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CONTENTS

Space Weather Data in A Flash

Susan Sahm, Larry Puga, and Sue Greer, National Oceanic and Atmospheric Administration/Environmental Research Laboratories Space Environment Center

The Space Environment Center (SEC) conducts research in solar-terrestrial physics and develops techniques for forecasting solar and geophysical disturbances. SEC also provides real-time monitoring and forecasting of solar and geophysical events to customers, and prepares data to be archived by the National Oceanic and Atmospheric Administration's (NOAA) National Geophysical Data Center. SEC operates the national and world warning center for disturbances in the space environment that can affect people and electronic equipment.

In the fall of 1991 development began on an in-house data archive and retrieval system that would provide easy access to and analysis of SEC scientific archival data. The completed system, dubbed the Space Environment Laboratory Retrieval and Analysis System (SELRAS), has quick and easy access to SEC data and includes graphics and analysis tools that allow you to view and analyze the data. SELRAS meets the requirement that the system be extensible, so that new data sets are added as they become available, and also allows integration of new analysis tools as they are developed.

SEC receives giga-bytes of data from multiple sources on a daily basis, including measurements from the Geosynchronous Orbiting Environmental Satellites (GOES), NOAA Television and Infrared Observation Satellites (Tiros) and WIND satellites. Data from the Continental Meteorological Data System (Air Force teletype), the Boulder, Colorado, ground-based magnetometer, and full solar images will also become part of the SEC database. The GOES satellites provide three second X-ray data, one minute particle and electron data, and 0.512 second magnetometer data. The data are available in SELRAS as one minute averaged X-ray data, five minute averaged particle and electron data, and 0.512 second and one minute averaged magnetometer data. NOAA satellite data are received in two second data records, and are available in the SELRAS database as 16 second averaged data records. WIND satellite data from the Magnetic Fields Investigation, Solar Wind Experiment, and Energetic Particles and Three-Dimension Plasma Analyzer are received in real-time for two hours a day, in resolutions as small as 23 seconds. Twenty-four hour playback data are also received from the WIND satellite, and both of these data sets are available in SELRAS. The data from these satellites are available with a delay of only one day.

Approach

The heterogeneous SELRAS data sets are stored in the common data format (CDF) developed by the National Space Science Data

The purpose of the SCIENCE 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 Information Systems in support of NASA's Office of Space Science. Articles of interest for other programs and agencies are presented as well.

Center (NSSDC) at Goddard Space Flight Center. The CDF format stores metadata with the data file, and all the diverse data sets are written in the same file format. This allows portability between platforms and across networks and enables a single interface to access all data sets. SELRAS, written in interactive data language (IDL), runs on multiple platforms and has the ability to create graphical user interfaces, plots, and graphics. It also has extensive analysis tools. SELRAS is portable to UNIX workstations, Macintosh, and PC platforms.

The SELRAS database management system consists of CDF data sets, a list of the current directories containing the various data sets, and file-naming conventions for each data set. It is easier to maintain and use than commercial database management programs, and does not require files to be added to or deleted from a database management system. New data sets are easy to add to SELRAS because information about the data sets is kept in files and updating these files will add the new data sets without any additional programming. It is also a simple process to incorporate new IDL algorithms into SELRAS. Numerous scientific algorithms and stand-alone procedures written both within and outside SEC were ported into SELRAS with minimal effort.

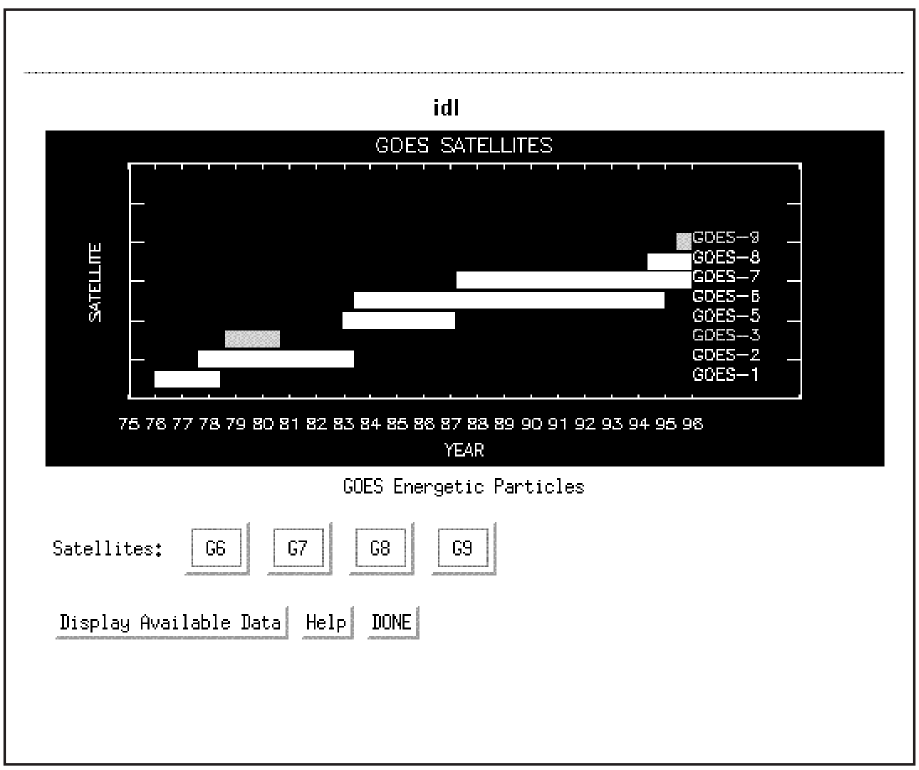

Figure 1. GOES satellite selection screen

SELRAS components

SELRAS is a distributed system that is linked through many diverse platforms. This system configuration is in a constant state of flux, with new equipment and operating systems being added and removed as needs dictate. SELRAS currently consists of two HP computation and data servers running the HP-UX operating system, two DEC 5000 workstations, three HP workstations, and multiple CD-ROM readers. These machines provide the hardware and disk space for the SELRAS distributed database. The data are accessed, transparently, through linked directories on each machine, using network file server (NFS) mounts. SELRAS can be accessed by any SEC user with a computer that has an X-Windows interface.

The SELRAS database has approximately 10 GB of data, and it grows daily. Data from the NOAA, GOES, and WIND satellites, and ground based magnetometers, make up the majority of the online data. GOES energetic particle data, magnetometer data, and X-ray data are available from GOES6, GOES7, GOES8, and GOES9. NOAA data are available from NOAA6, NOAA7, NOAA10, NOAA12, and NOAA14, dating back to July 1979. WIND data are available beginning in November 1994. The data from the GOES and WIND satellites are updated daily, so researchers have access to historical archive data up through the present. Geophysical indices (Ap, Kp, DST) are also available.

The SELRAS graphical user interface (GUI) allows you to choose data sets containing multiple files of the same type, or specific data files, and then obtain plots or ASCII listings. It also allows you to run specialized plotting programs. In the main SELRAS screen, you choose either a data set or an individual file to examine. Private CDF files can also be viewed using the *Manual File Selection* option in the SELRAS main interface. A list of SELRAS data sets is displayed from the *Data Set Selection* button on the main screen.

If you choose a data set, a screen describing available options is displayed. In the example shown in Figure 1, GOES X-ray data was the data set chosen. The data from a particular satellite number to be viewed is selected next. Multiple data sets can also be selected. After picking the data sets and/or file names, you can

Figure 2. SELRAS plot options screen

choose to create an ASCII listing or plot the data. In the example in Figure 2, *Draw Plots* has been chosen and the Plot options screen is displayed. All of the default plot options shown on the screen are used if other choices are not made. You will usually override the default start and end times. The *Sample Interval* is the record interval to use when accessing the data (usually 1). *Frames Per Page* are the number of plot frames to put on a page (this is currently limited to twelve), and there is a choice of either a *Time Series* or *X/Y* plot drawn as either a *Line*, *Bar*, or *Scatter* Plot on a *Linear* or *Log* scale. X and Y axis values must be chosen from the displayed variable names that are obtained directly from the CDF file. After choosing *Draw Plot*, the Plot Screen (Figure 3) is displayed, with the option of re-scaling the plot to different scale types. The *SAVE PLOT FILE* option allows a postscript file of the page to be saved; the plot may also be sent to a printer using the *PRINT PLOT* option. The *<– and ->* buttons allow you to move forward or backward in the data set, at a length of time equal to the interval chosen in the main screen.

Achievements and future plans

SELRAS has proven to be an effective tool in accessing large databases, is extensible, easy to maintain, and can expand with new data sets and algorithms. SELRAS is used by space weather forecasters and researchers at SEC. GOES X-ray, proton, and magnetometer data are used to analyze events associated with interplanetary disturbances (for example, those that occurred in 1991 and 1992) and to statistically analyze solar events of long duration. The X-ray data are also used to study flares. Instrument comparisons between GOES satellites is accomplished with SELRAS, as is the validation of GOES data processing. TIROS data are used with SELRAS to study the distribution of measured radiation intensities; this helps researchers to determine the causes of spacecraft anomalies. Forecasters use SELRAS to view the WIND data in an effort to improve

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Readers are invited to contribute articles or information regarding published works, awards, announcements (research, opportunity, or CANs), or calendar events for publication. All submittals, changes of address, or questions or comments on content should be sent to theEditor, Sandi Beck, Telos Information Systems, 320 N. Halstead #260, Pasadena, CA, 91101; 818-306-6691; sandi.beck@jpl.nasa.gov

All articles and photographs without bylines were written or taken by the editor, Sandi Beck. Editorial assistance is provided by Pat Kaspar, Ames Research Center, and Judy Laue, Goddard Space Flight Center. This issue's print layout by Faye Elman, graphic enhancement by Chris Hawley, and Web layout by Jim Jackson—Electronic Layout and Production Team, Jet Propulsion Laboratory.

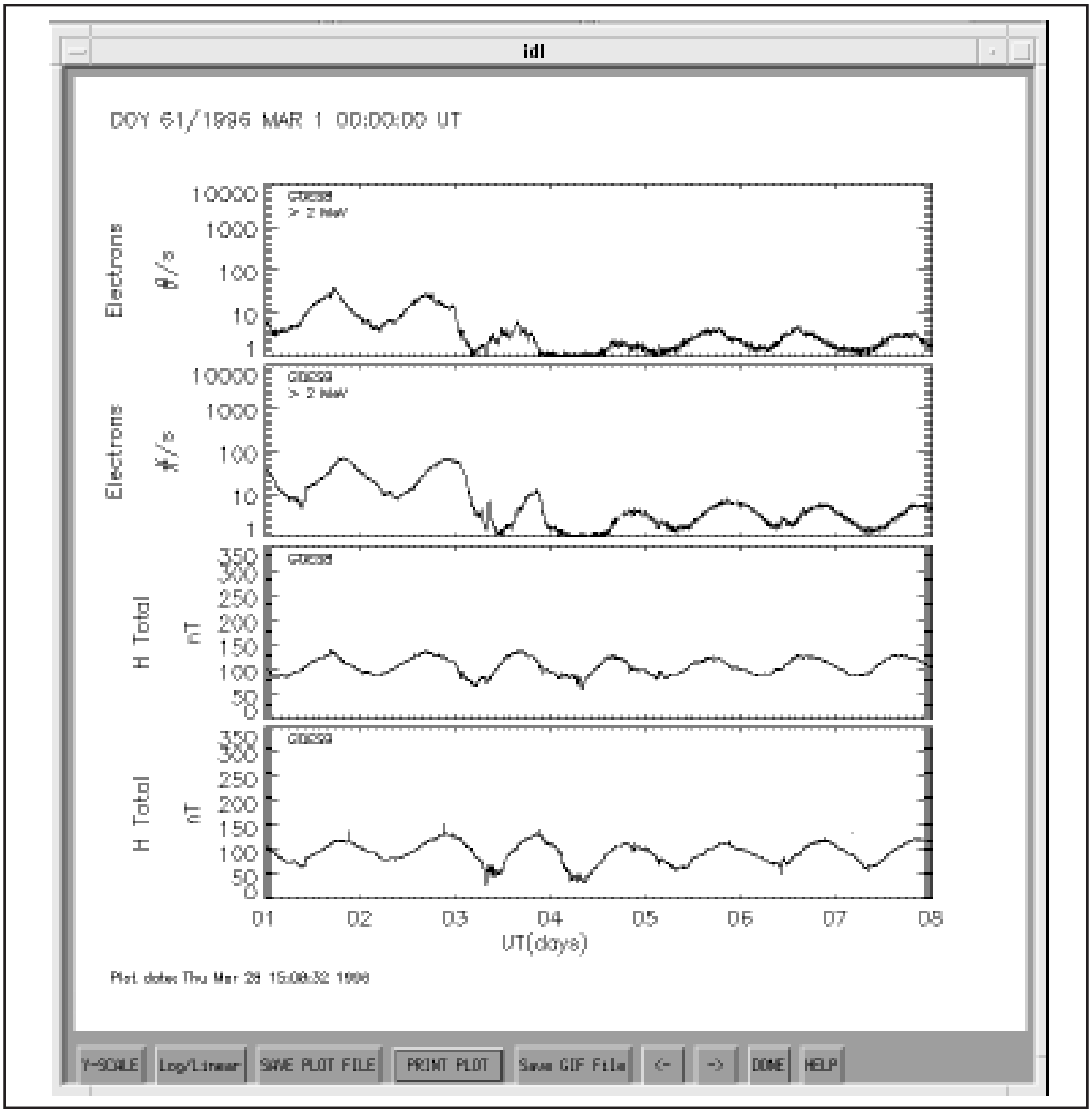

Figure 3. GOES plot with electron and magnetometer data

their space weather predictions. These are just a few examples of the many uses of SELRAS.

SELRAS will provide access to new data sets as they are acquired by the Center, and will incorporate new scientific algorithms as they are developed by researchers. There are also plans to enhance the current graphics capabilities.

For further information contact Susan Sahm or access the SEC home page at, respectively:

ssahm@sec.noaa.gov
http://www.sel.noaa.gov/sec.html

References

The following reference materials were used in the preparation of this article:

S. R. Sahm, L.C. Puga, M.S. Greer, "Space Environment Laboratory Retrieval and Analysis of Scientific Data (SELRAS)," *NOAA Technical Memorandum* ERL SEL-87, 1995, p. 69.

Calendar

AUGUST

4-9 SIGGRAPH '96, New Orleans, LA; Smith, Bucklin & Associates, Inc.; 312-644-6610; Fax: 312-321-6876; siggraph96@siggraph.org

4-9 Remote Sensing, Optical Science, Engineering, and Instrumentation International Symposium, Denver, CO; SPIE; 360-676-3290; Fax: 360-647-1445

12-16 International Conference on Parallel Processing, Bloomingdale, IL; Mike Liu; 614-292-6552

18-23 Information Technology Conference; Seattle, WA; Graphic Communications Association; 703-519-8193; Fax: 703-548-2867; mle@gca.org

20-22 PECORA, Thirteenth Symposium (Human Interactions with the Environment: Perspectives From Space); Sioux Falls, SD; USGS EROS; 605-594-6040; Fax: 605-594-6083; pecora13@edcserver1.cr.usgs.gov

SEPTEMBER

17-19 Data Warehousing Conference, Phoenix, AZ; DCI; 508-470-3880; http://www.DCIexpo.com

OCTOBER

16-19 Web Net '96, San Francisco, CA; The Web Society and AACE; 804-973-3987; Fax: 804-978-7449; AACE@virginia.edu; http://AACE.virginia.edu/AACE

17-19 National Science Teachers Association Western Regional Convention, Phoenix, AZ; NSTA; 703-312-9221; conventions@nsta.org

22-25 28th Annual Meeting of the Division for Planetary Sciences, Tucson, AZ; American Astronomical Society; Steve Larson; 520-621-4973; slarson@lpl.arizona.edu

24-26 Online Expo, Los Angeles, CA; International Marketing Association; 310-285-8728

27-31 Visualization '96, San Francisco, CA; IEEE; nejohnston@lbl.gov

29-31 Tech 2006, Anaheim, CA; NASA Technology Utilization Foundation; 212-490-3999

NOVEMBER

4-7 Eco-Informa '96 Global Networks for Environmental Information, Lake Buena Vista, FL; ERIM; 313-994-1200

6-8 ESRI southwest Users Group Conference, Flagstaff, AZ; ESRI; Fax: 520-771-3257; http://www.bslnet.com/accounts/raven/www

17-22 Supercomputing '96, Pittsburgh, PA; ACM and IEEE; Kimberly Iles; iles@netdesign.com

DECEMBER

15-19 American Geophysical Union Fall Meeting; San Francisco, CA; 202-462-6900; meeting@kosmos.agu.org

27-29 1996 Global Summit on Science and Science Education, San Francisco, CA; NSTA; 1-800-328-8898

Announcing New Internet Services at the Astronomical Data Center

Gail Schneider and James Gass, Hughes STX, Astronomical Data Center, Goddard Space Flight Center

The Astronomical Data Center's (ADC) new Internet services include an Internet site hosting enhanced World Wide Web (WWW) and file transfer protocol (FTP) access to the ADC's archives. From ADC's new home page, Web users can easily explore the new FTP site or query a database of descriptions of the catalogs and journal tables. ADC's new WWW home page can be accessed at :

http://adc.gsfc.nasa.gov/

Perhaps the biggest single improvement is that now the entire public data holdings of the ADC are retrievable from magnetic disk via anonymous FTP. This should be quicker and more convenient for users than the previously used write-once-read-many system. More than 760 astronomical catalogs and 625 journal tables are now retrievable online via anonymous FTP. For direct FTP access, from Internet connect as follows:

ftp adc.gsfc.nasa.gov
or
128.183.106.99

Log in as "anonymous" and give your email address as the password. Once connected, move to the pub/adc/archives subdirectory, which is the root of the catalog and journal table archive directories. You will find a "key" file present at each level of the directory tree that contains an index of each subdirectory.

Please note that all catalogs and journal tables except for the "readme" and other miscellaneous documentation files are stored in a UNIX compressed format. The "readme" file should be read first. It normally contains the catalog and journal table identification, a summary of the files, a description of the data, and a description of the format, and is used as the basis for a full-text search for the catalog or journal file. To allow such a search to be made, a skeleton "readme" file was added to each catalog directory that lacks a standard "readme" file. The skeleton files are incomplete; they do not contain format tables. You are advised to refer to the additional documentation where available. The main files are compressed binary files. The server allows on-the-fly decompression of compressed files by omitting the "gz" suffix from the file names. If you prefer to receive the main catalog files in compressed form, once copied (using the bin option via FTP) use gunzip to uncompress the files.

When using these data in any reports, publications, or formal presentations, please acknowledge ADC.

For further information contact:

help@adc.gsfc.nasa.gov

Circulation Database

Please help us update our circulation database by sending your email address and new ground mail address (if applicable) to:

sandi.beck@jpl.nasa.gov

Telemedicine in Real Life

Pat Kaspar, NASA Internet, Ames Research Center

On Tuesday, May 14, the Ames Research Center (ARC) Internetworking Technologies Group (ITG) staff was requested to support a real-life demonstration session of the Telemedicine Space Bridge to Russia project before its pilot program was fully underway. A patient in Moscow began having problems with a heart valve that had been inserted at Texas Medical Center (TMC) in Houston under the supervision of Dr. Michael E. Debakey* of Baylor College of Medicine, part of TMC. Doctors at Moscow State University (MSU) needed a network connection to Baylor in order to collaborate with Dr. Debakey on a solution.

ITG staff members Hugh LaMaster, David Meyers, and John Meylor worked long hours with their counterparts at Baylor (Dale Samuelsen, Marc Newman, and Lynne Van Arsdale), MSU (Alexander Mikhailov and Konstantin Scherbatukh), and the Space Science Research Institute, called IKI, in Moscow (Alexey Sadchikov and Michael Zakharov) to get the connection up and running by Friday, May 17. The Baylor staff had to acquire a Silicon Graphics Inc. (SGI) machine capable of running high-quality Internet-capable videoconferencing tools. The ITG staff had to establish a connection with Moscow, which meant that MBone connectivity had to be arranged. Finally, the MBone path between MSU and IKI had to be re-established, as did the NASA Internet–IKI MBone "tunnel." However, on the day of the session MBone via the Texas Sesquinet would not work, so a direct tunnel was established from ARC to the demo SGI at Baylor. The final medical session included use of unicast video from Baylor to MSU via the Goddard Space Flight Center (GSFC) link; audio was accomplished via a teleconference established through Marshall Space Flight Center. Some medical records were sent from MSU to Baylor using a multi-purpose Internet mail extensions-compliant Internet mail program, called MediaMail. An electrocardiogram was sent using an "Elmo Presenter" video camera an the Lawrence Berkeley Lab-developed "vic" videoconferencing tool.

The demonstration session helped confirm the diagnosis of the Russian physician, and the doctors were able to discuss treatment options. It also highlighted several problems, including the need for greater bandwidth between IKI and GSFC to ensure successful multiway audio/video/whiteboard sessions with Russia-based participants, and the need for greater control of traffic access over critical links with limited resources. The success of this effort was due to the outstanding collaboration between the technical staff from Baylor, SGI, NASA ITG, IKI, and MSU.

For further information contact Dan Machak at:

machak@nispo.arc.nasa.gov

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* Dr. Debakey is well-known as the first person to attempt to use an artificial heart to keep a patient alive while the heart organ healed. This was around the time of the first heart transplants in the late 1960s.

NASA's wealth of technology is being re-used in the fields of medicine, industry, and education and by the military to develop products and processes that benefit many sectors of our society. Spinoff applications from NASA's research and development programs are our dividends on the national investment in aerospace.

Have You Been Published Lately?

NASA/Office of Space Science is proud of the contributions many of its science and applications researchers, scientists, and engineers make to professional organizations and publications. If you have been published in the last six months and wish to be noted in this newsletter, send the citation to:

sandi.beck@jpl.nasa.gov

Virtual Workbench Technology Assists Reconstructive Surgery

Ames Research Center (ARC) is collaborating with Stanford University Medical Center, Palo Alto, California, to develop a virtual environment workbench for twofold use: planning complex craniofacial reconstructive surgery and training new surgeons. This technology will enable surgeons to plan complex surgical procedures and to visualize the potential results of reconstructive surgery in a virtual environment simulator. This new, advanced technology is based upon 3D reconstruction software originally developed for space research to visualize structural changes in the organization of gravity sensors in animal exposed to microgravity. The virtual environment workbench is a new application of this NASA-developed software.

Preoperative laser scans of a patient's face will be integrated with computer tomography (CT) scans of the patient's head, enabling the creation of highly precise, 3D images of the face and skull. ARC's computer specialists will match the facial laser images to the skull features in CT scans by extracting the bone structure from the series of scans, contouring it, and using special software to reconstruct the skull. Because the reconstructed face is transparent, the bone structure is visible behind it. Muriel Ross, director of ARC's Biocomputation Center, explained that the goal is to allow surgeons to 'see' the face with the skull and enable them to use the same tools in a virtual environment that they would use in the actual surgery.

By using this technology, surgeons will be able to practice an operation in different ways and view the results; something surgeons have not been able to due previously with accuracy, according to Dr. Stephen Schendel, chair of the Department of Plastic and Reconstructive Surgery at Stanford. Furthermore, because the system is interactive, surgeons in other hospitals will be able to collaborate in complex or critical surgery via high-speed networking lines.

The NASA-Stanford team is especially interested in working with children who need reconstructive surgery to correct deformities of the head and face, and with mastectomy patients needing breast reconstruction. Because the system is very generalized, according to Ross, eventually it should be applicable for use in other medical specialties or surgical procedures. An added benefit in developing these tools is the possibility of producing virtual environment simulations of common surgical procedures to be used in space for long-term missions.

Excerpted from NASA press release 96-119 authored by Ann Hutchison, ARC, and Mike Goodkind, Stanford University Medical Center News Bureau, Palo Alto, CA.

On The Web

The *Science Information Systems Newsletter* is now available on the Internet at:

http://www-sisn.jpl.nasa.gov

Please send comments or suggestions to Sandi Beck at:

sandi.beck@jpl.nasa.gov

Space Physics Catalog Provides Access to National Space Science Data Center Information

Emily Greene and Karen Horrocks, Hughes STX, National Space Science Data Center, and Bob McGuire, Space Data Physics Data Facility

The National Space Science Data Center (NSSDC) and the Space Physics Data Facility (SPDF) recently announced the availability of a new World Wide Web-based interface to facilitate electronic retrieval of the wide range and large volume of space physics data now being held near-line in the NSSDC Data Archive and Distribution System (NDADS). This new interface, termed the Space Physics Catalog or SPyCAT, supports access to data including current key parameters (KPs) of the International Solar Terrestrial Physics (ISTP) program now expanded by permission of Japanese and Canadian investigators to include all Geotail and CANOPUS KPs. A brief but complete list of space physics data (generally fields, plasmas, particles and images)—at this time a total data volume approaching 200 GBytes near-line—that are retrievable via SPyCAT is shown in Table 1.

The SPyCAT interface may be found at:

http://nssdc.gsfc.nasa.gov/space/ndads/spycat.html

The SPyCAT home page consists of a list of spacecraft with data currently available from NDADS. The system holds near-line data on optical platters accessible automatically on a robotic jukebox. When you select a spacecraft, a perl script queries an ASCII database containing information on different types of data available for that mission and a data availability check page is generated. This page contains information about each type of data available plus links to more detailed documentation. You then select the desired type of data and enter the time range of interest. Dates can be entered as either month and day or Julian day.

When the request is submitted, a second perl script takes your request and formulates a standard query lanquage query to the NDADS database. The database is queried in real time, generally in less than 30 seconds, and all data matching your request are displayed on an archives request form page. From this final page, you can request to have the data staged to NSSDC's anonymous file transfer protocol area or to have the data automatically transferred to your home machine. The request is usually filled within five minutes, depending on the current system load. After the data is made available, you are notified by email of the location.

For further information on the SPyCAT interface contact:

Emily Greene
301-441-4234
Emily.Greene@gsfc.nasa.gov

or

Table 1

Mission	Data Span	Approx Volume
ISTP and ancillary	9/92 - present	7 GB
- investigation KPs: including Geotail, Wind, IMP-8, GOES, LANL, DARN, CANOPUS, and Sondestromfjord (additional data arriving daily)		
- SAMPEX (with additional data arriving)	7/92 - 9/92	2 GB
- Dynamics Explorers (DE) 1/2 (including SAI image data)	8/81 - 11/89	70 GB
- Hawkeye	6/74 - 4/78	30 GB
- IMP-8	10/73 - 6/95	10 GB
- International Sun-Earth Explorers (ISEE) 1/2/3	10/77 - 6/92	12 GB
- Pioneer 10/11	3/72 - 12/94	1 GB
- San Marco	4/88 - 12/88	1 GB
- Ulysses	10/90 - 12/94	2 GB

Bob McGuire
301-286- 7794
Robert.E.McGuire@gsfc.nasa.gov

For information on space physics data, NDADS, and other services of NSSDC contact the NSSDC Coordinated Request and User Support Office at:

301-286-6695
request@ncf.gsfc.nasa.gov
FAX: 301-286-1771

These services also support the space physics community as an extension of the Space Physics Data System.

Coordinated Data Analysis via the World Wide Web

Mona Kessel, Dick Burley, and Bob McGuire, Space Physics Data Facility

The Space Physics Data Facility (SPDF) and the National Space Science Data Center (NSSDC) announce the release of a recently developed World Wide Web (WWW)-based interface to enable the browsing of data. Coordinated Data Analysis (Workshop) Web (CDAWeb) supports viewing variables from multiple instruments on multiple investigations simultaneously, as well as viewing on various time scales. The various CDAWeb databases, including the International Solar-Terrestrial Physics (ISTP) public key parameters, are available through the SPDF WWW home page at:

http://nssdc.gsfc.nasa.gov/spdf/

Guidelines

The ISTP and the Interagency Consultative Group (IACG) are multispacecraft, multi-national programs. Their primary objective is to promote further understanding of the complex plasma environment surrounding the Earth, other planets, and in interplanetary space. Extensive data sharing and data analysis are needed to ensure the success of the overall ISTP/IACG program. For this reason there has been a special emphasis on data standards throughout ISTP/IACG. It also led the projects early on to adopt NSSDC's common data format (CDF) as the standard for data products.

To ensure correct interpretation of the data products, the ISTP/IACG guidelines were designed on top of and separate to CDF and specified exactly how to structure data and what descriptions to include. The combination of CDF and the ISTP/IACG guidelines enabled the development of numerous tools with the ultimate goal of visualizing ISTP/IACG data and obtaining meaningful scientific objectives.

The databases

The distributed nature of the ISTP/IACG collaborations makes the WWW a natural vehicle for browsing and dissemination of data, and can serve as a springboard for coordinated data analysis. CDAWeb supports viewing variables from multiple instruments on multiple investigations simultaneously, as well as viewing on various time scales. CDAWeb can be tied to any database containing data in the CDF and using the ISTP/IACG guidelines. The following databases are presently tied to the CDAWeb system:

1. IACG First Campaign Data
2. ISTP Magnetopause Skimming Campaign Data
3. ISTP Key Parameter Data
4. Space Weather Education Initiative CDAW 9 Database

These databases consist of both public data and data initially restricted to use by campaign participants. “Rules of the Road” and procedures to participate in the campaigns are accessible via each campaign’s home page. This article focuses on the ISTP key parameters, which are preliminary data intended for use as browse data. Users interested in a publication quality version of this data are encouraged to contact the appropriate principal investigator. The platforms supporting these large databases will be upgraded soon, but response may be slow at this time. The software and control are also still evolving, and some problems probably still exist.

The user perspective

The system is essentially a hierarchy of choices consisting of only four pages. The top level page offers a choice of mission group and/or instrument type. This is followed by a list of data sets available on the second page. The third page contains the list of variables for each selected data set with a time range specification and the choice of seeing either a plot of the selected variables or an ASCII listing of the selected variables or you may download the data files yourself. The fourth and final page is the result of the choice specified on the third page: the plot(s), the ASCII listing(s), or the site of the data files themselves. The data is also available from NSSDC/SPDF's Space Physics Catalog-SPyCAT-web system attached to the NDADS near-line archive. The various CDAWeb databases, including the ISTP public key parameters, will be available through the Space Physics Data Facility page at:

http://nssdc.gsfc.nasa.gov/spdf/

In the initial CDAWeb page you can select data either as a mission group or as an instrument type. The first category contains individual spacecraft such as Geotail, Wind, Polar, Interball, IMP-8, and also groups of investigations such as Geosynchronous spacecraft and ground-based investigations. The other category contains investigations grouped together by type such as electric fields (space), magnetic fields (space), particles (space), plasma and solar wind, radio and plasma waves (space), ground-based high frequency-radars, ground-based imagers, ground-based magnetometers, riometers, sounders, and ground-based very low frequency/extremely low frequency/ultra low frequency photometers. You can select one or use them together to constrain the selection.

After selecting the mission and/or instrument type and pushing select, you are presented with the list of the available data sets specified as a combination of mission, instrument, and data type. The entire list is pre-selected but you are given the opportunity to de-select entries before going on to the next page with the lists of plottable variables. The names of the variables are detailed enough to enable sensible choices for display.

A time range is also pre-selected with the latest day of all of the selected data sets. The start and stop time can be changed. The time can be expanded to a few days, a week (remember that for ISTP key parameters data the files are stored as single days at approximately minute resolution so that long time spans will take longer to plot), or shrunk down to a few hours. After seeing the plot, you can return to this page with everything as selected previously and modify the time range to look for specific features.

The kind of plots displayed on the final page are selected by information contained with the data variables themselves. The majority of plots will be displayed as time series plots with a single time axis and no space wasted between plots. Spectrograms are also supported for variables such as the EPIC variable listed above and shown in Figure 1, which also shows several time series plots. There are also thumbnail images that can be expanded to a full image by clicking on the thumbnail itself. High frequency radar plots from the Dual Auroral Radar Network ground stations are special circular plots where local time (and hence UT time) labels the circumference, the radius represents a scan line with points along containing vectors representing ionospheric convection velocities. At this time, the type of plot used for a particular variable is pre-selected and cannot be changed. Other plot types and functionality will be added in future.

The design perspective

Several different technologies have been utilized to achieve the functionality of CDAWeb: the WWW, CDF, perl, and interactive data language (IDL). Understanding the CDAWeb system and technologies can be best achieved by following the sequence of events required for CDAWeb to produce its pages and plots.

First, a collection of CDF's is assembled. Because of the portable nature of CDF files, it does not matter whether these files were created on a Vax, a UNIX machine, a personal computer, etc. Next, an IDL program is run that locates and "cracks" each of the CDF files, and utilizes the self-documenting abilities of CDF to determine to which dataset the particular file belongs, its start and stop time, and other metadata information. It accumulates all of this

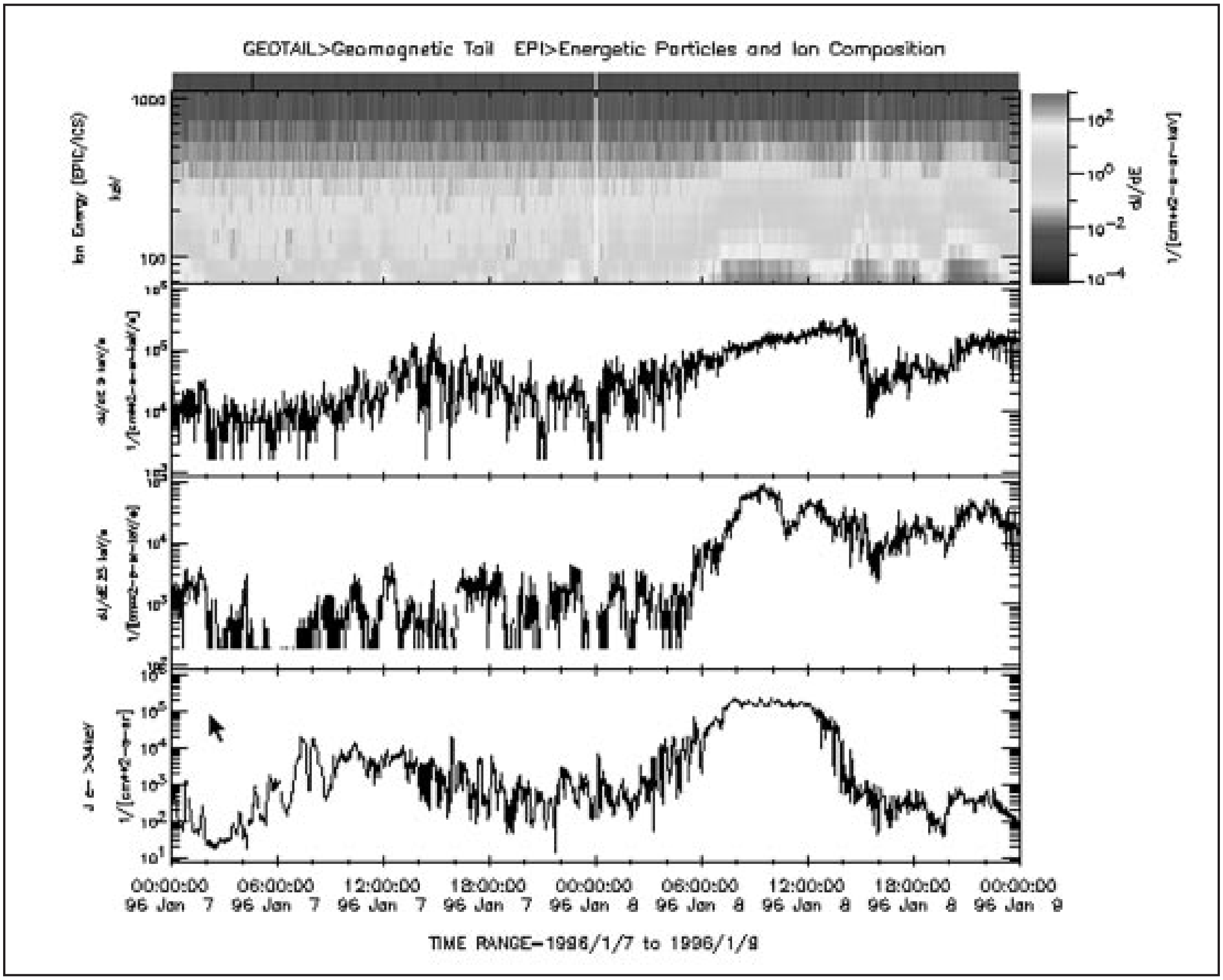

Figure 1. Time series plots of variables from the Geotail energetic particles and ion composition experiment.

information internally, and then dumps it out as an ASCII file. Then a set of perl scripts reads this ASCII "database" and generates the common gateway interface forms you see when you use CDAWeb. All CDAWeb forms are generated dynamically, on-the-fly, utilizing the contents of the "database". When the "database" is updated with new data, the forms generated by CDAWeb reflect this automatically. Once you have selected variables from given datasets, and supplied a start and stop time and requested that a plot be generated, another perl script actually writes a short IDL program to generate the plot. It reads the ASCII "database" to determine the names and locations of files within the requested start and stop times, and the names of the variables. The IDL program is then executed. Next, the IDL program utilizes a library of CDF-savvy functions to read all of the data and metadata from the requested files and variables, and any related variables, into a single IDL structure. This IDL structure is then dropped into the plotting program that creates the plots as GIF files. Plot types, scaling information, fill data filtering, and data gap detection, etc. are all achieved using metadata information read from the CDF files. And finally, another perl script reads a log file produced by the IDL program, and posts all GIF files listed in the log, then deletes the GIF files, the log file, and the IDL program.

Future development will include replacement of the metadata database with an object-oriented database to enhance performance and volume, additional plot types, and additional data selection options.

Data standards and master skeletons

A CDF data set with ISTP/IACG guidelines by definition forms a logically complete and self-sufficient whole (data and descriptions), carrying a logically-internal data dictionary. The goal is to make the resulting data package (CDF data set) a useful and understandable data product available for convenient research use with a standardized and automated set of retrieval and analysis software, for example CDAWeb. All of the descriptions and structure are contained within the "skeleton" of the file and the data completes the "body". CDF software can split out this "skeleton" as a specially formatted ASCII text file that can then be simultaneously viewed and edited. Alternately, CDF software can add the data back to an updated "skeleton" and produce an improved version of the CDF data file. This flexibility enabled use of the "skeleton" in the design of CDAWeb. A set of master "skeletons" is maintained that can be updated as needed to enhance the CDAWeb interface or increase functionality.

For the current implementation of CDAWeb, a number of global attributes (used to provide information about the data set as an entity) were added in order to populate the WWW pages. For example, the following attributes were added to the Geotail EPIC instrument master "skeleton" in Table 1.

A number of new variable attributes were also added (linked with each individual variable, and providing additional information). For example, the following attributes were added to the scalar variable, "Density", in order to identify it as a plottable variable with a detailed, informative name, and necessary plotting specifications (Table 2).

As a data-browse and dissemination tool, the CDAWeb is a mechanism for encouraging coordination among the distributed ISTP/IACG collaborations. As Web technology evolves, more features will be added to allow more functionality, perhaps through the use of JAVA.

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Table 1

Attribute	Example Value
"Logical_source"	"GE_K0_EPI"
"Logical_source_description"	"Geotail Energetic Particles" "and Ion Composition, Key Parameters"
"Mission_group"	"Geotail"
"Instrument_type"	"Particles (space)"
"PI_affiliation"	"JHU/APL"

Table 2

Attribute Name	Data Type	Example of Attribute Value
VAR TYPE	CDF_CHAR	data
CATDESC	CDF_CHAR	proton number density determined from a moment calculation, scalar
SCALETYP	CDF_CHAR	linear
AVG_TYPE	CDF_CHAR	standard
DISPLAY_TYPE	CDF_CHAR	time_series

Using A Web Interface for Searching Archival Research Data

Nancy Oliversen, Patricia Lawton, Stephen Voels, Hughes STX, and Michael Van Steenberg, Astrophysics Data Facility, Goddard Space Flight Center

The NASA Data Archive and Distribution Service (NDADS) near-line archive contains about 1.7 terabytes of astrophysics, space physics, and solar physics data from 31 missions and/or data sets. Eighteen of the data sets are astrophysics data. Until recently, however, locating all the relevant data in the archives on a particular astronomical object was not straight forward. Typically, the metadata information contained in the standard information servers such as the NASA Master Directory are not sufficiently detailed to allow a researcher to locate astronomical observations of a particular object. In order to find and request data on a particular astronomical object from NDADS, a researcher would first have to obtain the appropriate catalog(s) from NDADS or the National Space Science Data Center (NSSDC) and/or search a database maintained by one of the projects and then make a separate NDADS data request. In a few cases, the appropriate catalog has not been archived on NDADS or at the NSSDC. This multistep process was clearly not very efficient. Furthermore, if the desired data is located at different sites, the location and retrieval of relevant data becomes even more difficult. Therefore, the Web Interface for Searching Archival Research Data (WISARD) was developed to improve the accessibility of the NDADS archival data and to facilitate multi-wavelength, multimission astrophysics research using NDADS and related data archives. As the name implies, WISARD is a World Wide Web (WWW)-based interface that combines the catalog-searching and archival data-request steps into one session. The initial WISARD interface is designed for astrophysics data, although the overall architecture could be easily adapted to other disciplines.

WISARD features

WISARD supports queries on fields that are typically in common between the various astronomical catalogs (i.e., object coordinates and date of observation); galactic or equatorial coordinate searches; choice of search epoch catalog-specific field searches (e.g., instrument, object class, etc.); search criteria refinements; query unions and intersections on multiple catalogs; access to the NASA Extragalactic Database (NED), Simbad astronomical database and to the Astrophysics Data System (ADS) abstract service; default and user-specified display of the query results; and subsequent requests of selected data to the appropriate archives. WISARD currently contains the following databases:

- Advanced Satellite for Astrophysics and Cosmology (ASCA) public archive log
- Broad Band X-Ray Telescope (BBXRT) log from Astro-1
- Infrared Astronomical Satellite (IRAS) Pointed Observation International Ultraviolet Explorer (IUE) merged log of observations (spectral data)
- IUE Fine Error Sensor (FES) log
- Hopkins Ultraviolet Telescope (HUT) log from Astro-1
- Wisconsin Ultraviolet Photopolarimeter Experiment (WUPPE) log from Astro-1
- Roentgen Satellite (ROSAT) public archive log
- Extreme Ultraviolet Explorer (EUVE) public archive log of spectral

The IUE merged observing and FES logs are supplied by the IUE Data Analysis Center (IUEDAC) at Goddard Space Flight Center (GSFC). The ROSAT database was generated by scanning and extracting information (i.e., object coordinates, observation dates, etc.) from the ROSAT public contents files that are delivered to NDADS along with the individual data files. The HUT, WUPPE, BBXRT, and IRAS logs were derived from project-supplied observation logs. The EUVE and ASCA databases were derived from public archive log information available at the EUVE and ASCA guest observer facilities.

WISARD processing flow and software

An outline of the WISARD processing flow is shown in Figure 1. The database(s) to be searched, the type of search (union or intersection), and the type of form (default or custom) are selected from the WISARD main page (Figure 2). A process-ID or context-ID, which is tracked through WISARD, is assigned every time a new WISARD session is initiated. You are then guided through a series of screens based upon your selections on the WISARD main page. The database query criteria are entered on the next screen and a link to the Simbad or NED object name resolvers are also available. The selected search criteria are next displayed and the database search may be started or the query criteria modified or supplemented. A summary of the query results is next displayed. A default or custom format may be chosen for the display of the data sets that satisfy the query and the query display page also contains links to NED and Simbad. Large queries are mailed back to the requester. Specific data sets may be selected to order from the archives (NDADS or EUVE) and a data (NDADS or EUVE) order form is finally displayed, with the specific data set ordering information filled in by WISARD.

WISARD utilizes a master database (table-of-tables) that contains information about each of the databases accessed by WISARD. This master database contains such information as the NDADS project short and full names, data archive ordering information, coordinate accuracy estimates (used for intersection searches), and print/display information. Use of this master database allows new databases/data sources to be added to WISARD relatively easily without large amounts of recoding.

WISARD utilizes the client-server architecture of the WWW, making use of the standard WWW forms for passing of information back and forth between the requester and WISARD. Communications with the WWW are accomplished through a combination of Bourne shell, C shell, C, and interactive data language (IDL) programs. The shells are used to extract the WWW environment variables and data request parameters, control some of the WISARD process flow, and start up the IDL sessions.

IDL is used for most of the WISARD processing, including creation on-the-fly of the various WISARD WWW display pages and forms; searches of the databases; and special processing such as intersection searches and coordinate transformations. The various mission catalogs and the WISARD master

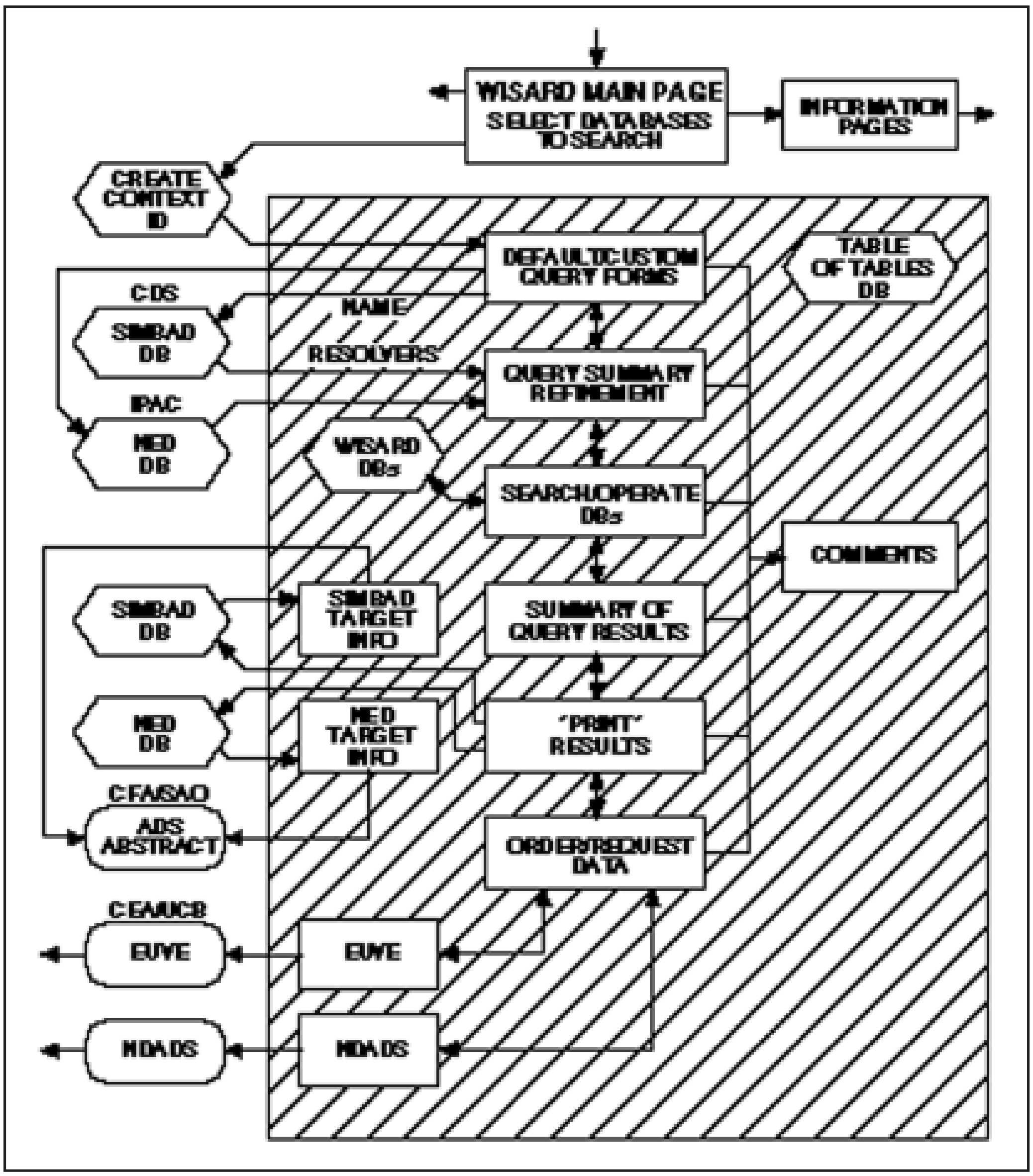

Figure 1. WISARD processing flow diagram

database are stored in IDL databases. Individual catalog fields (such as object coordinates and/or dates) can be sorted or indexed to increase the speed of the database searches. Use of IDL databases simplifies the transition between the database searches and the general WISARD IDL processing. IDL was used for the WISARD prototype because the IUE databases were already in IDL and the IUE/WWW merged log-search software, which could be generalized relatively easily, had already been developed.

WISARD also incorporates the Simbad and NED client-server software. The Simbad and NED (C client) programs open a remote session on the Simbad/CDS computer or the NED/IPAC computer to query the appropriate database. Output from the Simbad or NED programs are saved to IDL variables for further processing within WISARD.

Efforts have been made to make WISARD as user friendly as possible. Extensive catalog documentation and general WISARD 'help' information are available. Links to previous pages have also been included to facilitate the modification and re-submission of WISARD queries. At this time, a deliberate decision was made to not incorporate some of the latest WWW technologies in the WISARD interface, such as Netscape-specific tables or JAVA'aplets'. This decision was made because a significant fraction of our user community do not have access to the specific hardware and/or software needed to use this latest WWW technology.

Figure 2. WISARD World Wide Web home page

Future plans

The current version of WISARD only includes a subset of the astrophysics data on NDADS. There is a plan to add additional NDADS observation catalogs and archive access to WISARD as time and resources permit. Modifications to WISARD will continue to be made in order to make it easier to maintain the WISARD software, documentation, and databases. The use of standard relational databases for the catalog queries will also be investigated.

The IDL database software used by WISARD is available through the IUEDAC home page:

http://iuewww.gsfc.nasa.gov/iuedac/iuedac_homepage.html

Other Web locations to access are:

for WISARD:
http://hypatia.gsfc.nasa.gov/wisard/wisard.ht

for IUE Search:
http://banzao.gsfc.nasa.gov/IUE/search/IUE_search_menu.html

for NDADS:
\tab http://ndads.gsfc.nasa.gov/

Acknowledgments

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A Multimedia History of Glacier Bay

Judy Laue, Hughes STX, Goddard Space Flight Center

This video brings glaciers to life with nine spectacular "fly-bys" of scenic rides over 3-D glaciers, live video footage of ice fronts calving into the sea, and dramatic picture sequences of historical and satellite data, and more. . .

The Goddard Space Flight Center (GSFC) video tape, "Glacier Bay, Alaska, from the Ground, Air and Space," is an assemblage of live-captured and remotely-sensed computer images of glaciers at Glacier Bay, Alaska. Jim Strong and Cindy Starr, of the Scientific Visualization Studio (SVS) at GSFC's Space Data and Computing Division, produced this narrated video under the direction and guidance of Dorothy Hall, of the Laboratory for Hydrospheric Processes at GSFC's Hydrological Sciences Branch.

Dorothy Hall, along with other scientists, has studied the movement of some of the glaciers in Glacier Bay, Alaska, as well as glaciers in other parts of the world. For her studies of Glacier Bay, Hall obtained material from colleagues and historical collections including explorers' hand-drawn maps of these glaciers from as far back as 1794. She also studied satellite imagery from NASA's Landsat series of satellites, which has acquired images since 1972. Landsat enables study of the movement of glaciers from the MultiSpectral Scanner, with a spatial resolution of 79 m, and the more advanced Thematic Mapper, with a spatial resolution of 28.5 m.

The video's producers used their combined visualization and scientific expertise to weave the historical records, including photographs from the early part of this century, more recent slides, and graphic images, with live action video segments and computer animation of satellite imagery. The result is a video that provides a lively historical perspective of glacier changes in the region.

Pushing forward scientific analysis of these glaciers, the Laboratory for Hydrospheric Processes used special computer techniques to combine historical records of Glacier Bay with satellite data "... providing a wealth of information about the deglaciation at Glacier Bay" according to Hall. Scientists are able to measure changes in glacier terminus position for periods over the past two centuries by registering satellite images to maps drawn by early explorers.

The video shows how scientists can relate the movement of glaciers to regional climate change, where applicable. Because tidewater glaciers follow their own cycles of advance and retreat, their movement cannot be directly tied to short-term climate. Thus the tidewater glaciers in Glacier Bay are not good indicators of short-term regional climate change. However, the non-tidewater glaciers of Glacier Bay, which have shown some evidence of retreat over the last 40 years or so, most likely can be tied to regional climate change. Non-tidewater retreat is probably a result of amelioration of regional climate as evidenced by a tendency toward increasing air temperatures measured at nearby meteorological stations.

Starr produced a host of special effects for the video using images created by Janet Chien (Laboratory for Hydrospheric Processes). Starr created nine spectacular "fly-bys" of scenic rides over the glaciers using the SVS's Advanced Visualizer from Wavefront, Inc. In addition, the video contains dramatic, live footage of ice fronts calving into the sea, as well as other video footage shot by David Affens on location.

Visit GSFC's Glacier Bay web site at:

http://sdcd.gsfc.nasa.gov/GLACIER.BAY/glacierbay.story.html

to see stunning pictures of glaciers and dramatic quicktime movies from the video. At this science site you can read what a NASA glaciologist has learned about glaciers and how their formation could be related to climate change.

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Emerging Networking Technologies

Christine Falsetti, Internetworking Technologies, Ames Research Center

High-performance computing requirements such as remote operation of wind tunnels, virtual computing environments, and desktop collaboration are driving a whole new suite of applications that were not previously possible. These requirements demand increased bandwidth and decreased latency (lag time) over the networks. High-performance computer networking is therefore an important element in fulfilling the aeronautics and science communities high-performance computing requirements.

Networking technology is evolving rapidly, as is the demand for increased network speed, capacity, and reliability. Ames Research Center (ARC), as NASA's Center of Excellence in Information Technology, is part of the process of developing and promoting adoption of industry-wide open standards so that heterogeneous platforms and different networks can operate seamlessly and effectively with one another.

The Internetworking Technologies Group (ITG) at ARC is working to deliver high-performance networking systems for science and engineering computing that integrate emerging internetworking technologies into NASA's next-generation programs through the development of experimental networks and testbeds. In meeting these goals over the course of the next five years, ITG has focused its efforts in three strategic areas: research and development of internetworking technologies, technology integration, and technology transfer.

ITG's research and development activities focus on developing low-cost, efficient networking capabilities that will speed the delivery of science and research data and information to NASA's communities. The group tests and evaluates new network technologies, services, and protocols. Representative projects include the National Research and Education Network; Space Bridge to Russia, a telemedicine international collaborative communications testbed for medical consultation; and the remote wind tunnel operation project, the Developmental Aerodynamics Revolutionizing Wind Tunnel & Information Systems at NASA, known as DARWIN. ITG also provides integration and interoperability testbeds for these projects.

ITG works with commercial providers to integrate these technologies for both its customers—the aeronautics and NASA science communities—and its suppliers, including Sprint, MCI, AT&T, and Pacific Bell. ITG also leverages alliances with government partners such as the Department of Energy, the Advanced Research Projects Agency, and the National Science Foundation. Through these alliances ITG evaluates and tests technologies such as asynchronous transfer mode and multicasting. Once the technologies have been proven, ITG integrates them into the NASA Internet (NI). NI provides a reliable, high-performance, high-speed, end-to-end "operational testbed" network supporting NASA's aeronautic and science missions. During the transition period, ITG examines network management tools to see if they can be easily integrated with other technologies and how well they perform. It also works closely with industry to encourage development of non-proprietary, commercial off-the-shelf products.

The third strategic thrust of ITG is the active transfer of networking technologies to other centers. Technology transfer is an integral part of ARC's approach to working with its high-end customers and in operating high-end prototype testbeds. Once the technology is well understood and stable, it is transferred to other centers to allow the rest of the agency to leverage it for production. Technology is ultimately outsourced to commercial providers.

Throughout the process of developing, testing, and integrating these new technologies, ARC's goal is to meet and maintain its customer commitments.

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Network Applications and Information Center Changes Name

Mary Stahl, Sterling Software, Network Information Center, Ames Research Center

The recent consolidation of the NASA Science Internet (NSI) and Numerical Aerodynamic Simulation's (NAS) AEROnet wide area networks into the NASA Internet (NI) has brought about a change in name and mission for the Network Applications and Information Center (NAIC) at Ames Research Center (ARC). To more accurately reflect its broader role as the second-level network information center for NASA, the NAIC has assumed the new name, Network Information Center (NIC).

The mission of the NIC has evolved to reflect its intimate alignment with NI. The NIC continues its dedication to high quality information services and applications support for the NASA science, research, and education communities. Its mission includes providing second-level support on integrating networking tools to first-level center NICs and collaborating with NASA centers to establish a system of distributed NICs. It fosters the use of information protocols, standards, applications, and procedures that are conducive to efficient discovery and retrieval of networked information resources and acts as a catalyst for integration of next-generation networking tools. It provides liaison between NASA and other government and appropriate non-government network information activities, and it disseminates information about the NIC and its affiliations via the most appropriate medium.

For further information about NIC services access the World Wide Web site:

http://nic.nasa.gov/nic/

The NASA NIC is part of the Internetworking Technology Group (ITG) whose mission is to provide advanced networking technologies to accelerate the delivery of data and information among NASA's science and research communities. The ITG and NASA NIC are located at ARC.

Supporting Russia's Network

JoAnn Nelson, NASA Internet, Ames Research Center

The NASA Internet (NI) provides network connectivity to Russia for every major NASA science discipline including aerospace medicine, astrophysics, earth science, life and biological science, space science, and solar system exploration. Leading-edge collaborative programs NI supports include the Spectrum X Gamma/Spectrum Roentgen Gamma, Mir Space Station/NASA Shuttle, Exobiology studies, Space Physics, Telemedicine, Mission to Planet Earth (MTPE), International Solar Terrestrial Physics/Solar and Heliospheric Observatory/Ground missions, Spectrum UV, and Mars 96.

NI has worked closely with its Russian counterparts over the years to establish a strong network that will support NASA science and has sent technical experts in network engineering, operations, and security to workshops in Moscow. NI has helped train Russian Space

Science Internet (RSSI) staff on secure systems administration and network security incidence support and response, and has taught network operations management techniques, providing hands-on lab experience and training in the Ames Research Center (ARC) NI Network Operations Center (NOC). NI has been monitoring and managing the entire RSSI network but is now in the process of transitioning responsibility for day-to-day management of the RSSI network to the Space Science Research Institute in Moscow, called IKI. NI is also working to establish its router on the Russian backbone.

Some of the US-Russian collaborative science requirements serve as testbeds for advanced internetworking technologies. The Space Bridge to Russia Telemedicine Project recently tested multicast capabilities over the NASA Internet to conduct sessions between Moscow State University and participants at NASA Headquarters, Lewis Research Center, and ARC. These tests verified audio and video using various commercial off-the-shelf tools.

The space science community is working with Russia and other international partners to share explorations of our solar system. . .

The space science community is working with Russia and other international partners to share explorations of our solar system and the science that results from these efforts. Mars 96 is one of these projects. In November 1996, a proton rocket will launch the Mars 96 spacecraft from Russia for arrival at Mars two years later. This mission will deploy two small stations (landers) to the surface of Mars and two penetrators to pierce the surface of Mars. US scientists have identified 10 sites in Russia which they need to communicate with electronically in support of this mission, and NI is working with RSSI to develop this network connectivity.

MTPE has worldwide networking requirements, including some in Russia, to support the Meteor-3M Sage III mission, a Distributed Active Archive Center, and the Sea-viewing Wide Field-of-View Sensor, called SeaWIFS. The Sage III mission, which will launch in 1998, involves duplicate transmission of data from Sage to two downlink sites—Wallops Island, VA, in the US, and NPO Planeta, Dolgaprudny, Russia. Information will be shared equally between the US and Russia.

When NASA scientists require electronic access to databases and colleagues in Russia, NI determines how to meet their requirements and prioritizes them into “tiers” to meet demand effectively and efficiently. Russia supplies circuit connectivity to the various sites, and NI supplies the hardware, both at the RSSI network and at the tail sites. Finally, the NI NOC works with IKI to get them operational and online; IKI staff provides the interface with the scientists at their end.

There are many challenges in international cooperative arrangements, including distance (which makes face-to-face contacts difficult), language, and changes in personnel on both teams. Physical facilities also present problems where aging infrastructure and cost make it difficult to get the facilities necessary to handle digital communications. There are also challenges to be overcome in establishing cooperation between Russian institutions that have previously worked independently. However, the advantages to the scientists in fulfilling their missions, far outweigh the difficulties. At present, many scientists still have to waste resources and time traveling to their colleagues’ sites—especially troubling in an era of shrinking budgets. One scientist recently expressed his appreciation at being able to conduct a “talk” session over the Internet (“talk” allows both parties to see what is being typed as it is entered). Even this basic capability saved him the $2 per minute phone bills and allowed him to communicate in a timely manner.

As part of its ongoing efforts, an NI team traveled to Russia in late May to complete the NOC transition and train the staff on the custom-configured network management packages. The team also traveled to St. Petersburg to review current requirements and discuss future ones. NASA’s relationship with its Russian networking counterparts holds promise not only for improving relations between nations but also for advancing science and technology.

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National Research and Education Workshop Report

Pat Kaspar, NASA Internet, Ames Research Center

In the first comprehensive meeting of its kind, the major players in the National Research and Education (NREN) program came together at Ames Research Center's (ARC) NREN Workshop May 21–23. The workshop brought together the networking experts of NASA and the High Performance Computing and Communications Program (HPCCP) customers to establish an on-going forum for discussion and action. ARC, as the Center of Excellence (COE) in Information Technologies, organized the workshop to ensure that the agency does not duplicate its efforts. Computing and communications are cross-cutting technologies needed to advanced the COE focal areas of integrated design systems, simulation and information management, automated systems, space systems, and aviation systems. The major challenge is to bring the agency together around these issues to consolidate supercomputing and networking.

First-day speakers covered such topics as HPCCP, the Internetworking Technologies Group, NREN Strategy and Policies, the Department of Energy, and Sprint Government Systems. Tours were arranged of the NASA Internet Network Operations Center, the Digital Video Laboratory, and the Federal Internet Exchange. Day two covered the major NREN customer entities, including Computational Aerosciences, Earth and Space Sciences, Remote Exploration and Experimentation, and Information Infrastructure and Technology Applications. Splinter groups focused on distributed computing, tools and testing, NREN policies and procedures, digital video, "native ATM," and internetworking and interoperability.

The workshop will serve as a catalyst for collaboration in high-speed networking among NREN sites and network providers. It will also help NREN participants avoid duplication and facilitate the establishment of the NREN testbed. Future NREN workshops will concentrate on technical issues.

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The workshop was organized by Debra Bailey, NREN Project Manager, Advanced Computing and Communications Division.

Visit This Web Site

The Applied Information Systems Research (AISR) program supports applied research in computer and information systems science and technology to enhance NASA's Office of Space Science (OSS) programs. The AISR program maintains an awareness of emerging technologies applicable to space science disciplines, stimulates application development, and provides for the systems analysis and engineering required to transfer new technology into evolving OSS space science programs through NASA Research Announcements in the areas of high performance computing and networking, scientific data analysis and visualization, scientific data storage and management, and software technology (including World Wide Web tools). To view the AISR home page, access:

http://www.hq.nasa.gov/office/oss/aisr/aisrp.html

A Graphical User Interface for Science Data Processing

Bob Deen, Science Data Processing Systems, Jet Propulsion Laboratory

The Science Analysis Graphical Environment (SAGE) is a graphical user interface (GUI) being developed for science data processing performed at the Jet Propulsion Laboratory (JPL) Multimission Image Processing System (MIPS). SAGE takes maximum advantage of legacy code and is designed to be easy-to-use for novices but is powerful enough for experienced users. SAGE allows easy integration of applications from diverse systems, and is even being used with applications that have nothing to do with image processing.

Image processing software

The primary image processing software used at MIPS is the JPL internally developed Video Information Communication And Retrieval (VICAR) software. VICAR was originally developed in the late 60's on IBM mainframes to support JPL's first planetary spacecraft missions. It was converted to run on VAX/VMS hardware in 1983 and was ported to several UNIX platforms in the early 90's. It has been used to process data from NASA planetary missions since Mariners 6 and 7, including Viking, Voyager, Magellan, and Galileo.

Over the years several hundred application programs have been written for VICAR, with a wide range of capabilities ranging from image restoration to stereo photogrammetry. Spacecraft data is processed from the first telemetry acquisition to a wide variety of output products. Many of these capabilities, especially those dealing specifically with spacecraft or planetary data, are not available in commercial software. This installed base of applications represents a huge investment in legacy software.

The VICAR system uses a command-line interface based on the Transportable Application Environment (TAE+) from Goddard Space Flight Center. It is a powerful command-line system but, as with all command-line interfaces, new or occasional users find it hard to use. Because many scientists or researchers use VICAR only occasionally, it was clear that a better user interface was needed. With the proliferation of graphics-capable hardware on desktop workstations, a GUI became the obvious choice.

Designing SAGE

With this in mind a GUI design team was formed in 1992, tasked to define requirements, develop a design concept, and evaluate existing products. To get a wide representation of viewpoints, the team consisted of internal users, external (science team) users, developers, and system engineers. Involving the users from the beginning was very important.

Following extensive discussions, analysis of how users performed their jobs, and demonstrations of existing products, the architectural concept of a dataflow graph emerged, where individual application programs are chained together, with the outputs of one application becoming inputs to the next. This relatively decoupled architecture allows maximum re-use of existing legacy applications (compared to a monolithic program) and provides for extensibility because each application is largely independent. Armed with this concept, several users tried existing dataflow-style packages, including AVS, Khoros, and SGI Explorer (now IRIS Explorer). These users reported that they liked the idea of an icon-chain interface with a visual dataflow, but they unanimously agreed that it was too difficult for novices.

The final design has two cooperative, visually distinct styles. The first allows direct editing of the graphical dataflow diagram, while the other is a "direct manipulation" interface, using drag-and-drop technology to apply processing functions directly to the data without worrying about the process. This duality of styles has many benefits, in the opinion of the team, but could not be found in any currently available package. When combined with many other factors, such as licensing and redistribution issues, multiple platform support (including VMS), and limited customization, the make-or-buy decision was obvious, and SAGE was born.

Realizing that building a GUI was a large task, the team looked for ways to reduce the level of effort. This led to the discovery of the Graphical Execution Manager (GEM) software, written by Alan Mazer of JPL's Imaging and Spectrometry Systems Technology section, that was developed for the Advanced End-to-end Simulation of Onboard Processing (AESOP) task. AESOP uses GEM to investigate different data compression schemes in the face of transmission errors from spacecraft. Unfortunately, the GEM user interface was insufficient for SAGE. It is a static interface where you have to edit files in order to change the processing sequence—the graphics are display-only. The GEM core, however, already contained an execution manager for a dataflow diagram, which SAGE needed, so it was integrated, with some changes, into the SAGE design. The changes were implemented, with Alan's support, so that the applications and projects are able to run in either interface.

Important concepts

SAGE is based on the concept of a dataflow. Data from some source enters the dataflow, where it is transformed by a sequence of application programs. The output of one program becomes the input of the next, in a chain of actions, until the desired output is achieved. The chain does not have to be linear; branches and some forms of looping are allowed (in computer science terms, it is a directed graph). This dataflow model closely matches how analysts and scientists typically process instrument data. Through SAGE, this dataflow can be created interactively, then easily used as a systematic processing stream to process a large collection of data in the same way.

SAGE has two cooperative, visually distinct interface styles: visual programming language (VPL) and direct manipulation interface (DMI). Both of these may be used simultaneously and interchangeably; there are no "modes" to switch between them. Both affect the same underlying dataflow model, and changes using one are reflected in the other. The VPL is a graphical representation of the dataflow diagram, where processing modules are represented by icons and flows by lines between them, *a la* AVS or Khoros. You can directly edit the dataflow, adding or deleting applications or connections between them. This interface implements a "verb-noun" style, allowing you to concentrate on the process to be performed, while seeing the result on the data.

The DMI uses drag and drop technology to create connections between modules directly, and to apply processing functions to data. For example, you may look at an image and decide that it needs to be filtered. Rather than manually inserting a filter into the dataflow, a filter application can be dragged from the toolbox and simply dropped on the image. The system automatically inserts the filter into the dataflow at the appropriate place (right before the display). This interface implements a "noun-verb" style, allowing you to concentrate on the data itself, without worrying about the process. You may choose to not even view the process. Based on the team's studies, the data-centered model of the DMI seems more likely to be used by new or occasional users, or scientists exploring their data. As the processing steps get more complex, users will tend to shift to editing using the VPL. The combination of these two styles allows easy use by beginners and efficient use by experts with the same GUI.

Every application has a *parameter box*; a window that allows you to view and change the parameters to the application. These parameter boxes may be automatically generated from the parameter description, or they may be customized for the particular application. These parameter boxes are key to ease-of-use for legacy applications because they provide a graphical wrapper around non-graphical programs, without writing any GUI code.

The GEM core, and thus SAGE, also supports remote execution of programs. Applications can be set up to run on any machine on the network, even cross-platform. This allows for distribution of processing loads, as well as supporting applications that can run on only a limited set of platforms (e.g. a VMS-only application). Also, the GEM core was designed to allow easy integration of various kinds of applications. As a result, it is quite straightforward to add new applications, and new classes of applications to SAGE.

Another important concept in SAGE is that of a *multiplex*. A multiplex is simply an array of related items, usually a set of files. Items in the multiplex can be treated as a unit and processed in parallel by programs that know how. However, most VICAR programs process only one file at a time. For these, *pitcher* and *catcher* applications were created to handle each item of the multiplex in sequence. The

SAGE takes maximum advantage of legacy code and is designed to be easy-to-use for novices but is powerful enough for experienced users.

pitcher sends each item individually through a processing sequence, and the catcher rebuilds the array again at the other end. Multiplexing is valuable for systematic processing, where you want to process dozens of files in the same way. It is also especially useful in VICAR for color processing, since the red, green, and blue bands are normally separate image files. It has uses for multispectral data and animation sequences as well. Multiplexing allows each of these sets to be treated as a unit and yet still be sent through some programs individually.

The interface components

The first window you see when you start SAGE is the server window. SAGE is implemented using a client/server model. The server is the "nerve center" of SAGE, storing all information about the dataflow on which you are working. All other windows are client processes. The server window shows information about the state of the server, and allows you to load and save projects, start the various clients, and access parameter boxes.

The various clients allow you to build and manipulate the process you are creating. The Program Search client allows you to access any application that SAGE knows about. A Criteria Search option allows you to narrow the list down by name, function, parameters, system, etc. to find the desired program among the hundreds available. The Toolbox provides a convenient way to organize and access frequently used programs. Standard toolboxes, which can be customized, are provided with the system. Toolboxes can be hierarchical to help organize programs. The VPL window displays the dataflow graphically, using icons to represent programs and lines to represent the flows between them. The dataflow may be edited by using drag and drop in the VPL window or between other windows. The VPL also allows recalling of parameter boxes for the programs.

Parameter boxes are windows that display the parameters available to an application. Each application in the dataflow has its own parameter box (although normally not all are displayed at once). Through the parameter box, you can view and change values, as well as change the mode of a parameter. Normally, file parameters will be in "dataflow" mode, meaning the value comes from (or goes to) some other application, while integers, strings, reals, etc. will be either defaulted or "direct", meaning that the value is entered directly in the parameter box. These modes can be changed for any parameter, so for example an integer could come from another application or you could directly type in a filename.

Most parameter boxes are automatically built at run-time from the parameter descriptions found in the dictionary. Hints that change what the auto-builder does can be specified. Thus, no GUI code needs to be written for the majority of applications. However, any application can have its own custom parameter box if desired. A library of C++ classes makes creating custom parameter boxes much easier.

SAGE also includes an image display program, called xvd. It is designed specifically for image processing, and is capable of displaying arbitrarily large images. It is based on a Motif-compatible image widget that is reusable in other image display applications as well. Because xvd is really just an application integrated into SAGE and not part of the system, it can also be used stand-alone. Figure 1 shows a composite of SAGE major components' display screens.

Application support

The GEM core calls applications via a *glue function*. A glue function is simply a subroutine that accepts the program parameters in a standard format, does whatever is necessary to call the application, and sends the outputs back. A glue function can call its application in many ways; as a subroutine, by building a command line and submitting it, or by doing it inline—whatever needs to be done. It is really nothing but a protocol translator, translating parameters into the form the application expects, and calling the application. Glue functions are normally implemented in dynamically-loaded shared libraries, so new ones can be added without having to relink the system. Glue functions can be specific to an individual application, or generic to a class of applications. For example, all VICAR programs are called using a single glue function that understands the rules for calling VICAR programs. Iterative data language (IDL) programs are done similarly. If a set of applications has a regular calling sequence, a single generic glue can handle them all. Otherwise, a separate glue function is needed for each application.

In addition to the glue function, GEM and SAGE must know what parameters the program expects. The parameters are defined in a simple file called a dictionary, which specifies the parameter names and types. For VICAR applications, a proc definition file (PDF) already existed for the TAE command line's benefit. These files are read and converted to dictionary entries automatically, so nothing needs to be done to add new VICAR applications to SAGE.

Many kinds of applications are integrated into SAGE now, with many others possible. They include:

- VICAR: the image processing system developed at MIPS
- IDL: a commercial data processing system from Research Systems, Inc.
- PV-WAVE: a commercial data processing system from Visual Numerics, similar to IDL
- AESOP: a set of compression and spacecraft telemetry simulation programs, one of the original uses of GEM
- Multimission Data Management System: the internal database system used at MIPS
- xvd: an image display program developed by MIPS

Design highlights

SAGE is written almost entirely in C++, using an object-oriented approach, and is built on top of a modified version of the MotifApp library [1]. This was one of the first major projects done by MIPS in C++ (development began in late 1994), and it has proven to be successful. The design turned out to be quite clean; significant code re-use has already been achieved, both internally and between xvd and other display-oriented programs. All SAGE clients use a common framework, with both the automatic and custom parameter boxes using another framework derived from it.

The interface with the GEM core has led to a natural separation between the user interface

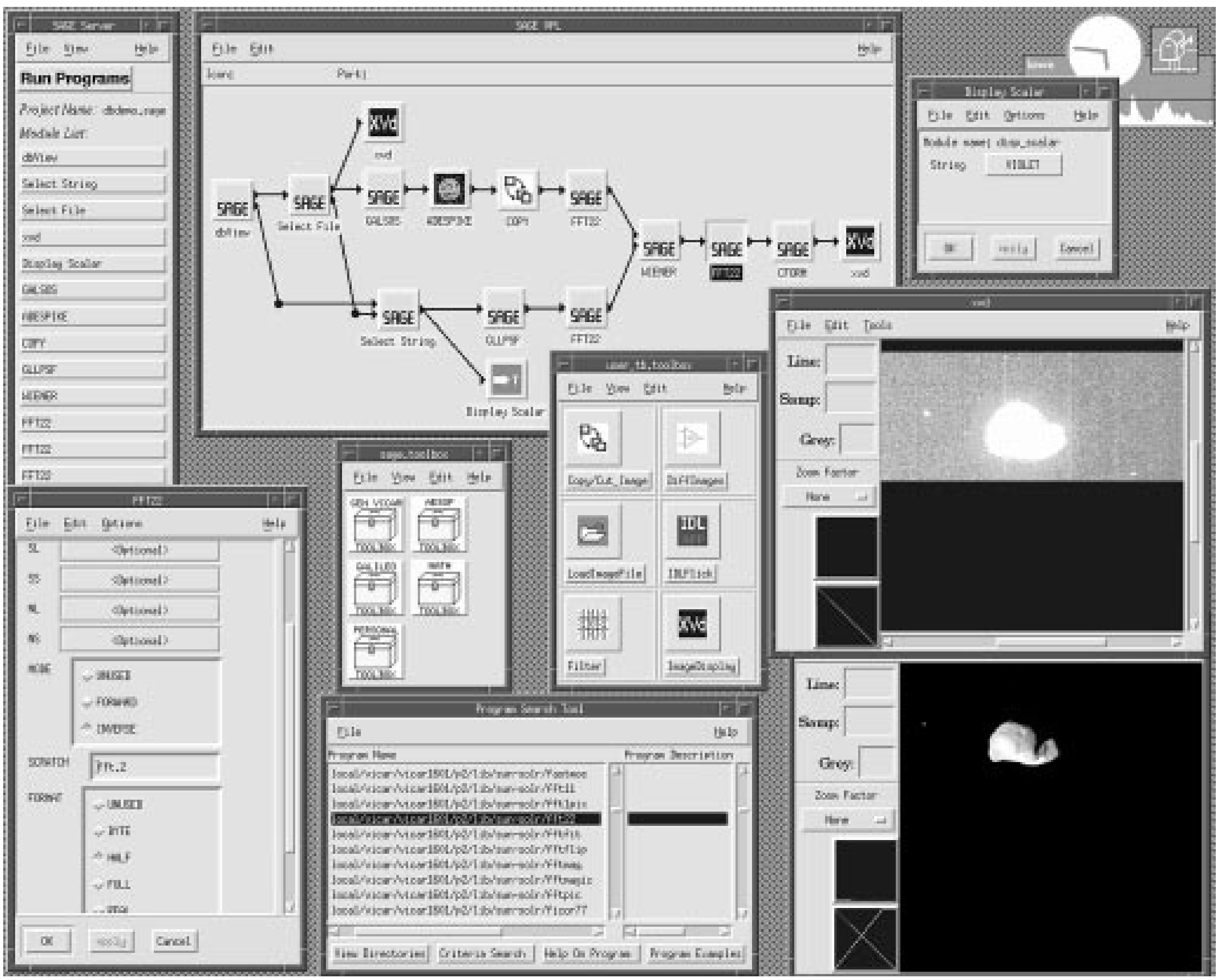

Figure 1. Composite of SAGE display screens showing most major components

(SAGE) and the execution manager (GEM). This results in much cleaner, more modular, and better-isolated code, and also allows for a GUI-less execution manager for batch jobs, which is planned. The SAGE interface itself is implemented using a client/server model, with the server maintaining all state information. Clients store nothing on a permanent basis, getting all their information from the server. In addition to being more modular, this also greatly increases the robustness of the system, because clients can fail without loss of any data. Only if the server hangs or crashes is any data lost.

The GEM core also uses a client/server model, but with the roles reversed. The SAGE server is a client to a myriad of application servers that manage execution of various sets of applications. This is not a one-to-one correspondence; several applications can be handled by a single application server. Both the GEM and SAGE client/server interfaces make it easy to run parts of the system on remote nodes distributed across the network. GEM has the remote execution feature mentioned above and SAGE clients can be remote if desired.

The SAGE client/server protocol is implemented using a message-passing scheme. Clients send requests to the server and get notified of events by the server. This protocol allows for the replacement of any client, or the addition of new clients. For example, if a project were to use SAGE in its environment, but the users didn't like the way the Toolbox worked, the project could write its own Toolbox and it would plug-and-play with the rest of the system, with no modifications.

Supported platforms

SAGE is officially supported on the following platforms:

- Sun SPARC, running Solaris 2.x
- Sun SPARC, running SunOS 4.1.x
- SGI, running IRIX 5.x
- DEC Alpha, running VMS 6.1 (Note: as of this writing, there are some problems with the Alpha/VMS version but they will be fixed)

In addition, SAGE has been run in the past on Hewlett Packard 700 series computers, running HP/UX 9. This platform is likely to be officially supported in the future, although it is not now. GEM itself runs on several other platforms; it should be a simple matter to port SAGE to any Motif-based system.

SAGE now and future

In addition to MIPS, SAGE is also being used by the Logical information gathering hyper-text Subsystem processing environment for expedited data management (LightSpeed) project at JPL. LightSpeed is a prototype that will demonstrate the feasibility of building a highly automated system that integrates the technologies from several groups into an easy-to-use, cost-effective, end-to-end mission operations environment. Using SAGE as its GUI, the LightSpeed development team has already integrated several legacy applications from Mission Design and is currently working to integrate sequencing applications using an object-oriented framework. LightSpeed involves a collaboration between MIPS, the Sequence Automation Research Group, and the Flight Information System Testbed, all of JPL.

SAGE is still under very active development. It has reached the point where it is a useful system, but there is still much left to do. Some of the important tasks planned for development are:

- DMI: the direct-manipulation interface (the second of the two interface styles described above) has not yet been implemented
- Macros: the ability to collapse part of the dataflow into a single icon for ease of manipulation
- Auto-rerunning: when a parameter is changed, automatically run only the affected programs, rather than starting from the beginning of the dataflow
- Batch Execution Engine: the ability to run a process developed by SAGE in a batch mode, without user interaction (useful for systematic processing)

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The GEM home page and the SAGE home page can be accessed on the World Wide Web, respectively, at:

http://www-msim.jpl.nasa.gov/gem/gem.html
http://www-mipl.jpl.nasa.gov/sage

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Acknowledgments

The SAGE development team at JPL currently consists of Bob Deen, Elmain Martinez, and Vadim Parizher (Science Data Processing Systems), Alan Mazer (Imaging and Spectrometry Systems Technology), and Jody Rosas (Information Systems Technology). The GUI Design Team is led by Danika Jensen (Science Data Processing System). Paul Jepsen (Science Data Processing Systems) is the task leader. Former developers include Paul Andres, Gloria Connor, Myche McAuley, and Helen Mortensen (Science Data Processing Systems), and Eric Lambrecht (Arizona State University).

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Geographic Information Systems Conference Report

Environmental Systems Research Institute, Inc. (ESRI) held its 16th annual user conference in Palm Springs, CA, this past May. ESRI, a Redlands, CA, commercial geographic information systems (GIS) company, partners with NASA on various projects involving spatial information. Attendees were welcomed on Monday by Jack Dangermond, ESRI president, who spoke on the role of GIS in enterprise. On Tuesday, Roger Tomlinson, called by some the 'father of GIS,' presented "GIS in the '60s—What Has Changed?" Tomlinson was followed by the Secretary of the Interior, Bruce Babbitt, who addressed the conference as the keynote speaker. Mr. Babbitt spoke on environmental conservation and the role GIS plays in that process. He spoke specifically of the planning and implementation of restorative flooding in the Grand Canyon immediately below the Glen Canyon dam.

"....the restoration of the Grand Canyon would never even have begun were it not for the careful and steady application of science, the many extensive comments of stakeholder, and, not least, the emerging and consensus building catalyst of geographic information systems," he stated.

According to Babbitt, the Interior Department's plan to implement nature-mimicking floods was initially met with skepticism on many fronts: fishermen, Arizona's Game and Fish Department, the Interior's Fish and Wildlife Service, the local Indian tribes, and hydroelectric power users in six states. Initially, the Interior Department had only charts and theoretical models to offer the skeptics. Eventually an interdisciplinary team was formed. This team, made up of biologists, hydrologists, geologists, and ecologists, began to integrate their data into a common database. Through the use of GIS the team was able to see the whole watershed as one interconnected unit, rather than just fragments of structures, roads, minerals, animals, plants, water, and soil. A week after the flooding finally took place, satellite photos showed that the habitat had been restored.

"...we used GIS as a tool to approach the complex challenges of Glen Canyon," Babbitt said. "The first lesson is how GIS empowers us to see our landscape in an entirely new spatial dimension."

Program overview

The conference program offered technical, scientific, application-specific, and general interest sessions, providing professional meetings, continuing education seminars, and networking experiences. Users were invited to attend preconference seminars, a welcoming reception and poster session, sessions on user success stories, the exhibit hall and demonstration area, a GIS solutions fair for ESRI's business and government partners, special interest groups, a knowledge faire for sharing project results, technical workshops, and papers and panels, including "super sessions."

The conference ran concurrent activities; workshops, the technology track, and the professional track. The workshops focused on software development. The technology track focused on broad issues that affect GIS technology users of all applications, offering sessions on database automation, database management, information access and the Internet, data publishing, new technology and systems integration, cartography and map production, remote sensing and image processing, and GIS management and implementation. The professional track featured paper presentations on implementation experiences of GIS users within specific disciplines: environment and natural resources, business, government, AM/FM and utilities, and education. The super sessions presented papers on subject matters of interest to a wide range of GIS users across multiple disciplines: Open GIS, metadata standards, and Internet topics.

"The first lesson is how GIS empowers us to see our landscape in an entirely new spatial dimension."

—Bruce Babbett
Secretary of the Interior

Program highlights

The preconference seminars included a "GIS for Schools and Libraries" workshop. This workshop provided an overview of GIS and explored new tools and resources. During the conference the professional track "Interdisciplinary" session presented panel discussions for university-and-above educators and for Kindergarten Through Grade 12 (K-12) educators, administrators, and librarians. The discussion for the university level highlighted recent trends in GIS education and research and examined the increase in community colleges and technical schools that provide GIS training. Topics presented for discussion on the K-12 level were:

- GIS education in primary, middle, and high schools
- GIS training with the educational system
- GIS curriculum development
- using GIS in multiple disciplines: math, science, history
- Association of Research Libraries literacy project
- public education through libraries
- electronic town hall
- local government and library partnerships
- policies and issues affecting public access through the library

Using GIS in schools allows students to engage in active learning and can help students and teachers become more involved as global citizens.* ESRI offers a Schools and Libraries home page at:

http://www.esri.com/resources/k-12.html

One of the user success stories was presented by Randy Raymond, a biology and chemistry teacher at Cass Technical High School in Detroit, Michigan. Raymond directed a project on urban environment. The project's goal was 1) to teach young people to value their urban environment and 2) to provide technological resources to schools with limited access to such resources. The Cass Tech students worked with research scientist to develop an educational outreach program using GIS technology to inform Detroit residents about the dangers of lead in drinking water.

The welcoming poster session showcased 600 GIS technology application maps. The individuals and teams, from all over the world and various regions of the US, who created the posters were on hand to describe their applications. A wide range of applications was displayed; from use of GIS in precision farming to territorial alignment between countries.

The demonstration area presented GIS applications in health care, earthquake monitoring, sales analysis, beehive movement and new hive reproduction modelling, wild fire tracking, violence suppression/gang tracking, online information networks for real estate, watershed analysis and modelling, zoning administration, agriculture management, trail mapping with historical information for tourists, and in creating an interactive world tour that examines 14 different satellite scenes of places around the globe.

Nearly 200 paper presentations highlighted how GIS technology is being used to develop solutions to problems that affect many businesses and communities. Papers were presented

* Excerpted from ESRI's *Exploring Common Ground: The Educational Promise of GIS.*)

on such topics as emergency planning and response, development of crime analysis, environmental justice, benefits of using GIS in economic development, detecting changes in the ecosystem using remote sensing, preparing sustainable yield plans for private timberlands, producing maps of territorial alignment for use in peace talks between the Bosnian Federation and the Serbian Republic, and integrating GIS with the World Wide Web.

Two super sessions were presented. The special Assistant to the Secretary for Geographic Data Coordination, Department of the Interior, Nancy Tosta, moderated a discussion of current activities to promote spatial data infrastructure development in the session, "Overview of National spatial Data Infrastructure." The session "Spatial Data on the Internet—National Geospatial Data Clearinghouse" explored the issues of serving, searching for, and accessing geospatial data in a distributed environment. The moderators for this session were Doug Nebert, Federal Geographic Data Committee secretariat, and Fred Gifford, Montana State Natural Resource Information System.

For further information on this conference access:

http://www.esri.com

Virtual Reality Modeling Language Symposium Held in San Diego

A three day symposium on Virtual Reality Modeling Lanquage (VRML), sponsored by the San Diego Supercomputer Center, was held in December 1995 in San Diego, California. The symposium—the first of what is expected to be an annual event—was atttended by approximately 280 people from 20 countries. The attendees came to discuss the future of the VRML standard and general technical issues relating to World Wide Web (WWW)-based browing of three dimensional data.

Leading figures in the development of this technology were on hand to address the symposium audience. The keynote speaker, Steve Bryson of NASA, spoke on "Real-time Collaborative Scientific Visualization: Can VRML Meet the Challenge?" Invited speakers were John Hughes of Brown University and Gavin Bell of Silicon Graphics, Inc. Brown presented "The Limitations of Generality: Lessons for VRML from the Graphics and Visualization Center". Bell's talk was titled "Octopus Wrestling". The capstone speaker was Mark Pesc, called the inspirational leader of VRML, who talked about growing VRML—"Root, Trunk, Branch".

The symposium consisted of round table discussions, technical sessions, and exhibits and demonstrations of academic and non-profit VRML research. Round table discussions were held on Wednesday. Exhibits and demonstrations and the technical sessions were held on Thursday and Friday. The technical sessions consisted of two categories: applications and behaviors. Technical and white papers were presented on such topics as:

- Web-based volumetric data retrieval
- creating VRML extensions to support vector field visualization
- database visualization
- VRML-based Web interface to MPI video
- visualizing the structure of the Web in 3D hyperbolic space
- distributed virtual reality
- adding behavior to VRML
- behavioral language protocol
- adding multi-user support
- internetwork infrastructure requirements for virtual environments
- building and exploiting levels of detail
- browser designing

The vendor exhibits showcased the latest VRML software, such as browsers, Web chat environments, automated world builders, world editors, and program development tools. Two Web browsers were introduced: the i3D and VRweb. The i3D is a high-speed browser. VRweb is a multi-protocol browser.

New Results in Astronomical Image Compression

Fionn Murtagh, University of Ulster, Faculty of Informatics, Londonderry, and Astronomical Observatory, Strasbourg, Jean-Luc Starck, Commissariat à l'Energie Atomique, Direction des Sciences et de la Matière, Départe'ment d'Astrophysique, de Physique Nucle'aire, et d'Instrumentations Associée, France, and Daniel Durand, Dominion Astrophysical Observatory, Victoria

Currently used astronomical image compression methods include hcompress [1], FITSPRESS [2], COMPFITS [3], and JPEG [4]. This article presents a new approach, the basis of which is through noise removal. Noise is determined on the basis of the image's assumed stochastic properties. This is potentially a powerful technique, since astronomical images are characterized by (i) the all-pervasive presence of noise, and (ii) knowledge of the detector's and image's noise properties, at least approximately. Rather than being open-ended in the amount of information that can be thrown away, the method described here has an inherent compressibility that is aimed at, for example, lossless compression of the noise-filtered image. The primary user parameter for controlling noise suppression is expressed in terms of the noise (e.g. a multiple of the noise variance).

The method

The median transform is nonlinear, and offers advantages for robust smoothing (i.e. the effects of outlier pixel values are mitigated). A succession of median transforms is used to build a pyramidal data-structure related to the given image. At each resolution level, the median kernel is bloated twofold. The difference between two successive levels is retained; this will hopefully represent the interesting new information superimposed on the previous resolution level's information. The values in these differenced images are referred to as multiresolution coefficients. Given the smoothing inherent in the median transform, decimation (i.e. keep one pixel in every 2 x 2) follows the median smoothing. In this way, the sequence of versions of the input image can be represented in a pyramidal fashion. Each level of the pyramid conveys information that together comprises the information content of the given input image.

To reconstruct the image, a simple iterative approach is required. Full details of the method are to be found in [5]. Next, the multiresolution coefficients are quantized. But before doing so, the information to be kept is carefully selected (i.e. by suppressing noisy multiresolution coefficients). A means to this end is to "variance-stabilize" the input image to perform the necessary transformation so that the input image's noise properties become Gaussian, and thus more readily handled. But then is there a risk of destroying valuable astronomical features? This is avoided by what is termed the multiresolution support; a mask image, defined separately at each level of resolution, on the basis of which any changes in multiresolution coefficients are excluded. Each resolution level is then coded using the Huang-Bijaoui method [6]. This consists of quadtree-coding each image, followed by Huffman-coding (with fixed codes) the quadtree representation. The noise is quantized if this is wished. Decompression consists of reconstituting the noise-filtered image (plus the quantized noise if this was specified).

Results

Figures 1, 2, and 3 show NGC 2683, which is photographic and digitized in origin. Both extended and point-source structures are to be seen in this image. Figure 1 shows the original image. Figure 2 shows an uncompressed image using hcompress (as well as rebinning), which typically gives a compression rate of around 90%. Figure 3 shows an uncompressed version of the image using the approach described here. The compression rate was more than 96%. The approach described here has been investigated in detail [5]. It may be the best available method at the present time for such images as photographic/digitized (ESO Southern Sky Survey, or Guide Star Scans) or charged

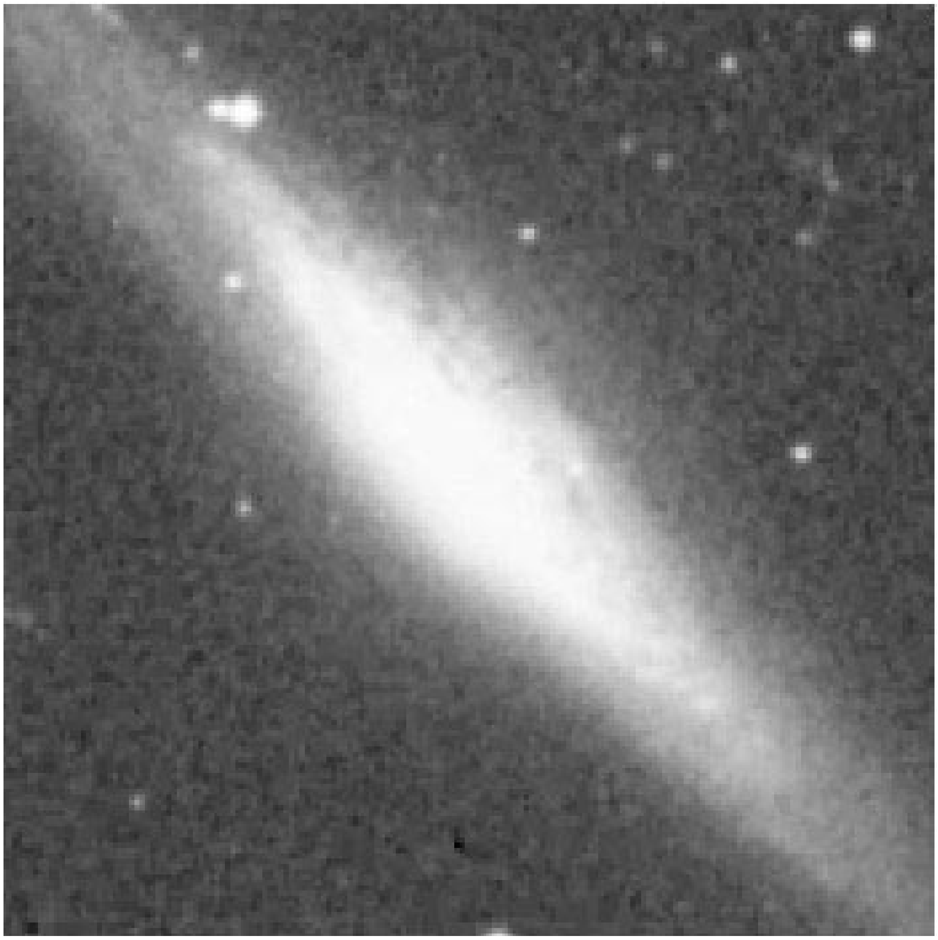

Figure 1. NGC 2683 original image

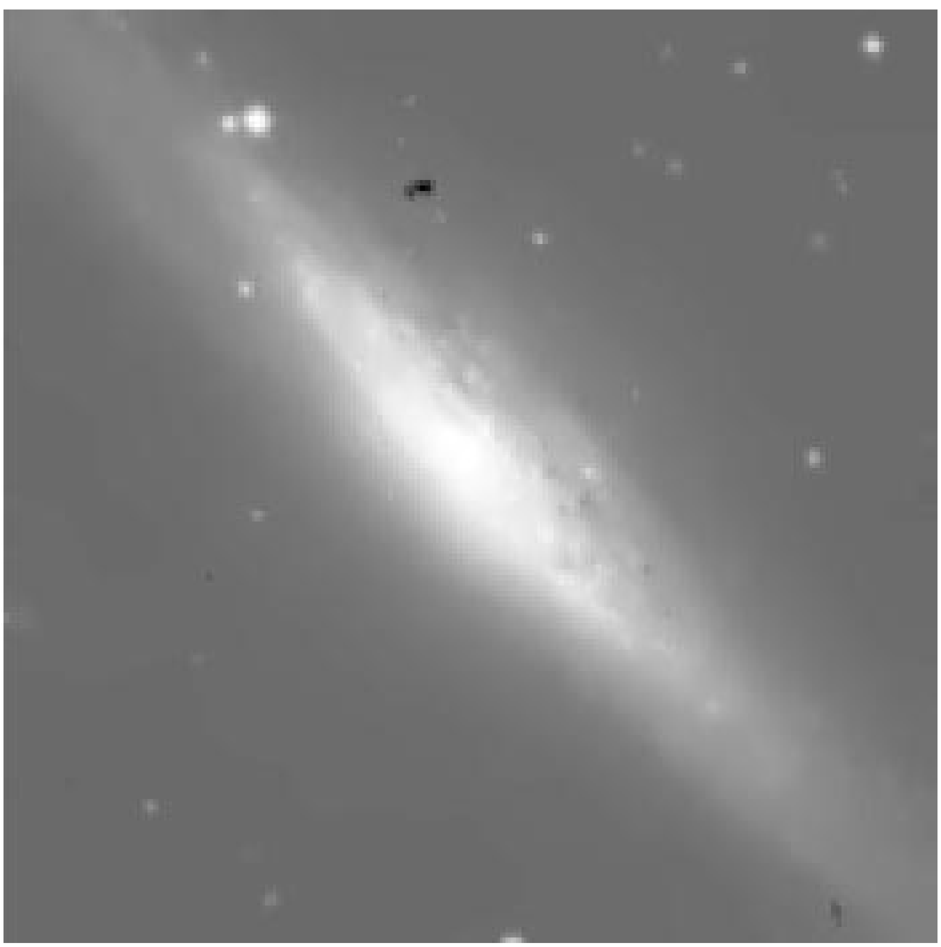

Figure 2. NGC 2683 uncompressed image using hcompress giving a compression rate of 90%

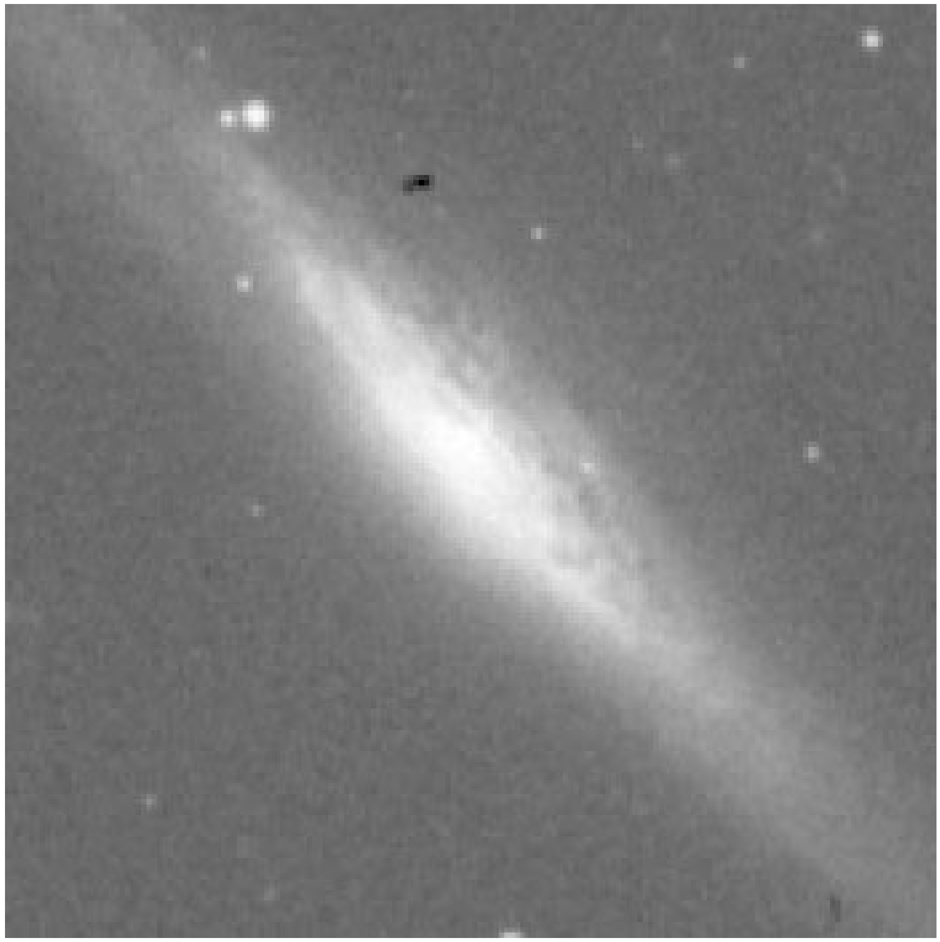

Figure 3. NGC 2683 uncompressed image using hcompress giving a compression rate of more than 96%

coupled device (Hubble Space Telescope) images.

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Educating Teachers About the Internet

Pat Kaspar, NASA Internet, Ames Research Center

Members of the Kindergarten Through Grade 12 (K-12) Information Infrastructure Technology and Applications (IITA) Internet Initiative project at Ames Research Center (ARC) participated in the March National Science Teachers Association (NSTA) meeting in St. Louis, MO, to help educate teachers about the Internet. Many teachers receive their first exposure to the Internet at meetings such as these. To demonstrate the Internet, the K-12 staff used seven Internet-connected computers in its booth. Members of the I-NET staff, led by Tom Dyson, networked a high-speed T1-line throughout the NASA exhibition area and also connected other booths such as the Global Learning and Observations to Benefit the Environment (GLOBE) meteorological project. Apple Computer, Inc., loaned NASA 10 computers for this exhibit in exchange for connecting the company's booth to the network.

"There is still an enormous number of teachers who have no connectivity," said Marc Siegel, K-12 staff member. "They have no support from their communities to set up a connection, but you can do a lot with the Internet without having a computer in the classroom. We try to convey to them that for about $20 a month a teacher can have an individual account from home. It doesn't have to be a $5000 investment in their school."

The K-12 staff also takes advantage of the NSTA meeting to inform teachers about the group's projects, such as "Live from the Hubble Space Telescope" and "Online from Jupiter," which teachers can use to involve students in science. The group typically sends out two email messages a week on its Quest server that contain scientists' journals telling what they do in their jobs. Teachers can convey students' questions to the scientist, then bring the answers back and share them with the students to stimulate their interest in science outside of the classroom.

NSTA meetings are also a fertile place to share ideas with other NASA people who are interested in educational outreach. "It's a good networking opportunity for people who are doing NASA projects," said Siegel. "We're planning to do one with the Shuttle/Mir microgravity project, but we hadn't talked with the right people before this conference. It gives us a chance to cross-pollinate ideas—these conferences are really quite powerful."

For photos of the event access the World Wide Web at:

http://quest.arc.nasa.gov/nsta/booth.html

For information on the K-12 IITA program access:

http://www.quest.arc.nasa.gov

Andrea McCurdy, staff member, at the National Science Teachers Association Conference. *Photo retrieved from the World Wide Web.*

Objectives:
Universal
Technology
Research
Education
Access
Community
Hands on

OUTREACH

The goal of NASA's many outreach programs is to promote to the general public an understanding of how the results of space science research make significant contributions to American educations systems and to institutions dedicated to improving science literacy. This newsletter provides one vehicle for reporting how applications, hardware, and research and development used for space science research can be adapted for use by teachers and their students and by non-NASA organizations.

Students Command KidSat Cameras

> **"Simple clouds looked fantastic."**
> **—Go Nagatani**
> **La Cañada High School**

The first KidSat payload to fly aboard the space shuttle, Atlantis, was commanded by middle school students from pilot school classrooms in Pasadena and San Diego, California, and from Charleston, South Carolina. Atlantis carried the KidSat payload during a docking mission with the Russian space station, Mir, in March of this year. The payload consisted of a Kodak digital still camera mounted in the overhead window of the space shuttle and a video camera mounted in the shuttle's cargo bay.

The cameras were turned on a day after launch and operated for 18 hours prior to the docking activities with Mir. When Atlantis docked with the Mir, the cameras were turned off. On flight day 8, the instruments were powered on again and students spent another 24 hours downloading images, enhancing them, and creating their first 3D flyby, using Jet Propulsion Laboratory's (JPL) Multimission Image Processing Subsystem laboratory and Digital Image Animation Lab.

How it worked

Students from each of the pilot schools operated the instruments from their classrooms, commanding the cameras to photograph specific regions of the world they wished to study. Commands to point the cameras were sent to a specially designed mission control gateway set up at the University of California at San Diego (UCSD), then to Houston's Mission Control Center at Johnson Space Center (JSC), where they were relayed via two communications satellites to Atlantis.

As specific regions of the world were imaged, the KidSat data were next downlinked directly from the space shuttle to JSC and then distributed to the data archive system at JPL where the pilot schools could access the data via the Internet.

Student teams

Students at UCSD and at La Canada High school (LCH), also in California, worked with JPL to develop KidSat. The LCH students were also part of the team that processed the downloaded images. One LCH freshman, Austin Leach, was at UCSD when the first image was received. "The KidSat project went amazingly smooth," said Austin. "The highlight was getting that first image in the lab at UC San Diego because once we got it, we knew the cameras were working. Everyone was cheering and clapping."

Students worked grueling hours and night shifts while the cameras were operating. Ben Polk, a junior at LCH, was on the 2–6AM shift, but was attending classes as usual. That meant he would go home for breakfast, then on to school for a full day of classes. "It was hard," he said. "But it was more interesting than hard."

"The mission was so much more than we expected," added Jenny Shanley, an LCH freshman, who worked with public information operations at the Kennedy Space Center press center on launch day. She was accompanied by Moon Young Choi, a classmate on the same team.

Go Nagatani, a sophomore at LCH, worked with the fifth-grade pilot classroom at Washington Accelerated Learning Center (WALC) in Pasadena. "The majority of the students from WALC said they knew little about space and close to nothing about how Earth looked from space," he said. "They were very excited about the first images coming down. When the images came down, they were nothing but amazed. Simple clouds looked fantastic."

Image taking was limited to times in which the shuttle was in daylight. Students had planned carefully for known daytime opportunities. Among some of their best images were views of the Great African Rift, which stretches the length of Kenya in Africa; the Ganges River Delta in Bangladesh; and Kangaroo Island in Australia. The students wrote photo captions to accompany each image and summarized key historical events that peaked their curiosity in learning more about the region. Students at WALC, for instance, were interested in studying the Ganges River Delta to learn more about the impact of the monsoons, which begin in August and continue through the winter.

"Students may investigate the seasonal changes in the flood plain by predicting the surface area of the flooding," said one pilot teacher. "Their conjectures can be confirmed with seasonal images on future flights of KidSat."

In all, about 350 images were taken during 42 hours of camera operations. Students continue to work on downloading them. "One-hundred and 15 images are still stored waiting to be downloaded," said Paul Andres, leader of the data-processing team at JPL.

The program

The KidSat program was developed by JPL and the Johns Hopkins University Institute for the Academic Advancement of Youth, with support from JSC. The project is sponsored by NASA's Office of Human Resources and Education, with support from the Offices of Space Flight, Space Science, and Mission to Planet Earth in Washington, D.C.

Pilot classrooms helping to test the new KidSat payload and data transmission system were :

- Buist Academy, Charleston, SC
- Washington Accelerated Learning Center, Pasadena, CA
- Samuel Gompers Secondary School, San Diego, CA

Images and student interpretations of the imagery are available on the Internet at:

http://www.jpl.nasa.gov/kidsat

Excerpted from the JPL UNIVERSE, *April 5, 1996, article by Diane Ainsworth, Public Information Office, Jet Propulsion Laboratory, and Go Nagatani, La Canada High School, La Canada, CA.*

Nuts/Bolts of Mission Ops Find New Uses

Diane F. Miller, Advanced Mission Operations Section, Jet Propulsion Laboratory

To monitor and command interplanetary robotic spacecraft, Jet Propulsion Laboratory (JPL) mission controllers need to be grounded in the fundamentals of physics and astronomy as relevant to space flight missions, and understand the basics of spacecraft design and mission life cycles. Before 1993, there was no single document that could give mission controllers even the spacecraft and mission basics for deep space missions, much less the physics and astronomy basics. So the operations training group (of what is now called the Advanced Mission Operations Section), calling upon the writing talents of David Doody, a veteran mission controller and amateur astronomer, and George Stephan, training engineer, developed a tutorial workbook with the specific objective of giving mission controllers a context for the task-and-mission-specific training they would receive later. The result was the *Basics of Space Flight Learners' Workbook*, first published internally at JPL in August 1993.

What began as a solution to an internal gap in training has become a bridge between NASA's and JPL's hyper-technical missions and the public.

The workbook

The workbook, written at about a 10th grade level, has three main parts, each with several chapters. Each chapter begins with a learning objective, and several "Recaps" throughout the chapter allow the reader to self-test by answering fill-in-the-blank questions from the previous text. The first major part, called "The Environment of Space," includes basic information on the solar system, Earth's reference systems, gravitation and mechanics, interplanetary trajectories, planetary orbits, and electromagnetic phenomena. The second part, "Space Flight Projects," discusses how space missions are conceived and planned, what kinds of experiments they carry, the different classifications of spacecraft, summaries and drawings of all JPL's spacecraft to date, how telecommunications is done, typical onboard spacecraft systems and science instruments, and spacecraft navigation. The third part, "Space Flight Operations," describes what goes on during each operational phase launch, cruise, encounter, and extended operations. The workbook also includes an extensive glossary of terms, with brief and precise definitions of all terms that are introduced in the document and quite a few that aren't.

The supervisor of the training group, Larry Bryant, recognizing the general educational value of the workbook, showed it to his daughter's science teacher at nearby La Canada High School. The school subsequently adopted parts of it for use in their physics classes. The document was cleared for public release and made available to JPL's Teacher Resource Center, with parts of it used in numerous schools to supplement science curricula. Now, nearly three years later, interest in *Basics* continues to accelerate.

In April 1994, the workbook was made available in hypertext markup language (HTML) on the WWW (Figure 1), primarily intended for internal training of mission operations personnel. The Web version was subsequently linked from JPL's public home page, as well as a "Views of the Solar System" Web site maintained from Los Alamos National Lab. It is now linked from numerous sites related to astronomy and space exploration, including NASA's Spacelink site, which is an electronic information system designed to provide current educational information to teachers and students throughout the United States. Basics has become internationally known due to the WWW version.

Use and recognition

Basics was used by the Southern California Area Modern Physics Institute, a National Science Foundation-funded program, to upgrade physics teachers' training. JPL provided a number of copies of the document for these workshops, with many of the teachers going on to use parts of it as classroom materials. As of May 1996, plans are under way by the French Space Agency to have *Basics* translated into French.

Basics has received awards from various entities. In 1994 the Society for Technical Communication's Region 8 (California, Oregon, Washington, Arizona, Nevada, and Hawaii) gave it an Award of Merit in the category of training materials at the annual publication contest. The Operations Systems Training Group at JPL was given a NASA Group Achievement Award in 1995 for *Basics* "in recognition of outstanding contributions to the educational community by developing educational material that can capture the interest and imagination of the world's youth." The May 1996 issue of *Netguide* magazine reviewed the *Basics* Web site and gave it a four-star rating. Additionally, mention and a screen capture of the *Basics* home page are to appear in the book *Yahooligans: The Kid's Web Guide*, to be published by IDG Books Worldwide, Inc.

Figure 1. Workbook World Wide Web home page

Distribution

In addition to being available on the Web, *Basics* is also distributed by JPL's secondary distribution function, which is set up to accept payment from the general public to cover reproduction costs. The recent update to *Basics* is being distributed with a glossy, color photocopied cover that features a space flight painting by David Hardy.

What began as a solution to an internal gap in training has become a bridge between NASA's and JPL's hyper-technical missions and the public. It has also made a contribution to NASA's goal "to advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe . . ."

The *Basics of Space Flight Learner's Workbook* can be accessed on the Web at:

http://www.jpl.nasa.gov/basics

To order the Basics of Flight Learner's Workbook, email:

Elizabeth.A.Moorthy@jpl.nasa.gov
(818)-397-7952

All "marketing" external to JPL has been done in the course of conducting other business, or has been self-generating, once Basics became known on the Web and linked to other sites.

SmartSchool NetDay96

Pat Kaspar, NASA Internet, Ames Research Center

The efforts of over 8000 volunteers, including scores of Ames Research Center employees, recently helped create a Kindergarten Through Grade12 (K-12) network in Silicon Valley estimated to be one of the largest K-12 networks in the world. Prior to the March 9 “SmartSchools NetDay96,” volunteers spent weekends preparing more than100 schools in San Mateo and Santa Clara counties to be connected to the Internet.

The effort ranged from wiring schools, installing networking equipment, and fine-tuning the network to simply connecting equipment that had already been installed. For example, I-NET staff, on behalf of NASA, supported fiber optic cabling and connectivity to Independence High School, in northern California. Independence is the twelfth largest high school in the US. It covers 103 acres in eastern San Jose and is home to 4000 students and 302 faculty members.

Schools cooperated with area companies that donated money, equipment, and technical know-how to bring networking technology to the schools. The students will benefit from the new learning tools, and school districts will benefit from more efficient administrative tools.

For further information contact Mark Leon at:

leon@nipso.nasa.gov

Mark Leon, sitting, wires a school during NetDay96 as a teacher looks on. *Photo retrieved from the World Wide Web.*

Outreach Activities

Ames Research Center (ARC)

- Several ARC employees, as part of over 8000 volunteers, helped create a Kindergarten Through Grade 12 (K-12) network in Silicon Valley, CA, during SmartSchools NetDay96. The effort ranged from connecting already installed equipment, wiring schools, installing networking equipment, and fine-tuning the network.
- Members of the K-12 Information Infrastructure Technology and Applications Internet Initiative project participated in the March National Science Teachers Association meeting in St. Louis, MO, to help educate teachers about the Internet.

Information provided by Pat Kaspar, Contributing Editor, ARC.

Goddard Space Flight Center (GSFC)

- Members of the GSFC-managed Minority University-Space Interdisciplinary Network (MU-SPIN) Project completed the second round of FY96 Network Regional Training Workshops held at the MU-SPIN project's Network Regional Training Site (NRTS).
- Gloria Brown-Simmons, of Jet Propulsion Laboratory, is helping the MU-SPIN Project by defining expertise, computational requirements, and data necessary to expand the NTRS's research abilities for science, math and engineering. She is fostering partnerships with other Federal agencies in support of NRTS-identified research and education goals.
- Ely Dorsey of Howard University has been selected by GSFC as a Summer Faculty Fellow to identify issues among teaching faculty, staff, and students that could impede the maximum effectiveness of network technology to enhance research and educational quality at minority institutions.
- Pat Gary presented "Internetworking ATM LAN's, MAN's, and WAN's" on February 8 at Morgan State University's Society for the Advancement of Computer Science.
- MU-SPIN's Project Manager, Jerome Bennett helped promote MU-SPIN Project outreach at the annual National Association for Equal Opportunity in Higher Education (NAFEO) Conference in Washington, DC, on April 20. The NAFEO Conference is attended by top administrators of minority universities.
- At the request of the White House, the GSFC Global Learning and Observations to Benefit the Environment (GLOBE) group produced advanced animations and visualizations for use on Earth Day, with the focus on the growth of the GLOBE program over the past year. The GSFC GLOBE group produced custom products for use in special ceremonies at the Vice-President's ceremonial office, the United Nations, and several US embassies.

Information provided by Judy Laue, Contributing Editor, GSFC.

Jet Propulsion Laboratory (JPL)

- Middle school children in California and in South Carolina commanded the first KidSat payload to fly aboard the space shuttle Atlantis as it docked with the Russian Mir in March. Students downloaded images of Earth and created a 3D simulated flight over Saudi Arabia using the payload cameras; a Kodak digital still camera mounted in the overhead window and a video camera mounted in the cargo bay. The pilot schools operated the instruments from their classrooms, commanding the cameras to photograph specific regions of the world.
- JPL hosted its annual Open House on June 8-9, offering various interactive activities, laboratory and test demonstrations, multimedia presentations, and exhibits encompassing an entire range of endeavors—in chemistry, communications, computing, electronics, mechanical and thermal design, microdevices, robotics and automation, software, space science and instruments, and spacecraft instrumentation and design.

- A “float-off” was recently held in Galveston Bay, Texas, as part of an ongoing educational outreach program between JPL, the University of Texas Center for Space Research, and the Texas Space Grant Consortium, in conjunction with Colorado Center for Astrodynamics Research and the Colorado Space Grant Consortium. The students—from two Houston, Texas, high schools and from Boulder High School, CO, and the University of Colorado—launched boys into Galveston Bay to verify altimeter measurements from the TOPEX/Poseidon satellite. The “float-off” was a demonstration of how the satellite is calibrated. Each team of students designed and built their own buoy, which was equipped with a global positioning system receiver that allowed precise tracking of its position. The buoys recorded sea level and wave height measurements along a track on the water as TOPEX/Poseidon flew overhead. This information will be used in conjunction with data from several tide gauges in the area to validate the satellite’s performance.

Information excerpted from NASA press releases, the JPL Universe, and from the Public Affairs Office.

General

- NASA’s Mission to Planet Earth program has awarded a $500,000 grant to the Smithsonian Institution’s National Museum of Natural History to support planning for a new museum exhibition hall. The new hall, titled “Forces of Change”, will feature a series of regional case studies demonstrating the ways in which the Earth’s environment is changing and how humans affect or are affected by these processes. Initial case studies on the Antarctic polar region, the Hawaiian islands, the Chesapeake Bay estuary and the Great Plains grasslands will offer museum visitors interactive, state-of-the-art displays on how natural forces influence their daily lives.
- NASA’s Office of Equal Opportunity Programs has selected nine minority universities to receive a three year grant—Pre-college Awards for Excellence in Mathematics, Science, Engineering, and Technology—for educational outreach projects. The grants are intended to help students who have historically been under-represented in college preparatory mathematics and science classes gain the skills necessary to pursue science, engineering, and related fields in college. The selected universities to receive grants are:
  - California State University, Los Angeles, CA
  - Elizabeth City State University, Elizabeth City, NC
  - Fayetteville State University, Fayetteville, NC
  - Hampton University, Hampton, VA
  - Lehman College, Bronx, NY
  - Northwest Indian college, Bellingham, WA
  - Pasadena City College, Pasadena, CA
  - Southwestern Indian Polytechnic, Albuquerque, NM
  - Saint Augustine’s College, Raleigh, NC
- Twenty seven students from public and private schools across the US have won national recognition in NASA’s 16th annual Space Science Student Involvement Program competition. The students were honored, along with their teachers, at the National Space Symposium on May 4–8 in Washington, D.C. The competition, co-sponsored by NASA and the National Science Teachers Association, is an interdisciplinary program designed to address the need for greater literacy in the areas of science, critical and creative thinking, mathematics, and technology. In addition to their recognition in Washington, the students will have the opportunity to intern at a NASA field center for a week during the summer and receive a Space Camp scholarship.
- NASA and the Quality Education for Minorities (QEM) Network have selected 300 high school students as apprentices to engage in cutting-edge science and engineering research activities as part of NASA’s SHARP PLUS Research Apprenticeship Program. The program enables students, under the guidance of industry or university-based mentors, to spend eight

weeks in residence at 14 universities that have joined with NASA and QEM to increase the participation and success rates of highly talented students who are under-represented in mathematics and science courses at the pre-college level. The students, 179 females and 121 males, from 29 states, Puerto Rico, the US Virgin Islands, Washington, D.C., and a US military base in Germany were chosen from among a 1000 applicants.

- US Space Camp, which began as an idea by NASA's Wernher von Braun and Edward Buckbee, provides trainees an opportunity to learn the basics of space shuttle operation, the science and history of the space program, and to participate in simulated space missions conducted in space shuttle orbiter mockups. Space Camp offers different types of camp, geared to age levels: a fourth through sixth grade students program, a seventh and eight grade program, and a high school program. Additionally, Space Camp offers an adult program and a parent-child program. In 1995 America's Teachers-of-the-Year from each state, along with selected students, were invited to participate in the sixth International Space Camp in Huntsville, AL, with students from twenty-three nations. Space Camp's programs and curriculum are prepared by an education committee that includes NASA representatives, teachers, and veteran astronauts. The curriculum is correlated with the standard established by the National Science Teachers' Association and the standards of selected states. Space Camp is operated by a foundation made up of corporate sponsors and a scholarship foundation supported by NASA astronauts.

Information excerpted from NASA press releases. Space Camp information provided by Edd Davis, Media/Public Relations Manager, US Space and Rocket Center.

Pluto's Discoverer Honored on 90th Birthday

Pat Kaspar, NASA Internet, Ames **Research** Center

Dr. Clyde Tombaugh, discoverer of Pluto, was honored on his 90th birthday by students from around the world. The Ames Research Center's Kindergarten Through Grade 12 (K-12) Internet Initiative project announced the project online prior to Dr. Tombaugh's birthday. Children from all over the United States and as far away as Croatia sent the birthday cards to Jan Wee, Passport to Knowledge outreach coordinator in Wisconsin, who scanned them for the K-12 project. After the cards were scanned, Jan Wee sent them to Tombaugh in New Mexico. The scanned cards were also transmitted over the Internet by the K-12 Internet Initiative project for viewing on the World Wide Web. The effort was organized by the Passport to Knowledge "Live from the Hubble" project.

Pictures of Tombaugh and the birthday cards can be seen online at:

http://quest.arc.nasa.gov/hst/kids/kidswk.html

The K-12 Quest home page can be accessed at:
http://quest.arc.nasa.gov/

First Grade Students Campaign to Save Pluto

Some of the students at Valley of Enchantment elementary school (in California's Rim of the World school district) recently campaigned to keep Pluto recognized as a planet. The first graders in Noelle Ladd's class were studying the solar system and space exploration, in this southern California mountain community school, using a teacher-developed thematic unit plus videotapes, photos, and print materials provided by Jet Propulsion Laboratory's Teachers Resource Lab. The children were dismayed to learn (from television and radio news sources) that Pluto's classification as a planet is currently being reconsidered because of the manner in which is was formed.

Mrs. Ladd had prepared a two week unit on the solar system, with an additional week on space exploration, utilizing NASA's educational resources. Mrs. Ladd stated that she was impressed by the questions her students asked about the planets and the solar system. For example, they wanted to know how cold is Venus, why does the Earth rotate, what is in the Black Hole, and what causes the storm on Jupiter. Some of the children even knew the origins of the planets' names; one student informed his classmates that Mars was the name of a warrior in Greek mythology. The entire class participated in making a mock-up solar system—of balloons and papier mache—that hangs in the classroom.

"I'm delighted that children in first grade are so interested in science, " Mrs. Ladd said. "However, they were very upset to hear that Pluto may no longer be considered a planet. It is their favorite of all the planets."

When the children learned of the possible reclassification of Pluto, they asked what they could do to save their favorite planet. After much discussion in the classroom and at home, the students decided to protest by writing letters addressed to NASA Administrator, Daniel S. Goldin. They also sent a photo of all the students in the classroom with a hand-painted sign that proclaims "Save Pluto".

Asked how her class will feel if this campaign fails, Mrs. Ladd explained that she had discussed this possibility with the students and they seem to understand that doing something constructive is better than simply complaining, even if the desired result is not achieved.

"Meanwhile, the children have learned to exercise their options as citizens, to voice their opinions in an orderly and productive fashion," she stated. "And, their interest in science is piqued. Many thanks to NASA for making so much educational material available."

Some of the childrens' letters are shown here, along with their teacher's accompanying letter to Mr. Goldin.

Valley of Enchantment
Elementary School
Rim of the World
School District
Lake Arrowhead, CA

Dear Mr. Goldin,

Recently my class was learning about the solar system. We heard through the news that Pluto may be declassified as a planet. My first grade students were very upset since Pluto is one of their favorite planets. They decided to write in protest. I am writing on their behalf to ask you to please read their letters and reconsider any decision to declassify Pluto.

Sincerely,
Mrs. Ladd

NASA 3-19-96

Dear Mr. Goldin, Pluto is the best. I dont want it to be forgotten, It is small. It is coll. I like it's name. Please keep Pluto a planet. Sincerely Matthew Zeldner

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NASA March 19 1996

Dear Mr. Goldin, I don't want pluto to change into a moon because, I really like it. It is my favorite planet. If you take it away I will forget. I want pluto to stay. It is my favorite name.

Sincerely

Kaela F.

NASA March 19, 1996

Dear Mr. Goldin, I Like Pluto just like it is. I dont want to change Pluto. It is my favorite planet. It is my favorite name.

Sincerely

Dustin

NASA 3-19-1996

Dear Mr Goldin,

please don't take pluto, my favorite planet.

I like Pluto.

I still want pluto to be a planet.

Sincerely

Claudia

NASA March 19 1996

Dear Mr. Goldin,

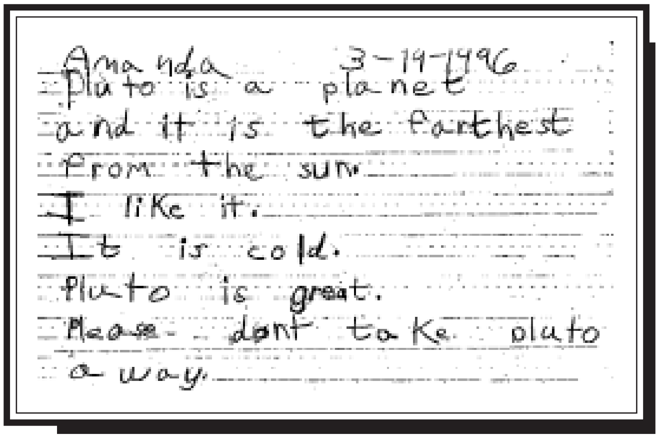
I like pluto.

Please don't take pluto.

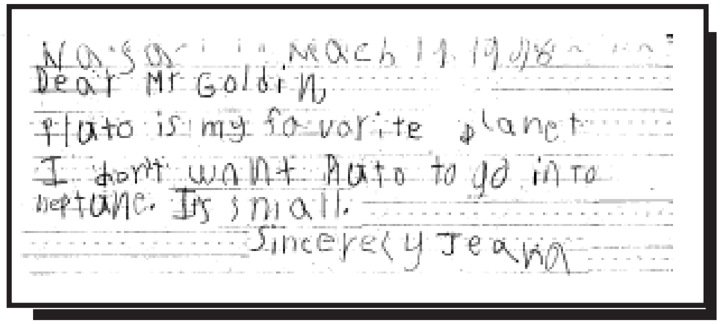
I still want pluto to be a planet. I like pluto.

I really like pluto. Sincerely

Anette



Amanda 3-19-1996
Pluto is a planet
and it is the farthest
from the sun
I like it.
It is cold.
Pluto is great.
Please dont take pluto
a way.



Nasa Mach 11 1996
Dear Mr Goldin
Pluto is my favorite planet
I dont want Pluto to go into
neptune. Its small.
Sincerely Jean

The students protest the declassification of Pluto as a planet. *Photo courtesy of Noelle Ladd.*

The mock-up solar system, created by Mrs. Ladd's students, hangs in the classroom. *Photo courtesy of Noelle Ladd.*

Acomplishments

Information Systems Program Highlights

Major accomplishments achieved by NASA's Information Systems Branch (Code ST) are highlighted below. They cover work performed from March 1996 through May 1996, and reflect the combined efforts of many people.

Ames Research Center (ARC)

NASA Internet—Christine Falsetti

- Asked to develop and permanently chair a new task team—Working Group Information Systems and Services (WGISS)—to provide long-range planning and the agenda for the WGISS. In addition, NI has reviewed and provided comments on the revised WGISS Five Year Plan that incorporated NI recommended changes for procedures and organization.

- Tasked to represent NASA and other US agency interests by participating in the G-7 Environment and Natural Resources Management (ENRM) Initiative's Task Working Group on meta information. ("G-7" refers to the world's seven industrial giants, including the US, France, Canada, Italy, Germany, Japan, and Great Britain.) In addition, NI provided recommendations for coordination of US agency contributions to the ENRM Initiative's agenda and recommendations for US agency demonstrations for the April 1996 ENRM meeting in South Africa.

- Hosted a three day meeting at ARC, March 6-8, to review the plans and status of NI-Earth Observing System (EOS) Project support of EOS Data and Information System (EOSDIS) external network (EN) requirements. These include requirements for basic user service, Data Active Archive Centers connectivity to the Internet, Quality Control Science Computing Facilities, and Instrument Support Terminals. The meetings included a detailed review of the NI process and budget, the EN Engineering Plan, interface documents between NI and other EOSDIS entities, and NASA development and reorganization plans that are expected to affect development of EOSDIS networks.

- Conducted initial testing of multicasting between NASA, the Space Science Research Institute, called IKI, in Moscow, and Moscow State University (MSU) in support of the Telemedicine project. Dave Meyers, the ARC digital video lab engineer who was in Moscow for the test, initiated sessions with various participants at NASA Headquarters, Lewis Research Center, and ARC. Tests included verification of audio and video utilizing various commercial off-the-shelf tools. Audio quality was good, little content loss occurred, and voice quality appeared clear at ARC.

- Supported the 27th annual Lunar and Planetary Science Conference in Houston, TX, March 18-22, by providing email and remote access, literature on network tools, and technical expertise to the solar exploration scientists attending. Other conferences supported include a National Research and Education Network (NREN) Workshop at ARC, May 21-23; the American Geophysical Union Conference in Baltimore, Maryland, May 20-24; the American Astronomical Society, June 9-13, in Madison, Wisconsin; and Telemedicine 2001 Conference, June 19-23, in Montreal, Canada. Standard conference support includes Internet connectivity for those exhibitors who require it for electronic demonstrations, connectivity for the electronic poster sessions, and providing email equipment for meetings.

- Provided engineering consultation to the US Agency for International Development (USAID) for the development of a global Very Small Aperture Terminal (VSAT) system to extend the Internet to

USAID remote international missions around the world. The Indian Ocean Region (IOR) Hub at Goonhilly, England, is now online and operational with 12 new IOR sites connected. USAID has leased transponder space on the Intelsat satellite at 63 degrees east for downlink to this hub from IOR USAID missions using Hughes time division multiple access (TDMA) VSAT Personal Earth Station Hub equipment. This brings the total number of international USAID sites up to 44 now active in the USAID network.

- Moving forward with supplying a dedicated circuit between Kansas State University, Salina, KS, and the University of Wisconsin, Madison, WI, to support the Earth Research-2 (ER-2) flight mission SUbsonic Aircraft Contrail and Cloud Effects Special Study, called SUCCESS. The ER-2 is NASA's high-altitude research aircraft. The Program Support Communications Network at Marshall Space Flight Center is supporting the circuit order, and coordination with the campuses and ER-2 staff is working smoothly.

Information provided by Pat Kaspar, Contributing Editor, ARC.

NASA Network Information Center (NIC)—Mary Stahl

- The Webmasters Working Group of the InterCenter council for computer Networking is designing a NASA-wide search engine that is modeled on the Harvest Information Discovery and Access System. The Harvest search engine is a forms-based Web interface that gathers information from both Web and file transfer protocol servers throughout participating NASA centers. ARC is part of this collaborative effort. NIC staff member, Ted Hardie, presented a poster-session paper on his ongoing research at the fifth annual World Wide Web Conference in Paris in May. The paper, "A Grain of Sand or the Ocean: User Aims in Search Engine Interactions", analyzed search strategies and usage patterns employed by users, as well as common error patterns during a six-month study period. This research can be viewed at:

  http://nic.nasa.gov/Harvest

  or contact NASA NIC at:

  nic@nasa.gov

Information provided by Mary Stahl, NASA NIC, ARC.

Goddard Space Flight Center (GSFC)

Computer Networks and Communications Branch (CNCB)—J. Patrick Gary

- On March 28, 1996, at 6:12 PM EST, the high data rate terminal (HDRT) at GSFC transmitted and received data through the Advanced Communications Technology Satellite (ACTS) for the first time. In subsequent memory-to-memory ttcp tests between two SPARC 20's, when the default maximum transmission control protocol window size was increased to 10 MByte, ttcp throughput of 62.1 Mbps through ACTS was recorded. Over approximately 45,000 miles, this rate compares favorably with the throughput of 66.6 Mbps recorded between the same computers when connected to the same asynchronous transport mode (ATM) switch at a distance of 45 feet. Once technical difficulties with the HDRT are resolved, the CNCB will use this HDRT to support the Distributed Global Climate Model Experiment operating via ACTS between the Cray T3D at Jet Propulsion Laboratory (JPL) and the Crays at GSFC.

- The CNCB interconnected the GSFC-internal Earth System Science (ESS) Network at 155 Mbps with the GSFC-external NREN and Advanced Technology Demonstration Net through an ATM firewall router (AFR) the CNCB recently installed in GSFC Building 1. The CNCB conducted initial performance tests of the AFR demonstrating aggregate end computer-to-computer throughputs at the AFR's present configuration maximum of 134 Mbps.

- For the first time, the CNCB connected GSFC with ARC over the 155 Mbps NREN, achieving approximately 30 Mbps in ttcp tests so far.

Mass Storage and Scientific Computing Branch (MSSCB)—Nancy Palm

- The NASA Center for Computational Sciences (NCCS) has been in the news since announcing its plans to triple its computing power by switching from a CRAY C90 supercomputer that provided a peak of 6 GFLOPS to a cluster of three CRAY J932 systems that will provide 96 cpu's, 19.2 peak GFLOPS, and 12 GB of main memory to the NCCS user community. This equipment will enable the NCCS to move its production computing to a predominantly parallel environment. Recent articles include "NASA Trades in Cray Y-MP (C98) for 3 Scalable Systems," *Government Computer News*, Jan. 8, 1996; and "NASA Triples Cray Power," *Computerworld*, Dec. 11, 1995.

- The NCCS took delivery of a Cray J932 interim system in late December with 32 CPUs and 4 GB of memory (upgraded from 2 GB of memory) and transparently migrated the NCCS Earth and space science community from the Cray C98 (known as "charney") onto the J932 system on February 14. The name "charney" was kept for the J932. The C98 was de-installed in March and removed to the National Institutes for Standards and Technology, which acquired the system from Cray. In addition, a J916 interim system has been configured as a dedicated machine for the GSFC Data Assimilation Office. Each J90 system is configured with 218 GB of disk and 4096 MW of memory. The J932 is configured with two StorageTek silos: a STK 9310 Powderhorn with 4.8 TB capacity and a STK 9360 Powderhorn (aka "Wolfcreek") with 1 TB capacity. The 9310 silo has been configured with six StorageTek Timberline drives, delivering 36 MB/sec throughput.

- The NCCS upgraded its Convex/UniTree mass storage system to RedOak, release 2.0, with new features including parallel writes to tape, the ability to use up to 64 tape drives, and intelligent mounting of tapes to minimize robot pass-throughs. Since the upgrade, total daily traffic has averaged 81.5 GB per day, with peak days storing 86.1 GB and retrieving 88.2 GB. RedOak has also freed up to 200 GB/day of robotic storage for most actively used files by "vaulting" least recently used data to operator-mounted tapes. Adina Tarshish presented the RedOak 2.0 upgrade experiences at the Convex User Group conference in Dallas showing the degree to which the NCCS is on the leading edge in mass storage activity, in both the number of StorageTek silos (six), and the number of tape drives (32 robotic, eight freestanding). At the conference, Ellen Salmon described results of RedOak high performance parrallel interface performance testing.

- Nancy Palm, Head, MSSCB, was one of three speakers at the Data Storage Management session at UniForum '96, a conference and exposition for open systems solutions held in San Francisco. The session explored issues, functions, characteristics, and costs of a comprehensive distributed storage management solutions.

High Performance Computing Branch (HPCB)—Jim Fischer

- Lee Holcomb (HPCC Office of the Office of Aeronautics (OA)), selection official for the Earth Science Systems (ESS) Cooperative Agreement Notice (CAN) issued by GSFC in May 1995 (see "Accomplishments", issue 36, July 1995), gave authorization to begin negotiations with multiple Grand Challenge Investigator teams and one scalable parallel computing testbed vendor. This CAN by OA solicits proposals to refresh and link research in two major focus areas of the ESS project. One area is directed toward the development, testing, and use of advanced parallel numerical algorithms and simulations for enabling progress toward solving "Grand Challenge" scientific problems in ESS. The second area, driven by computational requirements of the first, is to hasten the development of teraflop/s-scalable computing systems to help ensure US-continued leadership and competitiveness in high performance computing. Names of investigators and the testbed vendor will be announced following completion of negotiations. The total three year value of the CAN is $24M including $10.8M for Investigators, $13.2M for the testbed, and an additional $13.2M of cost sharing by the testbed vendor.

- Tom Sterling (Center of Excellence in Space Data and Information Systems) chaired the HPCC agency-sponsored Petaflops Architecture Workshop (PAWS '96) held April 22–25 in Oxnard, CA. The workshop was held to identify key issues and objectives and set initial directions for early inquiry into potential petaflop/s-scale architecture. This workshop is one in a series intended to accelerate the realization of petaflop/s computing and to ensure its effectiveness and ease of use for intended applications.

Scientific Applications and Visualization Branch (SAVB)—Horace Mitchell

- White House Global Learning and Observations to Benefit the Environment directors authorized NASA HQ to provide full FY96 funding, an increase of almost 43% from FY95. The Scientific Visualization Studio (SVS) completed design and implementation of the new visualization products and interface as well as the design of new version 1.0 software. This fully documented, modular software allows full error reporting and recovery and is adaptable to on-request product generation.

- Members of MSSCB and SAVB played significant roles in the development of the SEWP II request for proposals (RFP) and are members of the Source Evaluation Board and the Data Server, Network and Compute Server Technical Advisory Committees. Horace Mitchell has been chairing the procurement. The RFP was released February 16 and proposals in response to the RFP were due April 1. The RFP is available on the Web at:

  http://sewp.nasa.gov:8000

- The SVS completed a 13 minute video on Glacier Bay, Glacier Bay National Park, Alaska, for Dorothy Hall (Laboratory for Terrestrial Physics) The video traces the recession of glaciers in the park from records written by explorers and glaciologists as far back as the 1700's, recent photographs and videos from the ground and air, and Landsat images from space.

- The 1996 Visiting Student Enrichment Program application announcement is available on the Web and has been distributed to high schools, colleges, and universities at:

  http://sdcd.gsfc.nasa.gov/VSEP_96_Brochure2_txt.html

- To assist in transitioning large NCCS production applications to new scalable parallel systems, HPCC and NCCS, the Space Data and Computing Division and the Data Assimilation Office' Laboratory for Atmospheres presented a class on message passing programming to about 40 employees of the laboratory. The class was based on Message Passing Interface (MPI), the new standard message passing library. Attendees learned to use MPI on the JPL Cray T3D, the NCCS Cray J90s, and a Dec Alpha workstation with multiple processors. Class instructors were John Dorband (HPCC), Andrea Hudson (NCCS), Peter Lyster (DAO/University of Maryland), and Hong Ding (DAO/JPL).

Information provided by Judy Laue, Contributing Editor, GSFC.

Planetary Data System Offers New Releases

Jean Mortellaro, Planetary Data Systems, Jet Propulsion Laboratory

The Planetary Data System (PDS) new CD-ROM releases for the past six months are listed below. These data can be ordered by accessing the *PDS Catalog* via one of the methods listed here or by contacting the PDS Operator for assistance. To place an online order, use telnet or the World Wide Web (WWW). For telnet, set host to :

jplpds.jpl.nasa.gov
user name is PDS_GUEST

To use the WWW, access:

http://stardust.jpl.nasa.gov

Then select “PDS Data Set” under “User Services”. For a complete list contact the PDS Operator at:

pds_operator@jplpds.jpl.nasa.gov
818-306-6130

Magellan Venus Full Resolution Radar Mosaics

USA_NASA_USGS_MG_1155	USA_NASA_USGS_MG_1168	USA_NASA_USGS_MG_1169
USA_NASA_USGS_MG_1170	USA_NASA_USGS_MG_1183	USA_NASA_USGS_MG_1184
USA_NASA_USGS_MG_1185	USA_NASA_USGS_MG_1198	USA_NASA_USGS_MG_1199
USA_NASA_USGS_MG_1200	USA_NASA_USGS_MG_1213	USA_NASA_USGS_MG_1214
USA_NASA_USGS_MG_1215	USA_NASA_USGS_MG_1228	USA_NASA_USGS_MG_1229
USA_NASA_USGS_MG_1230	USA_NASA_USGS_MG_1242	USA_NASA_USGS_MG_1243
USA_NASA_USGS_MG_1244	USA_NASA_USGS_MG_1245	USA_NASA_USGS_MG_1126
USA_NASA_USGS_MG_1127	USA_NASA_USGS_MG_1128	USA_NASA_USGS_MG_1129
USA_NASA_USGS_MG_1130	USA_NASA_USGS_MG_1131	USA_NASA_USGS_MG_1132
USA_NASA_USGS_MG_1145	USA_NASA_USGS_MG_1146	USA_NASA_USGS_MG_1147
USA_NASA_USGS_MG_1160	USA_NASA_USGS_MG_1161	USA_NASA_USGS_MG_1162
USA_NASA_USGS_MG_1167	USA_NASA_USGS_MG_1175	USA_NASA_USGS_MG_1176
USA_NASA_USGS_MG_1177	USA_NASA_USGS_MG_1191	USA_NASA_USGS_MG_1192
USA_NASA_USGS_MG_1206	USA_NASA_USGS_MG_1207	USA_NASA_USGS_MG_1208
USA_NASA_USGS_MG_1221	USA_NASA_USGS_MG_1236	USA_NASA_USGS_MG_1104

Pioneer Venus Supplementary Experiment Data Records CD-ROMs

USA_NASA_PDS_PV05_0001 USA_NASA_PDS_PV05_0002

Pioneer Venus Magnetometer and Electric Field Detector Data

USA_NASA_PDS_PV01_0059	USA_NASA_PDS_PV01_0060
USA_NASA_PDS_PV01_0061	USA_NASA_PDS_PV01_0062
USA_NASA_PDS_PV01_0063	USA_NASA_PDS_PV01_0064

Voyager Data

USA_NASA_PDS_VG_0025	USA_NASA_PDS_VG_0026
USA_NASA_PDS_VG_0027	USA_NASA_PDS_VG_0028

Galileo Near Infrared Mapping Spectrometer EDRs

USA_NASA_JPL_GO_1002 USA_NASA_JPL_GO_1003
USA_NASA_JPL_GO_1004

Galileo Solid State Imaging

USA_NASA_JPL_GO_0016

Corrections

The TOPEX/Poseidon Informational CD-ROM (“Perspectives on an Ocean Planet—The TOPEX/Poseidon Informational CD-ROM”, Volume I 1996, Issue 38, pages 25-28) was produced by the TOPEX Project—not the Planetary Data System. The Data Distribution Laboratory supported the production by providing staff and facilities, contracted to the TOPEX Project.

Judy Laue was listed as contributing editor for articles in previous issues (“Science Videos on the Move”, Volume I 1996, Issue 38, pages 30-32, and “Visiting Students Enriched in Information systems Technology”, Volume III 1995, Issue 37, pages 38-39). She should have been listed as the coauthor in issue 38 and the author in issue 37.

The fourth figure in Steve Chien’s article “The Multimission VICAR Planner: A Knowledge-based System for Automated Image Processing” , Volume I 1996, Issue 38, pages 45-48, was not made available at publication time and should not have been referenced.

In “Converging computing Methodologies in Astronomy”, Volume I 1996, Issue 38, pages 29-30, R. Molina’s (University of Granada) name was misspelled and the name of Andre Heck, of Strasbourg Observatory, was inadvertently omitted from the acknowledgments list. Our apologies.

Honors and Awards

Telescopes In Education Program Developer Honored

The Rolex Awards for Enterprise, presented by Montres Rolex S.A. every three years, are bestowed upon individuals who conceive and develop an original concept. Recipients are given cash awards for the continuation of their projects. Jet Propulsion Laboratory’s (JPL) Gil Clark received one of these coveted awards in Geneva, Switzerland, this past May for developing and managing the Telescopes In Education program for JPL and the Mount Wilson Institute in California. Clark, an engineer and staff member of JPL’s Educational Affairs Office, is one of five 1996 laureates. He was selected as the laureate in Applied Science and Invention.

The Telescopes in Education program began in 1992 as a volunteer effort, funded by loans and donations. This program allows students to use a research-quality telescope, via computers and phone lines, from the classroom. The students remotely aim the telescope and take digital pictures. They then enhance the received images on their classroom computers. Currently, more than 100 schools are regular participants, with about 100 additional occasional participants.

For further information about Telescopes in Education contact the JPL Teacher Resource Center at:

818-354-6916

1996 Software of the Year Awards

Computer software that helps scientists better examine geophysical and climatalogical data and software that provides solutions to aerodynamic problems in designing new aircraft are the winning entries for NASA's 1996 Software of the Year Award. Sponsored by NASA, the award is granted to individual(s) who develop software to enhance NASA's mission and assist the US aerospace industry in maintaining world-class technology. This year's recipients are the Linked Windows Interactive Data System (LinkWinds) software developed by the Jet Propulsion Laboratory, Pasadena, CA, headed by Allan "Bud" Jacobson; and the Tetrahedral Unstructured Software System (TetrUSS) developed by NASA's Langley Research Center, Hampton, VA, headed by Neal Frink.

LinkWinds is the world's most powerful viewer for scientific examination of geophysical and climatalogical data retrieved from satellite remote sensing. This software is a visual data analysis and exploration system that grew out of a research program to apply computer graphics to interactive science data analysis.

TetrUSS is an aerodynamic analysis and design system that is widely used throughout US industry, government, and universities to study aerodynamics and other problems in spacecraft, rotorcraft, automotive, turbomachinery, and medical analysis and design.

NASA will present the awards at the Technology 2006 Conference to be held in Anaheim, CA, this October. Recipients will receive a plaque and a substantial monetary award.

For further information about this software access the World Wide Web at:

http://www.hq.nasa.gov/office/codei/codeic.html

Excerpted from NASA press release 96-132.

Editors Note—*Readers are invited to submit special honors or awards received for group or individual achievements in work performed for the Science Information Systems Branch to sandi_beck@iplmail.jpl.nasa.gov*

Remote Sensing Techniques Used to Count "Marching" Men

On October 16, 1995, the "Million Man March" converged on the mall in Washington D.C. The National Park Service initially estimated the attendance to be approximately 400,000; an estimate that was challenged by the organizers of the march as a gross underestimate. Because of the brewing controversy, a physics professor at Harvard University contacted the Boston University Center of Remote Sensing to inquire if satellite remote sensing techniques applied to 35 mm photographs could be used to more accurately estimate the number of marchers. The answer was yes, so a team of geologists, geographers, and geographical information systems (GIS) experts was assembled, led by Farouk El-Baz, the director of the Center.

Approach and methodology

The team studied a videotape of the march and obtained digitized data from scanned color photographs taken by the National Park Service park police. After analyzing the photographs, the team determined that the best approach was to divide the mall area into a grid and estimate the number of people within each area based on a given crowd density. To build the grid, the mall area was measured using a scaled multispectral image. The crowd density was estimated based on different degrees of packing in each square meter, ranging from six people per square meter to one person per five square meters. The highest crowd density was estimated by simply drawing one square meter on the Center's lab floor to see how many people could easily fit inside. This number was then used for the most densely packed areas of the march, such as the Capitol area. The team relied on their practical experience in estimating tree numbers in the California forest and in counting sand dunes in the Kuwait desert, using remote sensing and GIS methodologies, to calculate the total attendees.

The result of the team's initial recount, based on the data used, was 878,587 attendees. With a 25 percent error margin, the lowest attendance was estimated at possibly 658,940 and the highest at possibly 1,098,234. In a secondary recount an additional set of photographs were developed by the Center's team from the original 35mm film obtained from the park police. These photos were then digitized using an instrument capable of resolving 5,000 dots per inch. Also, a photomap of the mall area, at 1-meter-per-pixel, was retrieved from the Internet. This geometrically corrected, vertical view of the area was used as a base. To overlay the grid on the photographs, it was necessary to translate the oblique views onto the vertical photomap. This was done by the time-consuming process of registering locations of fixed points, such as road intersections or corners of buildings, from the oblique view onto the vertical one. On average, each photograph required the registration 40 points from the digitized 35mm oblique view to the photomap.

In areas where computer-assisted enlargements of the 35mm photographs allowed the identification of individuals, a count was obtained by tagging each person's head or the top of his shadow. For example, at the Washington Monument, there were 3664 individuals. In most other areas, however, the crowd was so densely packed that it was impossible to distinguish individuals. In these cases, it was necessary to classify the density of people per unit area, and calculate the totals of similarly packed pixels. Again, the team assumed that six people could stand in one square meter, but used decreasing numbers in less packed areas—down to one person per 10 square meters in sparsely populated areas.

In addition to the use of original film negatives to obtain a better number, the main focus of the second count was to reduce the uncertainty factor as much as possible. The two factors controlling the margin of error were the exact boundaries of occupied areas of the mall and the variations in crowd density. For the second count, use of the negatives and the photomap improved both the resolution and the geometry of the images.

The next step was to accurately estimate the density of the crowd in various parts of the mall. This was accomplished using two methods. The first was based on defining the occupied area and then estimating the different densities within each pixel, by assigning a different color to each density. The total number of pixels for any particular region was then calculated and multiplied by the specific density for that region to obtain the number of participants. The second method consisted of utilizing GIS software, called GRASS, to create a 50 meter cell-grid and applying it to the registered images in order to estimate the density within each cell and then multiplying that by the cell size to get the crowd number. Both methods worked well, resulting in comparable numbers.

Results of the second estimate, based on the analysis of original negatives, was a count of 837,214 attendees, with an error margin of 20 percent—down by five percent from the first estimate. The error margin could not be further decreased due to inherent problems in the acquisition of the photographic data. This second estimate was widely reported by the media and seems to have gained general acceptance.

Explaining the discrepancy

Both the initial and secondary estimates achieved by the team were more than double that of the National Park Service. Following the team's first estimate, a meeting was convened to attempt to account for the discrepancy between the Center's estimation and that of the National Park Service. The theories and practices of crowd estimation used by both entities were discussed. It was determined that the park police calculated their numbers from 1) photographic enlargements of a videotape taken from a helicopter, 2) from the number of buses parked in the pre-designated lots, and 3) the excess of passengers on the metro system (above and beyond the normal Monday traffic).

Although 35mm photographs had also been taken, the processing time required was lengthy, which precluded using the photos as an estimation basis. Additionally, the helicopter had not been allowed to fly directly above the crowd, for safety reasons. Therefore, both the video and the 35mm photos were taken at oblique angles. The Smithsonian Institution buildings and the trees on the north and south sides actually hid vast areas of the mall at these oblique angles. Furthermore, no aerial photos were taken between 11:30 AM and 3:30 PM (the peak time of highest attendance was determined to be between noon and 2:00 PM). The result was use of a less than adequate data set.

Because of the problems with data acquisition encountered by the park police, it was agreed that videotape was not an accurate basis for estimating the Million Man March attendance. Subsequent to this determination, the negatives of the five, 36-exposure, 35mm films were offered to Boston University for use in their second estimate.

Lessons learned

From this exercise, valuable lessons in crowd estimation were realized. In order to accurately and efficiently estimate crowd size from photographs the photos have to be taken at hourly intervals using a fixed-wing aircraft looking straight down, with two systems on board: a digital camera with ground resolution equal to the size of an average person from the flying altitude and a conventional aerial photographic camera with 9x9 inch film to obtain high definition, stereo photographs for post-event analysis and archival purposes. Then data from the digital camera would be fed to a computer to tally the number of pixels with the specific spectral reflectance for a quick but reliable estimate.

For further information contact Farouk El-Baz at:

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Center for Remote Sensing,Room 433
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Boston, MA 02215
Phone: 617-353-5081

Excerpted from an article by Farouk El-Baz, first published in EOM, Geographic, Mapping, Earth Information, February 1996. *Farouk El-Baz helped establish the field of remote sensing by working on the selection of landing sites for the Apollo lunar missions. He is involved in using remote sensing data to locate ground water resources in desert environments.*

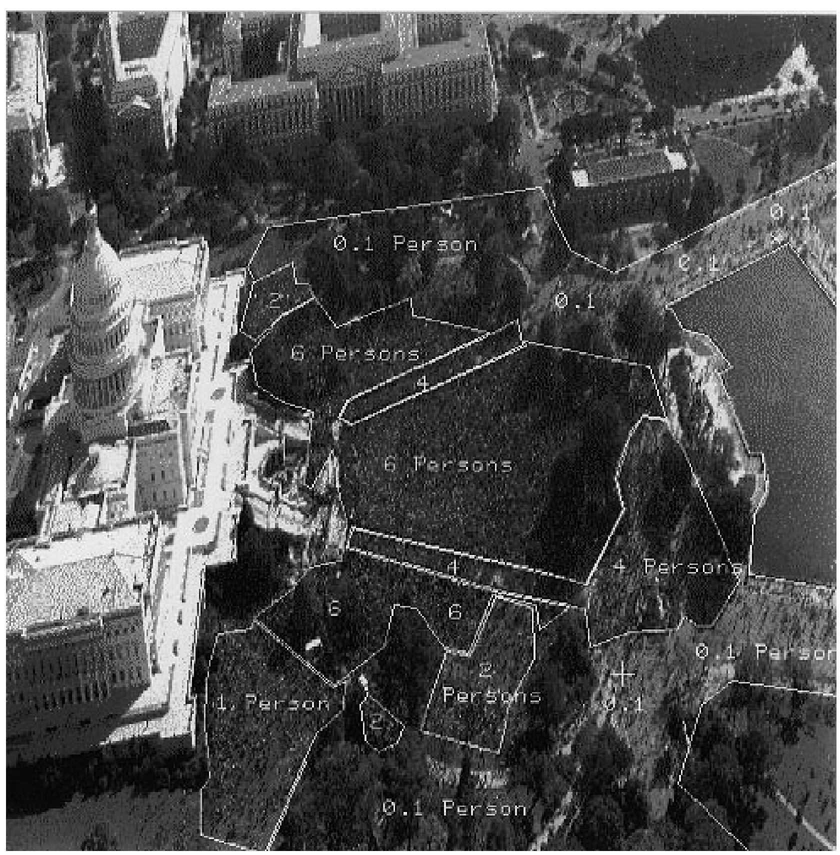

Photo map of the Capitol mall with a grid overlay to determine persons per meters.