernel into Mars Observer mission operations will occur during the next several months: EK integration into Galileo and MARS 94 will follow. These activities will certainly lead to improvements and extensions to what is available now. How well this element of the SPICE system will work remains to be seen. Will it have the right combination of ease of use and providing important information? Tune in about a year from now for an update! For additional information contact the author at: (818) 354-3868; NSI/DECnet: NAIF::CHA; Internet: cha@naif.jpl.nasa.gov

```
select * where command like "SPC*"
      and time GT 1995-01-15T11:00
      order by time;
```

1995-1-15T14:23:32	SPC002	UPRATE		Switch to 12.4 KS/sec
1995-1-15T15:02:55	SPC006	N-IMAGE	5	
1995-1-19T11:39:54	SPC004-2	POWER		Aux. heater #3 ON
1995-1-19T21:20:02	SPC002	DOWN RATE		Switch to 3.1 KS/sec
1995-1-19T21:20:28	SPC007	R-IMAGE	22	
1995-1-22T07:05:48	SPC002	UP RATE		Switch to 12.4 KS/sec

Figure 7. Example of data extracted from an EVENTS file

Kilauea Volcano Data to be Released on CD-ROM

George Karas, PLDS/JPL Node Manager, Jet Propulsion Laboratory

PLDS

Pilot Land Data System

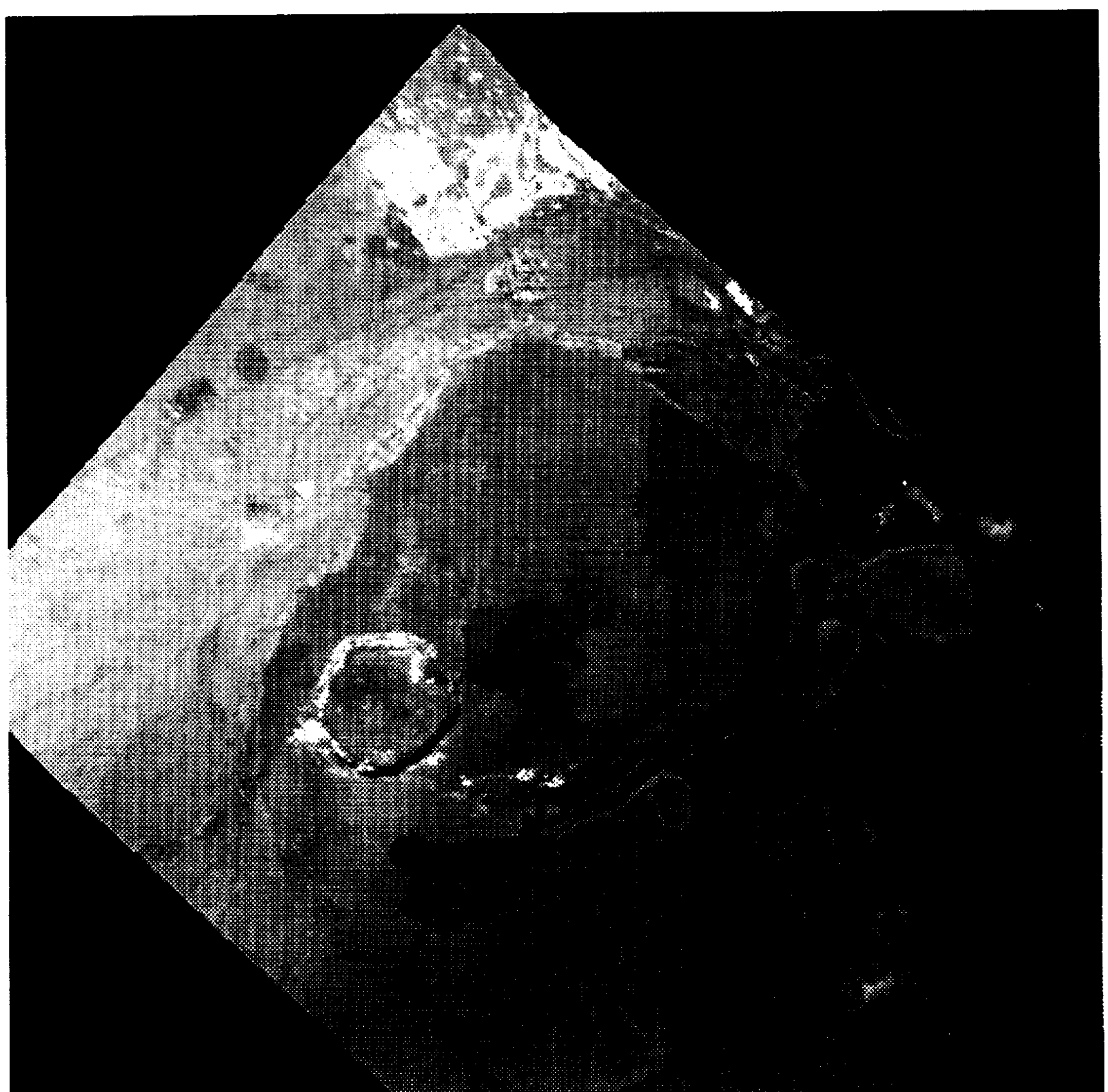
The goal of the Pilot Land Data System is to establish a distributed, interactive, data and information system to support access to data of interest to NASA's land scientists.

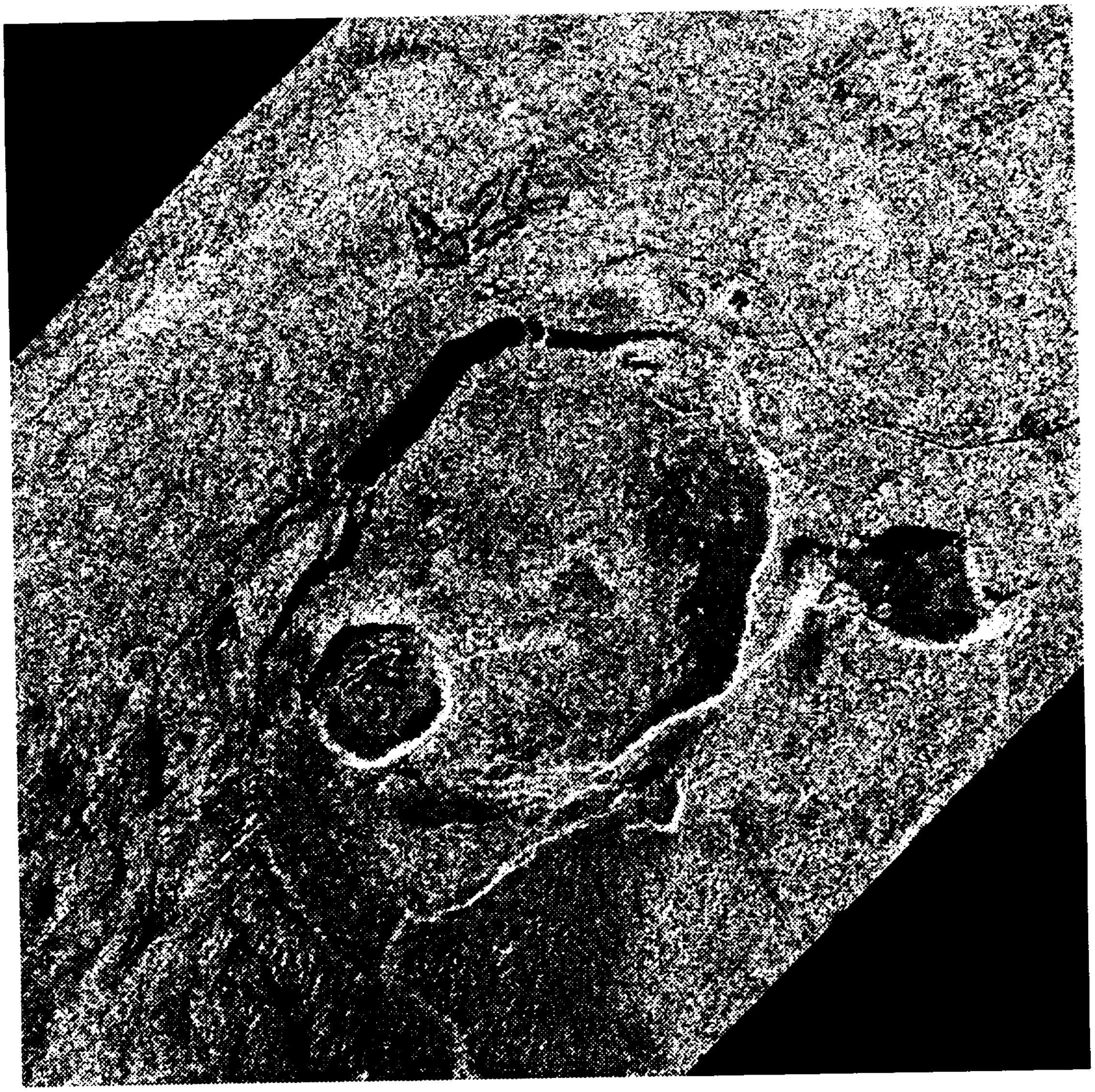
The Pilot Land Data System (PLDS) project at JPL, in conjunction with the U. S. Geological Survey at the Hawaiian Volcano Observatory (HVO), is about to release a six CD-ROM set of data of Kilauea volcano on the island of Hawaii. Kilauea is one of the most active volcanoes in the world and has been monitored by HVO geologists since 1924. The current eruption, which began on January 3, 1983, now ranks as the longest-lived and most studied eruption on the East Rift Zone of the island.

During most of Kilauea's eruption period, between 1985 and present, scientists at JPL have carried out a variety of NASA-sponsored observations throughout Hawaii. These include many observations of Pu`u, `O`o and Kupaianaha, Kilauea's active vents. Principal among the JPL campaigns have been several deployments of the NASA Earth Survey Aircraft, a heavily instrumented Lockheed C-130B Hercules, operated by the Ames Research Center. In addition, HVO scientists have been monitoring the activity of Kilauea and have conducted field investigations of and mapped the extent and growth of the current eruption since it began.

The CD-ROM set provides as comprehensive a set of data as possible, containing a variety of satellite and aircraft observations as well as ground data, laboratory spectra,

The Kilauea Crater on Hawaii is shown in this aircraft image recorded by the NS001 Thematic Mapper Simulator instrument. The data were collected on November 2, 1985.





This image of the Kilauea Crater was recorded by the Aircraft SAR instrument in the C-band with HH polarization on August 8, 1990.

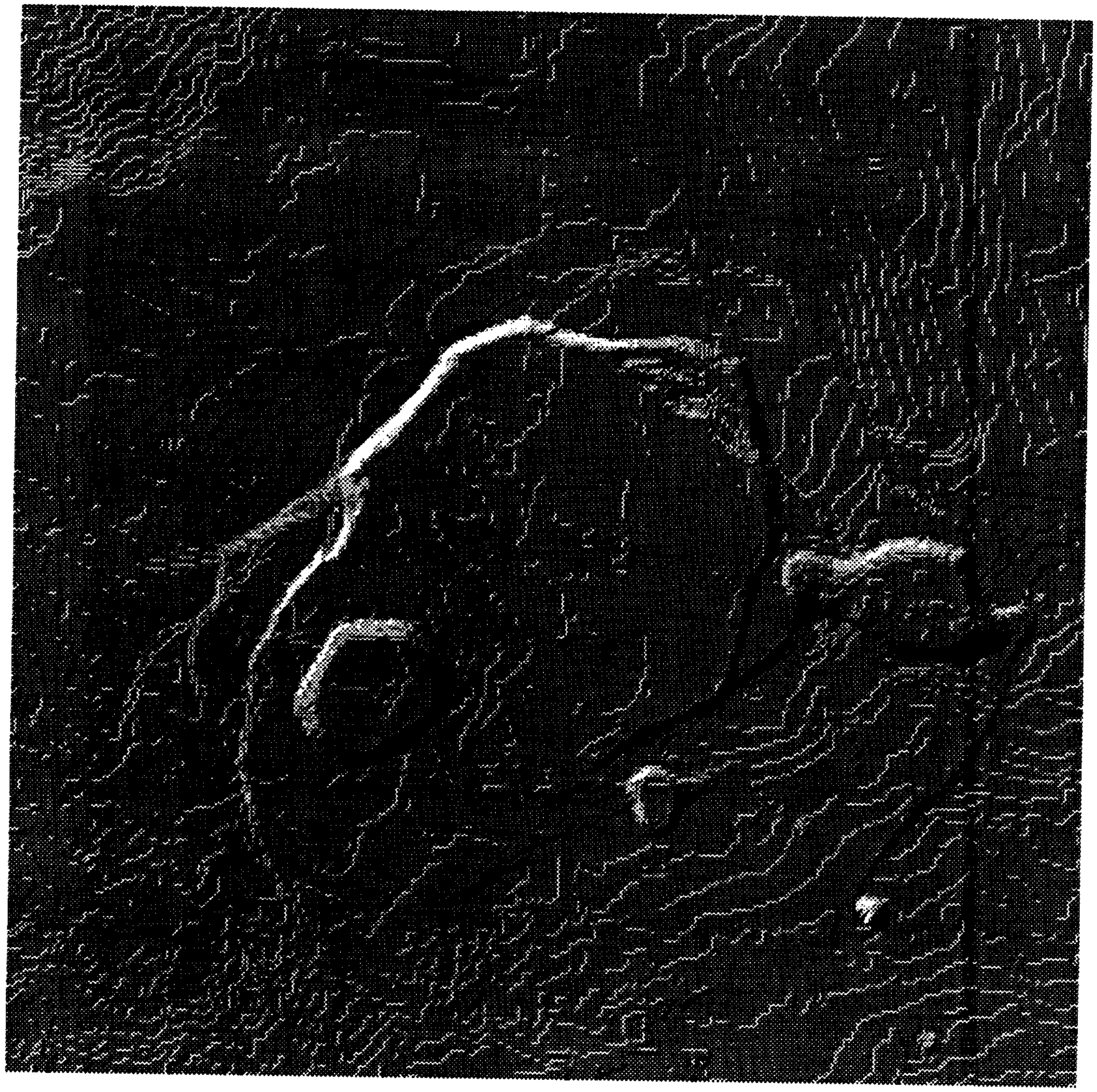
atmospheric conditions and maps. The image and spectral data represent a wide region of the spectrum, from radar to visible wavelengths.

The satellite data include Landsat Thematic Mapper (TM) and Advanced Very High Resolution Radiometer (AVHRR) images provided by the Planetary Geosciences Division of the University of Hawaii at Manoa, as well as a Landsat Multi-Spectral Scanner (MSS) image of the entire island of Hawaii.

The aircraft data on the CD-ROM set are from a suite of instruments, including Aircraft Synthetic Aperture Radar (AIRSAR), Thermal Infrared Multispectral Scanner (TIMS), NS001 Thematic Mapper Simulator (TMS), and a large number of digitized photographs. Browse images have been provided for all of these aircraft images at a resolution of 1:5. In addition, one image of each of these data types has been registered to a digital elevation model, which is also provided on the CD-ROM set. Also included are a set of image location maps that show the location of each aircraft image on the ground.

Finally, the CD-ROM set contains a wide array of ground and atmospheric measure-

The Kilauea Crater is shown here as a shaded digital elevation model. The two images on the previous pages have been geometrically corrected using the shaded digital elevation model.



ments. Radiosonde data collected during each of the aircraft deployments have been provided as well as thermal infrared laboratory spectra of lava samples collected from various areas of the volcano. HVO has provided a number of flow maps that have been digitized and included along with several other digitized geologic maps.

The CD-ROM set was designed to work on PCs, VAXs, Macs, and Unix workstations. Various software tools have been provided for DOS, VMS, Mac, and Sun Unix systems. Because the raw data on the CD-ROM set are in compressed format, decompression software has been provided. In addition, software for calibrating TIMS and NS001 images and for synthesizing AIRSAR images of different polarizations have been included. Image display software for Macs and PCs has also been provided.

For more information on the Kilauea CD-ROM set contact the author at: (818) 354-6363; Internet: george@pldsj2.jpl.nasa.gov

NOT JUST ANOTHER CD

Interdisciplinary Field Data Could Advance Forest Ecosystem Studies

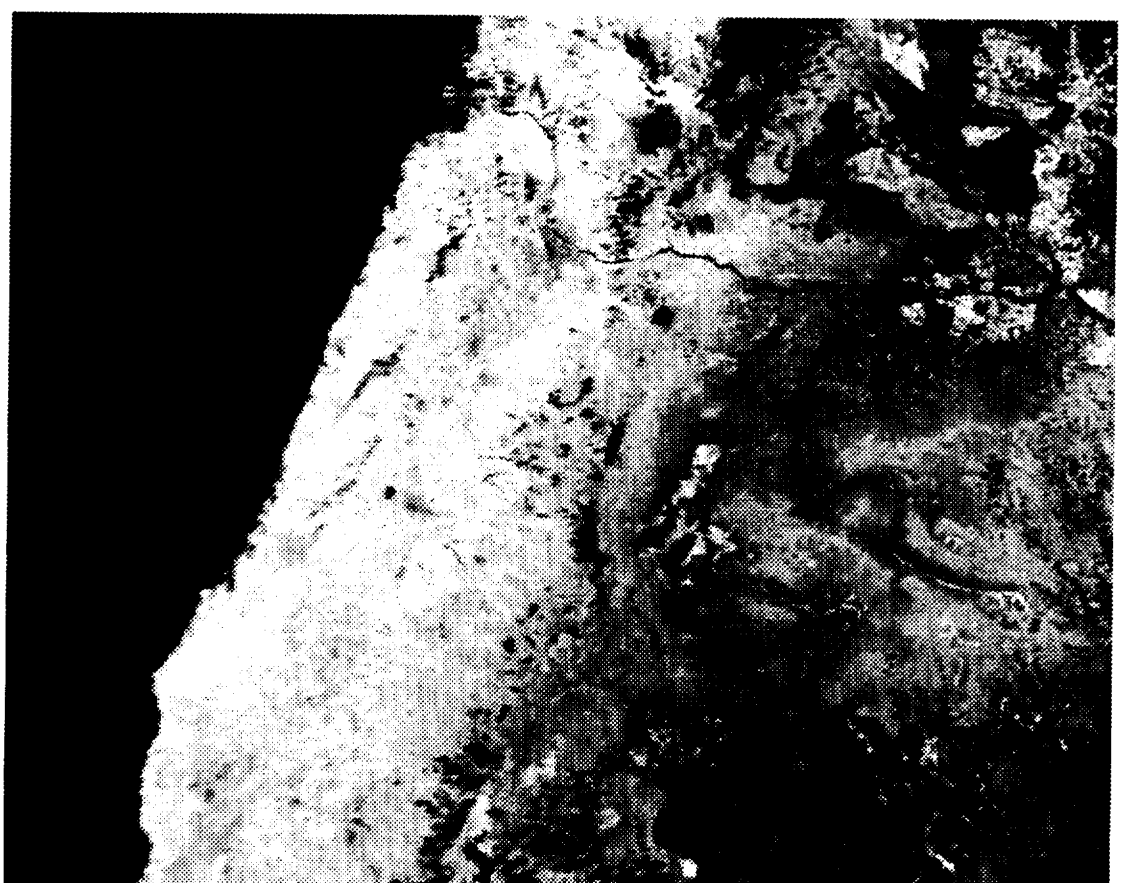
Gary Angelici and Lidia Popovici (Sterling Software) and Jay Skiles (Johnson Controls World Services), Ames Research Center

The first of a set of four CD-ROMs of data collected by the Oregon Transect Ecosystem Research (OTTER) project has been completed. The disc contains a coordinated set of satellite, aircraft, field, and laboratory measurements that were gathered during data collection campaigns and applied in the ecosystem research and modeling studies of OTTER project investigators.

The OTTER project

The principal objective of the OTTER project was to estimate major fluxes of carbon, nitrogen, and water through forest ecosystems using remotely sensed image data. More than 20 scientists from over 10 research institutions across the United States and in Canada participated in the testing and validation of the predicted fluxes and their biological regulation as simulated by ecosystem process models. Most data were collected in 1990 at six separate sites along an elevational and climatic gradient in west central Oregon to coincide with pre-budbreak (March), maximum growth (June), water stress (August), and senescence (October). Additional data were collected in the spring of 1991.

The bulk of the data collected for the OTTER sites consisted of remotely sensed imagery from instruments flown on satellites and on high-altitude and medium-level aircraft, such as NASA's ER-2, C-130, and DC-8. In addition, light and ultralight aircraft returned spatial, spectral, and video data. Satellite images for the project were registered composite Advanced Very High Resolution Radiometer (AVHRR) data generated by the EROS Data Center. The hundreds of aircraft flight



The following images have been extracted from the OTTER CD-ROM #1.

This image represents band 6 from the AVHRR instrument taken during June 1990 over Oregon. Note the Columbia River and the city of Portland. The OTTER transect runs west to east, from the coast inland, about one-fifth of the way from the top of the scene.

lines and scenes collected included data from the Advanced Solid-state Array Spectrometer (ASAS), Airborne Visible InfraRed Imaging Spectrometer (AVIRIS), Daedalus Thematic Mapper Simulator (TMS), NS001 TMS, and Thermal Infrared Multispectral Scanner (TIMS) instruments.

OTTER investigators used a variety of spectroradiometers to collect spectral reflectance measurements as ground truth for remotely sensed data. Other ground data collected include base station meteorological, soils, field sunphotometer, and ceptometer data. Data produced in the laboratory included various biochemistry, biophysical, physiological, and nutrient cycling measurements. Results from several simulation runs of a forest ecosytem model were retained, as well as data derived from mathematical calculations on raw data and from combinations of bands of raw data, such as leaf area index. The datasets collected for the entire project total nearly 16 gigabytes in volume.

CD-ROM contents

The image data collected from the C-130 aircraft (ASAS, NS001, and TIMS) on this and subsequent CD-ROMs were chosen to correspond to four times during the data collection periods. These times were 1) high sun, parallel to the plane of the path of the sun; 2) high sun, perpendicular to the plane of the path of the sun; 3) low sun, parallel to the plane of the path of the sun; and 4) low sun, perpendicular to the plane of the path of the sun. First, specific ASAS scenes with specific flight lines were chosen for inclusion on CD-ROM. Then, NS001 TMS and TIMS scenes were chosen so that they would have the same flight lines with the same sun angles.

Data for the aircraft imagery are provided for each of the six sites for the five data collection periods in 1990 and 1991. The disc contains one geo-registered AVHRR scene covering all sites for each month of 1990.

The OTTER imagery are provided in separate files in byte format for each individual spectral band with no header (except for the AVIRIS and ASAS scenes, which are stored in the format as distributed by the data providers). For example, there are 8 files of imagery for each NS001 TMS flight line, one for each band. In addition to the image files of Daedalus TMS, NS001 TMS, and TIMS, a file of housekeeping information is provided for each band with a summary file of calibration and other ancillary information for each scene.

OTTER tabular files of field and laboratory data, stored in ASCII format and containing mainly numerical data, were prepared for easy import into spreadsheet and database programs. The sunphotometer measurements can be used to correct the image data for atmospheric effects. The base station meteorological data, collected continually from 1989 to 1991, contain hourly measurements and daily summaries. Concentrations of several chemicals, such as sugar and starch, are given for several species on selected data collection days (during periods of aircraft overflights) for all sites. The data for one site, in which a portion was fertilized, is summarized over a monthly period in another file of chemistry data.

The data files on the CD-ROM follow many of the conventions and structures developed by the Planetary Data System (PDS). Each data file is accompanied by a descriptive PDS label file, which in the case of image data, permits easy display on personal computer systems. The public domain software package, "Imdisp," is provided on the disc for image display on IBM PCs (and compatible machines). The popular shareware program, "Stuffit," is necessary to extract the execution file for the Macintosh display program, "Image4PDS." All imagery, except for AVIRIS and ASAS data, can be displayed using the software on the disc. Complete documentation on PDS file formats as they relate to the OTTER data is provided on the disc.

General project documents on the CD-ROM describe the OTTER project, the precise location of the sites, the data collection campaigns, and each of the instruments/datasets. The disc includes files offering assistance in using the disc, such as a file describing the disc file naming conventions and an image index listing image files on the CD-ROM according to site, date and dataset name.

The remaining three CD-ROMs are scheduled to include the following datasets:

- Airborne SAR (Synthetic Aperture Radar)
- ASAS
- AVIRIS
- Compact Airborne Spectrographic Imager (CASI)
- Field Spectrometer Measurements
- Derived Data (such as Leaf Area Index)

This image of Cascade Head, Oreg. was taken using band 4 from the Daedalus Thematic Mapper instrument during June 1990.

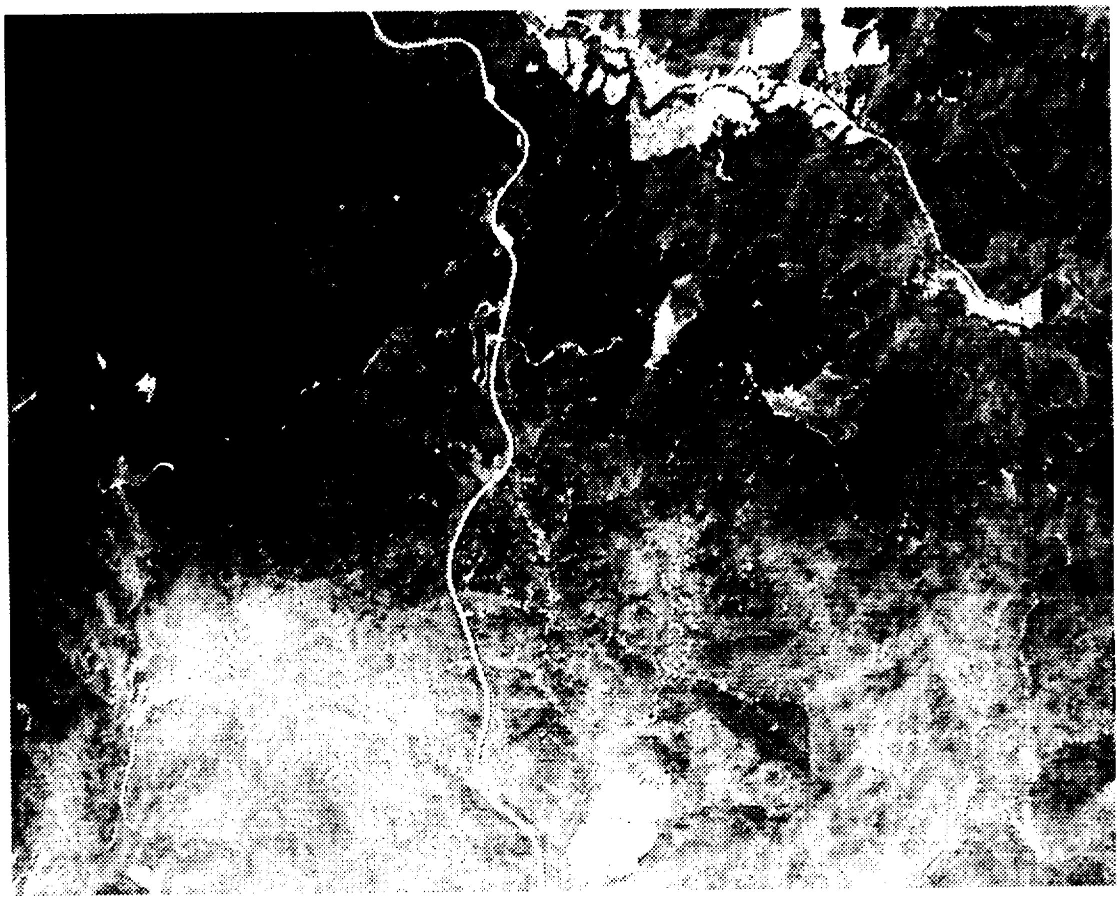
- Forest-BioGeochemical Cycling Model Simulation Runs

The imagery selected for these discs will conform to the rules adopted for the first disc. Sampler images from the large format instruments, such as Airborne SAR, ASAS, AVIRIS and CASI will be generated to enable easy display of selected bands. The remaining discs are scheduled to be available in late 1993.

It is anticipated that the coordinated datasets on these discs will be useful for studies of seasonal forest ecosystem dynamics, in studies of carbon and water fluxes in temperate coniferous forests, and in the application of remote-sensing technology to help answer ecological questions. While a number of analyses of these data are to be published in special issues of two journals, the data comprise a valuable baseline for future studies of forest ecosystems.

Pilot Land Data System staff members at the Ames Research Center, under sponsorship of the Ecosystem Dynamics and Biogeochemical Cycling Branch of NASA's Earth System and Applications Division, produced the disc as one of the services of the ongoing support of the OTTER project. The PLDS staff prepared the data, documentation and all supporting files for publication and premastered the disc on the PLDS/Ames Sun server using Makedisc premastering software.

For further information contact Gary Angelici at: (415) 604-5947; Internet: gary@pldsa1.arc.nasa.gov; or Jay Skiles at: (415) 604-3614; Internet: jay@pldsa1.arc.nasa.gov



This scene of Cascade Head, Oreg. is from the Thermal Infrared Multispectral Scanner instrument (band 6) during June 1990.

Adventures with Jukeboxes

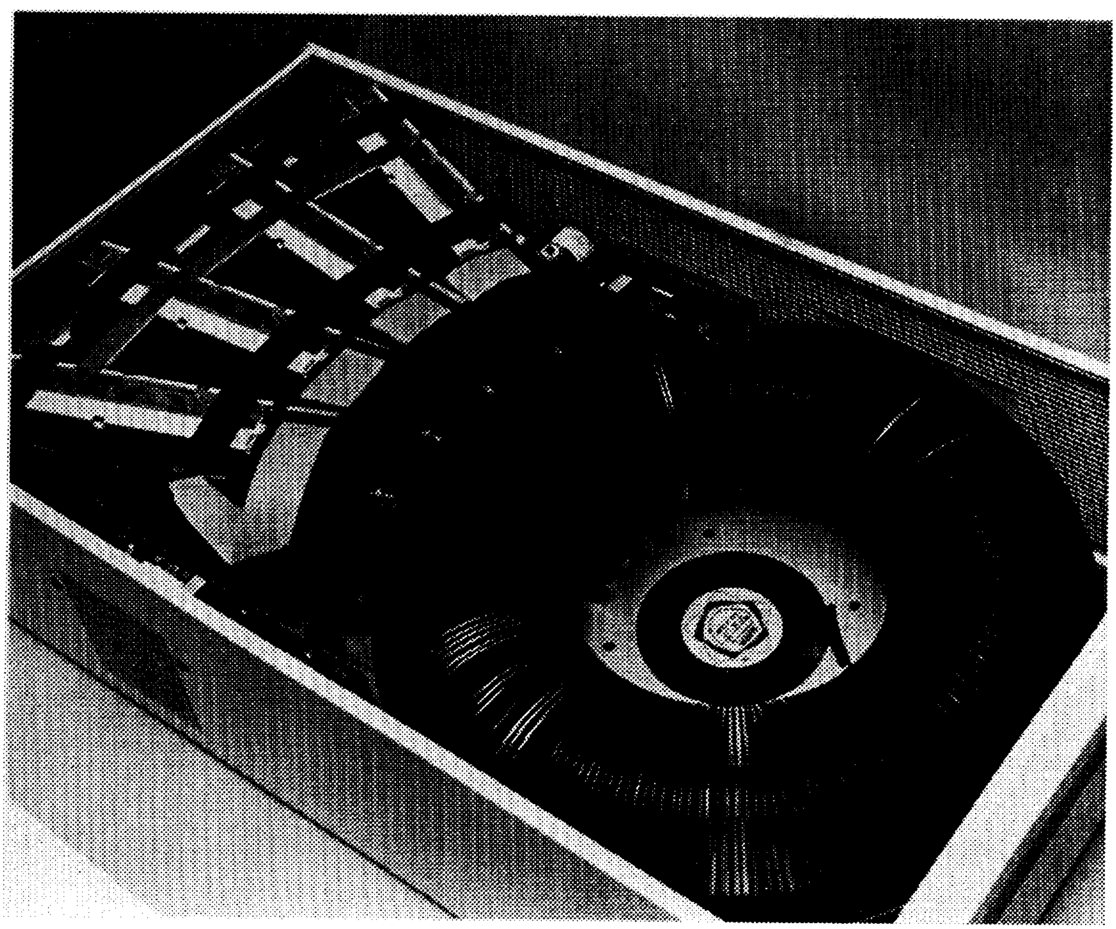
Mike Martin and Kalyani Rengarajan, Data Distribution Laboratory, Jet Propulsion Laboratory

The Data Distribution Laboratory (DDL) maintains a collection of scientific CD-ROM disks from all government agencies. Most titles are obtained through reciprocal distribution agreements (we provide copies of titles we produce, in return USGS, National Earthquake Information Center, EROS Data Center and others provide us their new titles). The collection has now grown to well over 200 disks, representing about 150 gigabytes of scientific data. The DDL publishes an illustrated *Catalog of Government Scientific CD-ROM Titles* (JPL D-9555), which can be obtained by contacting the PDS operator on Internet at pds_operator@jplpds. jpl.nasa.gov

Although this immense collection can be stored in several inches of shelf space in CD binders, it is not as accessible as we would like. We have been searching for several years for a CD jukebox that would house the collection and provide Internet access to data files on the disks. One device, developed by Kubik Technologies, has been demonstrated at trade shows for many years, but has always been just a few months away from real availability as a product. In October 1992 we were finally able to persuade Kubik Enterprises, Inc. to provide us with an evaluation unit.

Jukebox description

The Kubik CDR-240M Compact Disk Changer (Figure 1) holds 240 CD-ROMs and can be equipped with from one to four CD-ROM readers. The Toshiba XM-3301 player has been installed in most units produced to date, though Kubik advertises that other readers can be installed. Future deliveries will probably utilize the Toshiba XM-3401 double-speed



Kubik Jukebox with scientific CD-ROM collection

(300 kilobytes per second) reader. The jukebox is currently priced at $20,000.

The first jukebox was delivered to JPL in mid-October, and a Kubik representative flew to JPL to perform the installation. Unfortunately, when the equipment was unpacked it was found that all four CD players were damaged. The Kubik mechanism requires the use of a heavy steel CD caddy and the caddies were not properly secured before shipment. Another jukebox was delivered in mid-November, with caddies secured and no damage occurred.

The jukebox was supplied with IBM-PC software running under Windows 3.1. The software presents a scrolling menu of the CD titles in the jukebox (which are manually entered when disks are loaded in the jukebox). A DOS command can also be associated with each disk, so that an application can be automatically started when the disk is mounted. This is a useful capability in a reference library environment, but not as important with our scientific data collections. The software was developed using Toolbook, a hypercard-like application development system from Asymetrics. The 'driver' software for UNIX workstations that was mentioned in Kubik literature did not exist, which meant that we were essentially starting from scratch in our effort to utilize the jukebox on a Sun workstation.

Hardware interface

The Kubik has two interfaces, a serial port that controls the jukebox mechanism and a SCSI port that provides access to the CD readers. Our initial efforts to install the jukebox were hampered by interface problems. It took more than a week to successfully communicate over the serial interface, mainly due to our unfamiliarity with Sun serial port protocols and our inability to find anyone with expertise in this area. Once we were able to talk to the machine we found that the controls are simple, consisting of characters codes representing actions to be performed. For example, "P1S221M" tells the jukebox to mount (M) the disk in slot 221 (S221) in drive 1 (P1). Once the disk is loaded in the reader, a SCSI mount command must be issued to identify the volume to the Sun file system. This initially required superuser privileges, but we have since received a special program that allows unprivileged device mounts and dismounts (available via anonymous ftp at cdrom.com in /pub/mount.c).

The CD reader drivers we are using to access the drives are from Young Minds. To dismount the disk two steps are required. First a SCSI eject command must be sent to the reader, then the command "P1U" is sent to the serial port. The jukebox remembers (in nonvolatile CMOS memory) what slot the disk came from and will return it to the proper position. The "S221L" command instructs the jukebox to load/unload disks (one at a time) through a port in the front of the machine. The jukebox can be bulk loaded by removing the cover and inserting disks, but in normal operation the cover must be on the device, since some of the controls are light sensitive. Other commands include a sequential load that puts away the current disk in a specified drive then mounts the disk in the next slot number; a status query "?" that indicates what disks are in what drives; and the "CW" command to clear the nonvolatile CMOS memory.

The Sun workstation used to host the Kubik has two SCSI busses. The second bus was purchased with a large hard disk drive and we assumed could accommodate other devices. That was an incorrect assumption, apparently SCSI busses can be device specific and the vendor informed us that their bus did not support CD devices. Thus we were forced to completely reconfigure our workstation, moving all hard disk and tape drives to the second SCSI bus to free up the Sun SCSI bus for use with the Kubik. This involved about two weeks of effort. We were also informed by Sun technical support that their bus will reliably support only two CD-ROM readers, apparently because of the slow transfer rate. We ignored this advice and connected all four anyway and they seem to work, however it is possible that this architecture is responsible for some sporadic system problems we have encountered. It took at least a week to get a working version of the SCSI eject command, which was not included in the standard capabilities of the Young Minds CD drivers we are using and had to be extracted from a test program they provided.

Software applications

Two simple applications have been developed for testing the jukebox system. First a 'torture test' program randomly selects disks and drives and mounts and unmounts them for a specified number of repetitions. We want to make sure the device is not prone to recurring failures that would require frequent maintenance.

Second, a retrieval application has been developed for selecting and mounting disks. The database that is used to produce the *Catalog of Government Scientific CD-ROM Titles* was exported from Mac FileMaker Pro to an ASCII text file that was loaded into Sybase running on a UNIX workstation. A simple query menu was developed in Sybase to allow selection of disks by volume id, mission, target or title. Once a disk is selected by the user the Sybase program sends a request to our simple jukebox driver software to mount the specified volume on a drive. You are then informed that the disk is available on the file system.

Test results

Initial testing has resulted in an 'out of sync' condition on every reader in the jukebox. This condition requires physically resetting the drive, and is our greatest concern at this time. There also seem to be some idiosyncrasies in communicating with the serial interface, it does not always seem to respond per specification. The device should transmit a single acknowledgment character for each command received, but sometimes transmits extra acknowledgments. Also, when attempting to mount a disk in a drive that is busy the device should return an error code, but instead indicates that the command has been completed. Contrarily, sometimes a error code is returned even though the disk and drive are available. There also seem to be potential timing sensitivities, that is if commands are sent too quickly the controller hangs. There is a general problem that the commands do not time out, the failure to load a disk will result in infinite retries, essentially hanging the unit until it is manually reset.

As of mid-March the evaluation unit has been returned to Kubik to be retrofitted with all new internal mechanisms to bring it up to the state of jukebox units currently being manufactured. Our plan is to run the torture test for the equivalent of 3 months of average use, which we assume to be about 3000 mounts. This would be a reasonable period between maintenance. If the unit holds up under this testing we will purchase it, if not we will work with Kubik to resolve the reliability problems. It seems clear that the CD-reader caddy handling mechanisms are the most important threat to proper operation at this time. The mechanical positioning of the turntable has been cited as a potential point of failure, but we have seen no indication of this in our testing.

If we purchase the device, we then face the much bigger problem of determining the right user interface to a massive scientific collection of 150 gigabytes. There are many issues including:

- Should access be on a volume level or file level?
- How are drives allocated to users?
- How much time does each user get?
- Is there one global interface to the device or many different user interface applications dealing with a server?

As another consideration, many of the disks contain software that needs to be run to access the data. Ideally we would like to export these volumes to you for Network File System (NFS) access, so you can access them as local devices attached to your own host computers.

We are currently investigating all these issues. We plan to explore the virtual volume approach, as is used in many optical jukebox systems (the AMASS software for example), where all the disks appear to be online in a giant file system. We also hope to apply the STELAR interface approach (see *Information Systems Newsletter*, Jan. 1993), using WAIS as a front-end to portions of the database. It should be relatively easy to load a descriptive database for the Planetary Data System (PDS) CD-ROM collection, because each disk contains a standard set of documentation with detailed dataset and instrument descriptions. It would also be useful to tie the jukebox into the PDS Detailed-Level Catalogs, which reside at the Geosciences and Imaging nodes, so that searches of the massive Viking, Voyager and Magellan image collections could result in immediate image access. We would appreciate any collaborative proposals from other tasks that are investigating these issues.

There are several other jukebox options on the horizon. A German firm is developing a 100-disk jukebox with a single reader. Young Minds is currently evaluating this jukebox. It is expected to be available this summer for about $8000. It is possible that this unit could be equipped with a CD-recorder and 100 blank disks, providing a 68 gigabyte storage system for less than $10K. Of course the disks must be recorded a volume at a time, not file by file, so this would not be a competitor to magneto-optic jukeboxes at this time.

3rd Point Systems in Santa Monica, Calif. is negotiating with magneto-optic jukebox vendors to develop a 2000 disk jukebox system with 10 Pioneer DRM-604X readers included. The DRM-604X uses 6-disk cartridges and provides a quad-speed (600 kilobytes per second) read rate. Finally, Borett Automation Technologies (818-597-8664) offers a versatile robotics device that can be used with many different types of storage devices and media.

As another alternative, Peter Yee at Ames Research Center is installing 14 Pioneer Changers containing 84 CDs. The volumes can be accessed via Internet anonymous ftp at explorer.arc.nasa.gov.

For updates on the Kubik testing contact Kalyanir@michelle.jpl.nasa.gov

Acknowledgments

We would like to thank Stacey Teramae, George Karas, Dave Hecox and Steve Hughes at JPL for their hardware and software support. We thank Lyle Kerr and Jim Duncan of Kubik Technologies and Laslo Sipos of Kubik Enterprises, Inc. for providing technical support and for providing the evaluation unit.

Kubik Technologies, #110-13120 Vanier Place, Richmond, British Columbia, (604) 273-0400.

Kubik Enterprises, Inc., 18873 Allendale Avenue, Saratoga, CA 95070, (408) 867-7969.

Young Minds, Incorporated, 1919 Orange Tree Lane, Suite 300, Redlands, CA 92374, (713) 335-1350.

Research Announcements

ASTRO-2 Mission Guest Investigator Program
April 30, 1993, NRA 93-OSSA-14

Origins of Solar Systems Research Program
April 21, 1993, NRA 93-OSSA-13

Microgravity Science Research Opportunities
March 30, 1993, NRA 93-OSSA-12

ASTRO-D, Guest Observer Program
March 15, 1993, NRA 93-OSSA-11

Ultraviolet, Visible, and Gravitational Astrophysics Research and Analysis Program
March 15, 1993, NRA 93-OSSA-10

Research in Exobiology
March 5, 1993, NRA 93-OSSA-8

Instrument Definition for the Pluto Fast Flyby Mission
February 10, 1993, NRA 93-OSSA-5

Calibrating Voyager Data With PLATO Tool Set

Mihseh Kong, Image Analysis Systems, Jet Propulsion Laboratory

The first article on PLATO, the Planetary Analysis Tools Set, appeared in the Information Systems Newsletter, *Issue 27. Written by Richard Weidner, the article described a set of tools for interactive data browsing, customized database building, sensor attitude verification and registration, and making various maps and mosaics from Planetary Data System CD-ROM products. This second article describes the calibration process of Voyager images using PLATO.*

PLATO is a tool set developed to enhance the usage of Planetary Data System (PDS) archive data products. PDS CD-ROMs have revolutionized the way NASA mission data archives can be distributed and accessed. CDs are truly one of the greatest investments NASA has made to enable its data products to be studied by science communities world wide, as well as the general public.

Due to the mission-dependent nature of the calibration process, Voyager calibration is not considered as a generic PDS CD-ROM processing tool. However, those of you with PDS Voyager CDs and no calibration facility may find this article useful. The reasons why the Voyager Project decided to archive uncalibrated image products are beyond the scope of this article. What is within the scope however, is how to calibrate the images to satisfy each user's science objective.

The Multimission Image Processing Lab (MIPL) at JPL has calibration capabilities for Voyager images under VICAR (which runs on VMS). The calibration database that PLATO uses was provided by MIPL. PLATO's Voyager calibration tool can be described as a stand-alone software package (no executive is needed) that runs on any UNIX platform, understands the PDS CD-ROM data format, and is flexible and fully automatic.

Input image data to the calibration program may be either an IMQ-format PDS image that is Huffman encoded compressed CD-ROM data, or a decompressed 8-bit per pixel image. When the input data is in IMQ format, the following calibration information can be retrieved from its VICAR header: FDS (Flight Data System) time, planet body, mission (Voyager 1 or 2), camera field of view (wide-angle or narrow-angle), filter name (Blu-blue, Grn-green, Clr-clear etc.), shutter_mode, gain state (High or Low), exposure time, and scan_rate. When the input data is image only, the above information is extracted from the corresponding SPICE database (see article pg. 19) using the image (FDS counter) as the access key.

During the 11 years of the two Voyager missions, starting with the Jupiter encounter by Voyager 1 in 1979 and ending with the Neptune encounter by Voyager 2 in 1989, more than 100,000 images were received that revealed the surface of Jupiter, Saturn, Uranus, Neptune and their moons. The images were taken with wide- and narrow-angle cameras, applying six types of filters. The length of the mission, multiple sensor configuration, and extremely large distance between the sun (light source) and the observed planet bodies (observed reflectance) make the Voyager image calibration a complex and challenging process. The calibration database alone requires more than 200 Mbyte of data.

Calibration database

The calibration database for Voyager data products under PLATO was organized based on the datasets provided by JPL's Image Processing and Application Development Section. The detailed description of the calibration dataset generation process can be found in the *Voyager Imaging Science Subsystem Calibration Report*, by M. Benesh and P. Jepsen (JPL document 618-802). The organization of the calibration database under PLATO is briefly described below.

- Predicted reseau locations: Both the narrow-angle and wide-angle cameras in Voyager missions are equipped with a 25 mm all-magnet vidicon. The active image area in the vidicon surface is 11.14 mm by 11.14 mm, and contains 202 reseau marks. These reseaus are essential for geometric corrections. The reseau locations were originally measured in millimeters, then translated to pixel units. Each image frame consists of 800 × 800 pixels, therefore, the conversion factor from millimeters space to pixel space is 14 μm per pixel.

  The predicted reseau locations are stored in files "vgrMC.res" where M is 1 for mission 1 and 2 for mission 2; C is W for wide camera and N for narrow camera.

- Blemish locations: There are some image-independent blemish areas observed in Voyager images. These blemish locations and sizes are fixed with respect to each camera. Each blemish is modeled as a circle with a radius and center location. Due to image-dependent geometric distortion, the center location is described as a relative position with respect to the nearest reseau mark.

  The blemish locations are stored in "vgrMC.blemloc" (M = 1/2, C = W/N).

- Dark current images: The dark current refers to thermally induced charges built-up on the vidicon. The build-up occurs during the time between frame erasure and read-out, therefore it is a function of camera, image scan rate and exposure time.

  In the Voyager camera system, there is a simultaneous_shutter_mode in which wide-angle and narrow-angle frames are taken at the same time; the narrow-angle frame is read first, while the wide-angle frame is stored on the vidicon until the narrow-angle frame readout is completed. In this shutter_mode, wide-angle images have much higher build-up. Dark current frames are acquired during cruise and encounter by pointing the camera at an empty sky. Because the rate of dark current build-up is time dependent and highly sensitive to temperature changes, a dark-current frame with an FDS time as close to the input image as possible should be used.

  The PLATO calibration database contains all available dark current images for both Voyager 1 and 2 missions. To avoid searching through all images, they are divided into four image lists "vgrMC.DC" (M = 1/2, C = W/N).

- Light transfer functions: The light transfer curve is a function of photometric luminance units (ft-lambert) vs. image pixel intensity values. Because the sensitivity of the vidicon as a function of the exposure level is spatially variant, there is one light transfer curve per pixel. Each curve is a piecewise linear function of 10 data points, each data point is a 16-bit unsigned integer.

  Light transfer functions are stored in files "vgrMCF.ltf" (M = 1/2, C = W/N, and F = filter_name).

- Deblurring kernel: The Modulated Transfer Function (MTF) for each Voyager camera system can be modeled as a circularly symmetric function that is described with its one dimensional profile. To construct the deblurring kernel, the 1-D profile is interpolated into a 2-D circularly symmetric MTF. Due to the noise in the image, direct division of PSF in the frequency domain is not possible for deblurring. An estimated noise level was added to the PSF to prevent the noise blow up. The frequency domain PSF was converted to a spatial domain convolution kernel based on the fact that the energy spread of the PSF in the spatial domain is very much localized, which reduces the computation time. The final deblurring kernel for each camera was generated based on the empirical quality analysis.

  Deblurring kernels are stored in files "vgrMC.kernel" (M = 1/2, C = W/N).

- Planet body dependent constant: This is a constant scale factor that is a function of camera, filter, and planet distance from the sun. The scale factor was employed to normalize the dynamic range of the intensity quantization levels between the bright and dark plane bodies. The constants are organized as a 3-D vector in file "vgr.const."

Calibration functions

The Voyager calibration program includes the following functions: blemish_fill, radiometric_correction, geometric_correction, mtf_correction, and mask_out. These five steps are optional and can be turned on or off depending on the following data processing needs. For example, a scientist who studies cloud motion may not be interested in radiometric correction while someone else studying the photometric property of the planet surface definitely will. The calibration program is normally used in a batch mode due to the extensive calculation time required. An interactive mode is built using the XView toolkit for X11 windows on the Sun workstation; this is used mostly for the purpose of verifying the intermediate results. Figure 1 shows the user interface menu where the check mark indicates the enabled options. In batch mode, a user can set this option list as a bit map (e.g. the option code 13 is interpreted as "01101," which implies blemish_fill, MTF_correction).

- Blemish_Fill (option code 00001)

The *blemish_fill* function fills reseau marks, blemishes and missing lines. The variation of the reseau mark locations come from camera's geometric distortion and image content-based intensity variation. Thus, the predicted reseau locations must be detected for every image. Two calibration data files, predicted reseau location, and blemish location are required for this process. The true reseau locations are identified using a predicted local area reseau template matching technique. The actual blemish locations are then computed based on the true reseau locations. Figure 2 shows the locations of predicted reseau marks, detected true reseau marks, and the blemish locations.

The process creates a mask containing all pixels needed to be corrected where each reseau is modeled as a 9-pixel wide circle similar to the blemishes. The filling employs a multiresolution pyramid data representation method in order to minimize the image intensity discontinuity. The pyramid algorithm (Ref. Burt, P. J., "The Pyramid as a Structure for Efficient Computation," pp 6-34, Multiresolution Image Processing and Analysis, Springer-Verlag, 1984) can be seen as a global 2-D surface fitting that is far superior than a circularly weighted bilinear interpolation approach often used for blemish filling. Another added value of the multiresolution pyramid approach is that the blemishes can be in any shape and can be filled in one step with a proper mask.

Figures 3 and 4 are the original and blemish-filled images.

- Radiometric_Correction

This function includes the subtraction of the dark current and the intensity calibration that converts the quantized DN levels to the physical light intensity units. Four datasets are required as inputs to this process: dark current list, dark current images, light transfer function, and planet body dependent constant.

As described earlier, dark current is a time-varying quantity and it is important to apply proper dark current information that corresponds to the circumstance of the imaging

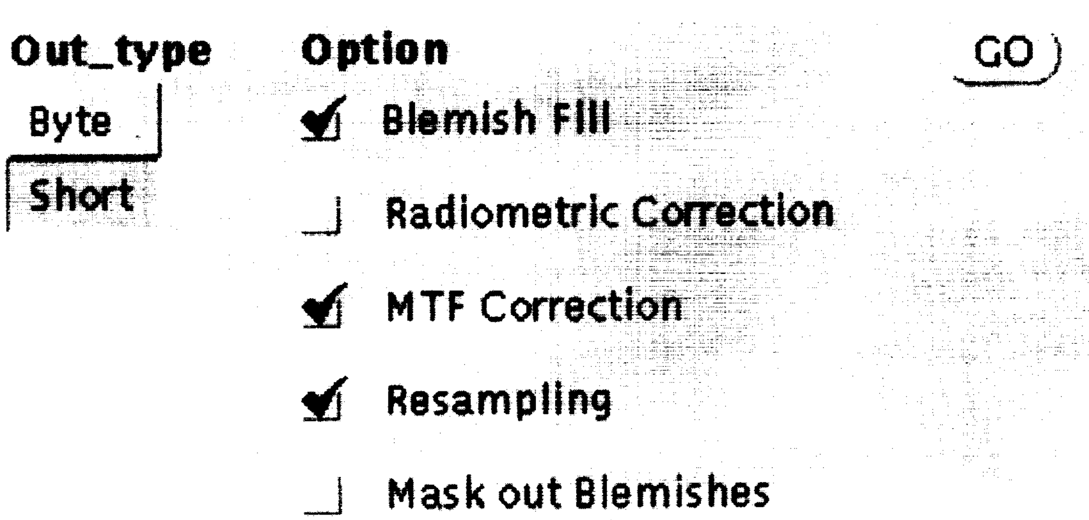


Figure 1. User interface menu. The check mark indicates enabled options.

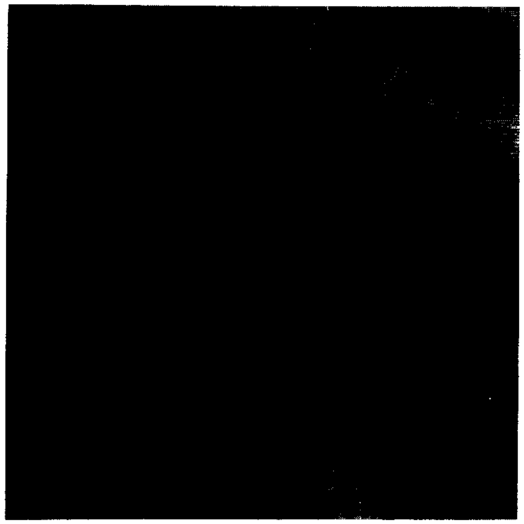


Figure 2. The locations of predicted reseau marks, detected true reseau marks, and blemishes are visible here.

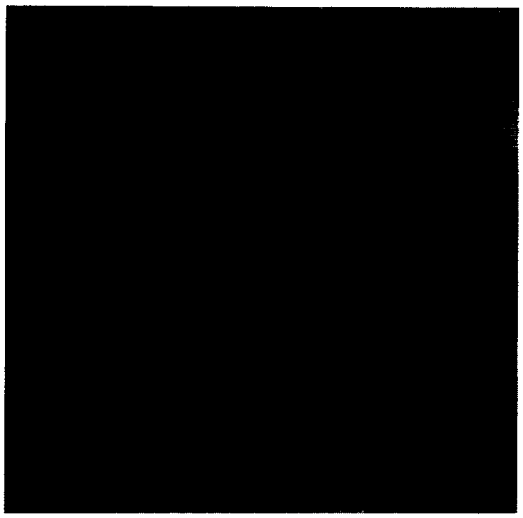


Figure 3. Original image

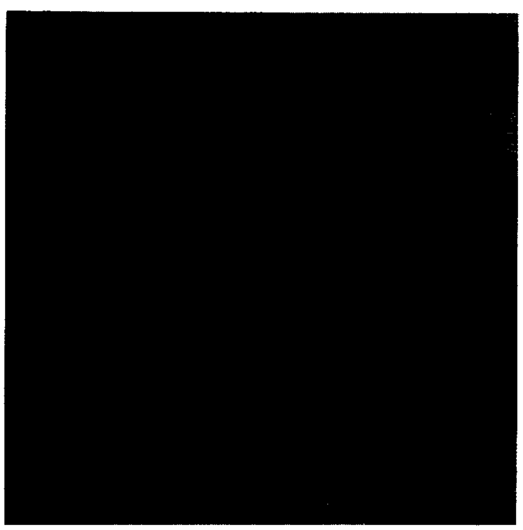


Figure 4. Blemish-filled image

instance. Dark current correction amounts to searching a database of dark current images to find one that is as close in time as possible, and matches the input image in terms of camera and imaging modes such as shutter_mode, exposure_time, scan_rate, for the subtraction of the dark current.

The radiometric correction involves reading the light transfer function and interpolating the given pixel with this function. The range of the luminance units is 16 bits, therefore the output image from radiometric correction is 16 bits per pixel.

The light transfer functions contain some erroneous data points. The last two or three segments of the piecewise linear curve around the extreme edges of the image area are often unreliable due to the erroneous data points as shown in Figure 5. The slope of the corresponding curve segment is verified before interpolation. When the slope is higher than the preset threshold (which is spatially dependent), the interpolation process traces back the previous segments until a proper segment is found.

- MTF_Correction

This function removes blurring caused by the optical aberration of the lens by convolving the deblurring kernel with the image. The resulting image has sharper contrast and the edges are more pronounced. The processing is equivalent to high-frequency component restoration (high-pass filter). Thus, any discontinuities due to blemishes in the image will be greatly exaggerated. The blemish_fill option must be set in order for the MTF_correction to be performed without undesirable artifacts.

- Geometric_Correction (Resampling)

Tie points formed using the predicted reseau locations, and the detected true reseau locations are irregularly spaced. To efficiently resample the image, these irregular tie points are regularized into grid tie points. Triangulation is used for generating regularly spaced grid tie points. However, at and near the boundary of an image where the algorithm is unable to locate a triangle enclosing the interpolating pixel, some tie points are added outside of the image boundary. These points are generated based on a global surface fitting method employing the second order least square fitting on the predicted and detected reseau location pairs (tie points). The image is resampled using bilinear interpolation based on these regularized tie points. Figure 6 shows the result of triangulation, the "+" marks are the regularized grid point. For each + mark, a triangle is formed using the three nearest tie points.

- Mask_out_Blemishes

The blemish-filling is required for most data product generation and data processing. However, sometimes it introduces false values that may hinder some scientific research objectives. This function replaces the blemish pixels with zero DN values so that the actually observed values vs. the blemishes can be easily distinguished and the blemishes do not contaminate the intensity averaging process.

For additional information about PLATO Voyager calibration contact the author at: (818) 354-3461; Internet: mihseh@elroy.jpl.nasa.gov

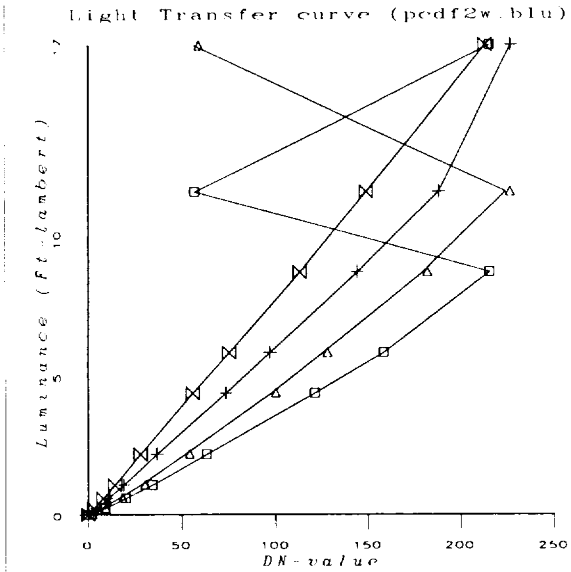


Figure 5. Segments of the linear curve around the extreme edges of the image area are often unreliable due to erroneous data points.

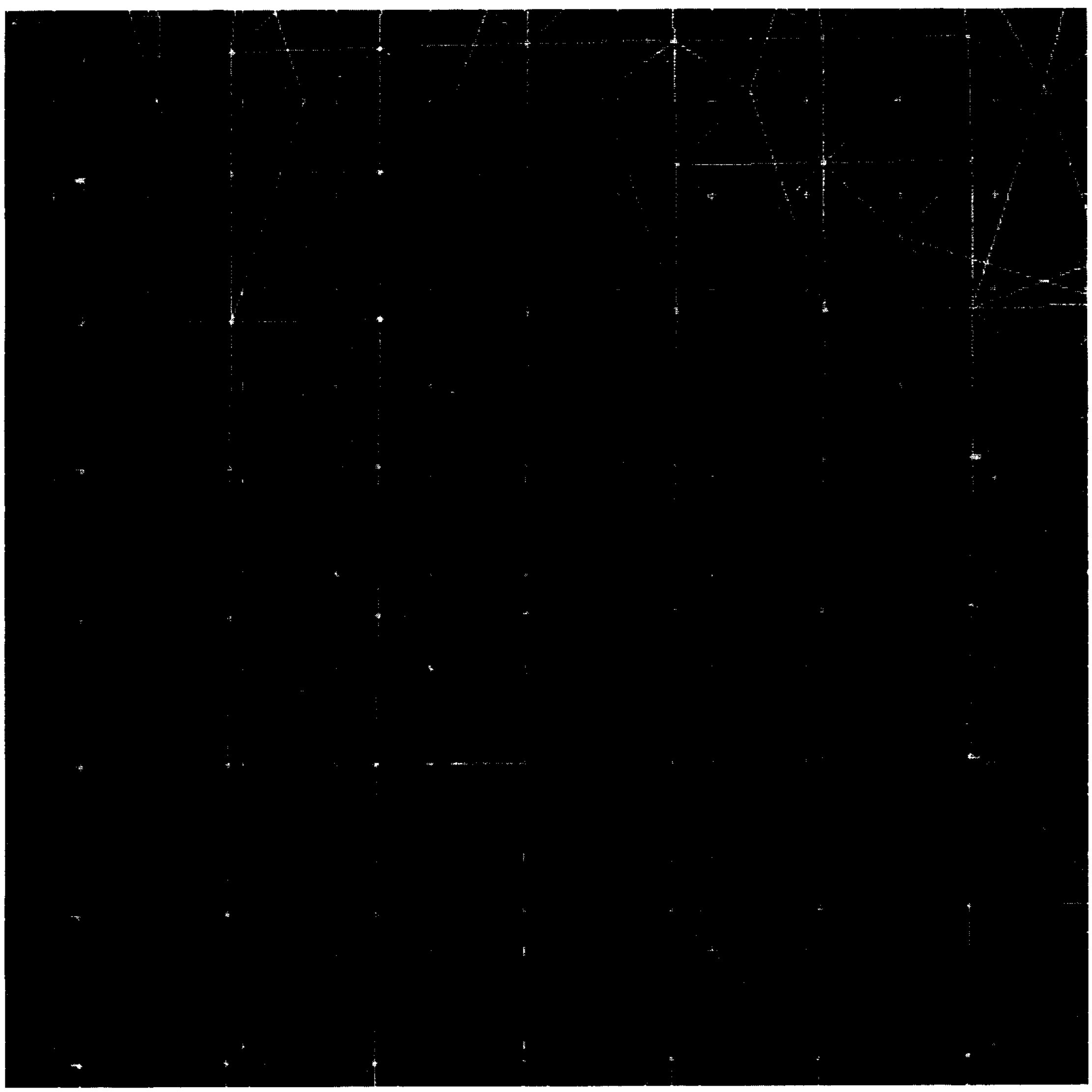


Figure 6. Triangulation results where the "+" marks are the regularized grid point. For each + mark, a triangle is formed using the three nearest tie points.

Accomplishments

Research and Technology Progress Report

Major accomplishments by the Information Systems Branch are highlighted below. They cover work performed from January—March 1993 and reflect the combined efforts of many people.

Ames Research Center (ARC)

NASA Science Internet—Joanie Thompson

- Implemented a 764-Kbps link to McMurdo Station, Antarctica, allowing the first live video transmission on national television from the White Continent as well as telepresence experiments using an underwater robot.
- Connected the Kuiper Airborne Observatory to the International Antarctic Centers' Novell network using wireless LAN technology. The IAC network is "gatewayed" to the Internet through the University of Waikato, New Zealand.
- Hosted a delegation from the Japanese Space Agency (NASDA) to discuss network planning and design to support joint NASA-NASDA science networking requirements.
- Hosted the 4th Annual High Energy Physics/Space Physics Analysis Network DECnet Coordination Group (HSDCG) Meeting at ARC. This meeting clarified DEC's planned support for DECnet networking during the next several years and provided for coordination of plans for the major DECnet networking providers (NASA, DOE, European SPAN, and European HEPNET).
- Participated in ESA-PSCN network coordination meeting at ESTEC. Negotiated bandwidth increases to support growing NASA/ESA science data traffic to/from the U.S. Resulted in planned increase in transatlantic bandwidth to ESA/ESOC (768 Kbps) and ESA/ESTEC (768 Kbps), and in ESA/ESOC upgrading their internal ESA network infrastructure to ESRIN (256 Kbps).
- Supported the 24th Annual Lunar and Planetary Science Conference held in Houston, Texas, March 15–19, 1993. Provided four terminals with Internet connectivity, demonstrated the use of the network, and presented literature on network tools, including the NSI email matrix.

Goddard Space Flight Center (GSFC)

Computer Networking—J. Patrick Gary

- Conducted network user workshops on campuses at Clark Atlanta University, North Carolina A&T State University, University of Puerto Rico, and University of Prairie View (near Houston) as part of outreach efforts for the Minority University Space Interdisciplinary Network Project. Trained over 250 faculty, technical staff, researchers, and/or students from surrounding schools in those regions. The workshops included introductions to resources and services on the Internet, operation and management of TCP/IP networks, and design and implementation of low-cost Local Area Networks.
- Set up Gopher-based information server enabling Xwindow and Ascii clients to easily locate and access a wealth of information about GSFC and other NASA on-line resources, transparently link with dozens of WAIS and ANON FTP sites, and automatically identify what's new daily on similar Gopher information servers maintained by several hundred other sites worldwide.

- Developed preliminary plans to begin evaluation of ATM/SONET-based gigabit per second local area networking technologies through participation in a DoD-sponsored metropolitan area network involving the Advanced Research Program Agency, the Defense Intelligence Agency, the Defense Information Systems Agency, the Naval Research Laboratory, and the National Security Agency.

Center for Excellence in Space Data and Information Systems (CESDIS)—Raymond Miller

- University Research Program in Parallel Computing is a CESDIS-sponsored research program that intends to attack key issues in the areas of parallel computing that affect NASA's efforts to collect, manage, store, and process massive Earth and space data. Preproposals were received and have been reviewed. Twenty-eight showed promise and the submitting groups were asked to submit full proposals by March 31. A peer review will take place upon receipt and awards will be announced about April 30. Funding is anticipated for six to eight groups, for 2- or 3-year awards of approximately $50K annually.

Scientific Applications and Visualization Branch—Horace Mitchell

- The Scientific Visualization Studio (SVS) held an open house March 9–11 to demonstrate visualization techniques and available services to the Goddard and space science communities. This open house consisted of a series of posters, video animations, and tutorials on the work of the SVS.

- Developed a real-time, 3-D visualization program for the JASON Project. This program accepts telemetry and bathymetry data via satellite and Internet broadcast from JASON, a remotely piloted submarine exploring hydrothermal vents in the Gulf of California, and displays a real-time visualization of the position and orientation of JASON along with the data being taken. This project is a collaboration between the National Geographic Society and Turner Broadcasting, and the software development was assisted by Gene Feldman of GSFC/Code 902.3 and Chuck Molyneaux of Silicon Graphics, Inc.

- As part of a new program to assist Office of Space Science researchers in gaining access to new visualization software and techniques, a visualization expert from the Scientific Visualization Studio has been jointly funded by the Atmospheric Chemistry and Dynamics Branch at GSFC. This expert will spend the next year adapting the techniques of the SVS to the direct problems and data of this branch In this way, the Scientific Applications and Visualization Branch hopes to provide in-depth assistance to OSS researchers and gain direct experience as to which techniques are of significant use to researchers in actual practice.

NASA Center for Computational Science—Nancy Palm

- On February 14, Cray Research, Inc. (CRI) added four CPUs to the existing four CPUs on the Space Data and Computing Division's Cray Y-MP supercomputer. The additional CPUs will improve interactive response time and batch job throughput. On February 20, CRI increased the Solid-state Storage Device (SSD) capacity of the Cray Y-MP from 128 to 256 megawords. The additional SSD will be configured as Secondary Data Segments.

- The UltraNet HiPPI interface to the Convex/UniTree hierarchical mass storage system, operational since mid-January, has contributed to a dramatic increase in UniTree usage. UniTree's daily net growth from November to mid-January averaged 5 gigabytes (GB)/day, but recent rates show users adding 20-40 GB/day, with nearly a terabyte of data stored and retrieved over a 6-week period. As a result, it is anticipated that UniTree's two StorageTek 4400 silos will be completely full by April.

Space Physics Support—Bob McGuire

- A focus and pacing milestone for much of the winter-spring 1993 CDAW and SSC activities will be the upcoming "Community-Wide Workshop on NASA's Space Physics Data System (SPDS)." Both systems are being upgraded and will be made publicly accessible during May in their latest forms. By agreement with NSSDC, we will use an extended and improved form of the NSSDC Online Data and Information Services (NODIS) guest account as a single unified point of entry to both these systems and the wide range of NSSDC systems/services already supported under NODIS. The NASA Master Directory will play a key role in the initial SPDS as the common "front-end" user interface.

- Extensive work continues to define and advance the use of common data standards by current space physics projects and programs. An updated description of the ISTP CDF guidelines was released in January, and a workshop was hosted under the auspices of the IACG and IACG/WG-2 to train key Interkosmos/Interball personnel in the use and application of these standards.

Jet Propulsion Laboratory

Navigation and Ancillary Information Facility (NAIF)—Chuck Acton

- Completed testing, documentation and first delivery (to Mars Observer) of the core SPICE E-kernel subsystem.

- Established a plan for and initiated participation in an EOS Interuse Experiment to demonstrate the applicability and advantages of the SPICE ancillary information system technology within EOSDIS.

- Presented the SPICE concept to Lunar Scout program/project management and PIs. Also provided SPICE description and some detailed documentation to AXAF program management.

- Produced and evaluated three test write-once CD (CD-WO) disks containing an assortment of SPICE and related navigation data.

- Worked on design and prototyping of SPICE kernel summary software.

- Provided samples of SPICE components for a demonstration (HyLite) of how modern information system technology could be used to organize, search for, browse and retrieve SPICE system components, including data, software and documentation.

Planetary Data System (PDS)—Yolanda Fletcher

- The Planetary Science Data Dictionary has been placed on/line as part of the existing PDS Central Node catalog.

- The PDS Small Bodies Node, in coordination with the International Halley Watch Project, has distributed 24 Comet Halley CD-ROMs containing ground observations taken during the 1981-89 period. The Planetary Plasma Interactions Node at UCLA released the first in a series of Voyagers to the Outer Planets Fields and Particles data on CD-ROM. This volume contains Voyager 2 non-imaging datasets from Neptune.

- PDS attended the founding meeting of the government special interest group SIGWAIS (Wide Area Information Server) and demonstrated several WAIS sources containing PDS-related information.

- The PDS Geosciences Node demonstrated science data available from PDS at the 24th Annual Lunar and Planetary Sciences Conference in Houston. The demonstration of the new Geoscience Magellan detailed-level catalog and *Journey to the Planets* were well received.

New Master Director Interface Offers Many Enhancements

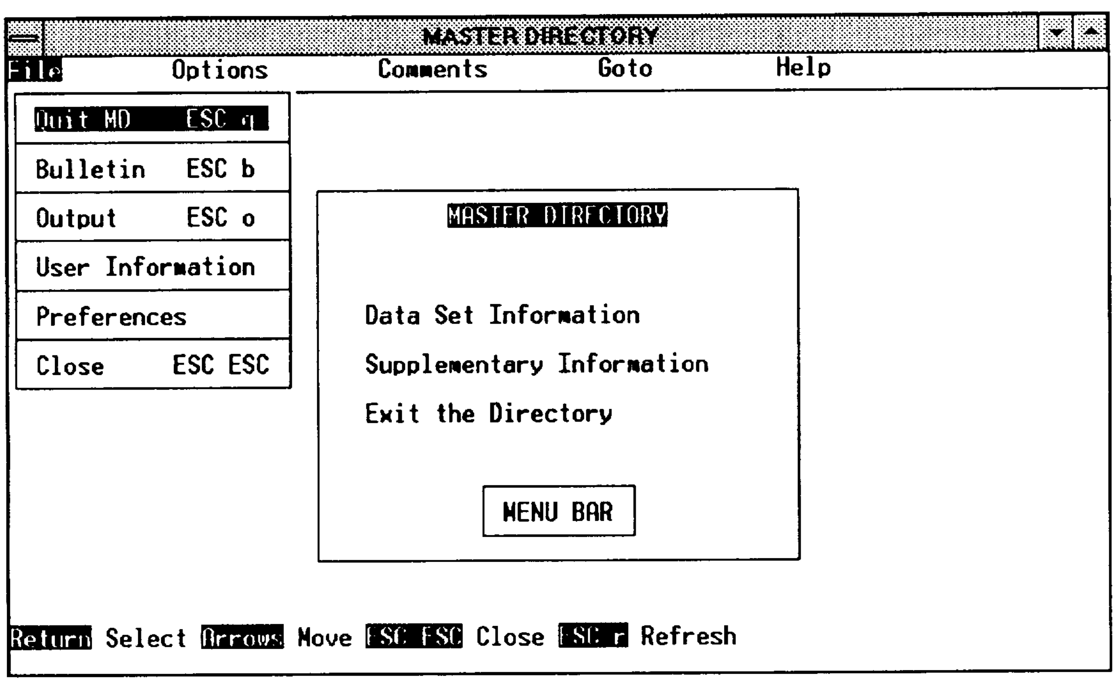
Patricia Bailey and Janis Shipe, Hughes STX

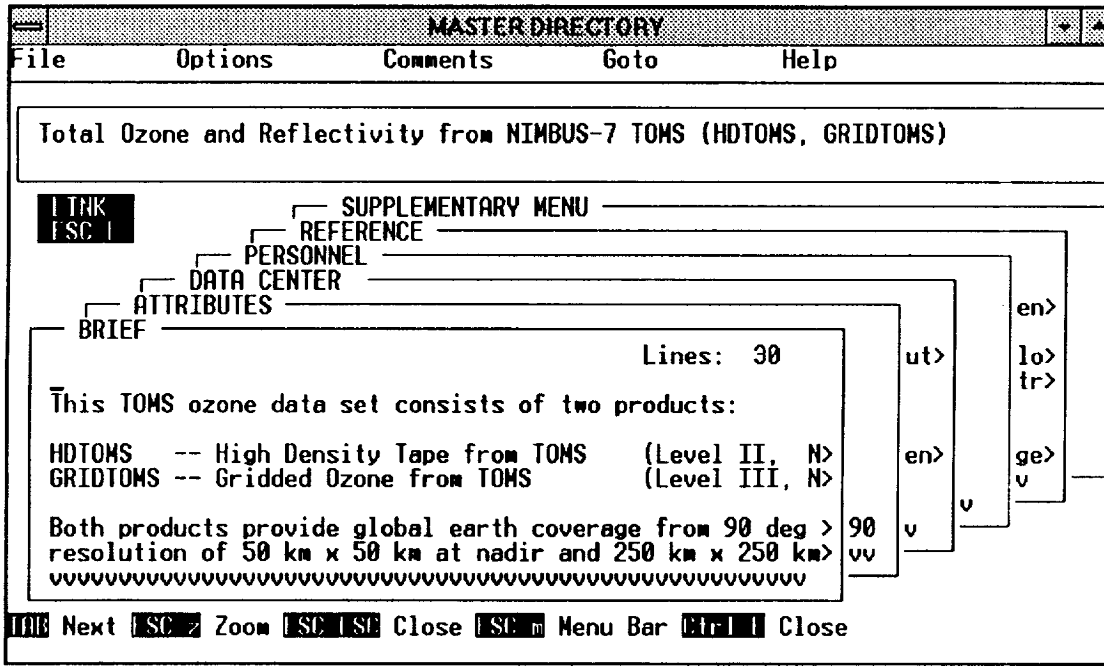
Throughout the lifecycle of the Master Directory (MD), the system and interface have evolved through interactive dialogue among system developers and science users. Initially, the MD system was developed based on requirements constructed by the Catalog Interoperability Working Group. This design and implementation included a database structure to store directory information, a data loader, and a user-friendly, menu-driven interface. Subsequent development tasks included a data extractor, data deletion utilities, database support utilities, and numerous reporting capabilities.

The introduction of the MD into the international science community altered the scope of the MD task. The new International Directory Network (IDN) required special tools for automatic transfer and loading of directory information between nodes. In addition, technical training and support were provided to each of the IDN nodes. The IDN environment along with the changing needs of the science community led to a second design initiative and new implementation. The current MD system design includes a client/server architecture and many enhancements as suggested by the science community. Several client applications are being developed including an alphanumeric client using JYACC Application Manager (JAM) and XWindows. Also, the original MD system is being converted to take advantage of the new client/server design. Currently, both the MD1 interface and the new the JAM client are available to the user community via the NODIS system at the NSSDC.

New features of the MD JAM client

The new MD client has many enhancements that offer extended capabilities over Version 1.





Pull-down menus provide access to automatic help and valids, session output, user information profile and session preferences, as well as a GOTO function. Titles resulting from a query may be sorted by one of several available attributes. The information display is presented on six "index cards" each containing a section of the directory entry. These cards may be zoomed to full screen display for easier viewing.

Accessing the Master Directory

NSI/DECnet
Set host: NSSDCA
Username: NODIS
Select option #1 from the menu
Answer "YES" to use Version 2

Internet
Telnet: 128.183.36.23
Username: NODIS
Select option #1 from the menu
Answer "YES" to use Version 2

Direct Dial
Set modem to 8 bits, no parity
1 stop bit for 300, 1200 or 2400 baud
Dial (301) 286-9000
For 9600 baud, dial (301) 286-4000
Prompt: Enter Number, you enter "MD"
Prompt: Call Complete, you enter <CR>
Username: NODIS
Answer "YES" to use Version 2

Where to get help

Contact the Master Directory User Support Office (MDUSO) for help on any aspect of the MD. The MDUSO will direct you to the appropriate MD team member who can assist you with questions about using the MD, about the specific contents of the MD, with preparing new data entries, and with establishing LINK connections. The MDUSO can be reached : (301) 513-1687; NSI/DECnet: NCF::MDUSO; Internet: MDUSO@nssdca.gsfc.nasa.gov