First Quarterly Report under

USRA Contract No. 5555-08

for work towards development of

McIDAS-eXplorer - A Version of McIDAS for Planetary Applications

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SUMMARY

This is the first quarterly report on McIDAS-eXplorer, a version of McIDAS for planetary applications under USRA/CESDIS contract No.5555-08. USRA is supported by NASA under contract # NAS5-32337. Prior work under the effort has been described in progress reports under USRA/CESDIS Contract # 550-80 and NASA/GSFC Contract NAS5-31347 for the preceding two years respectively. This report summarizes the accomplishments of the first quarter of the final year of development of McIDAS-eXplorer.

One of the original goals of this effort is to have a software product that is portable and useable on different platforms. To this end we have begun the task of porting the McIDAS-eXplorer code to other platforms. Originally developed under the AIX operating system running on IBM RISC-6000 workstations, we have first ported the code to IRIX operating system running on a Silicon Graphics Indigo workstation. The task revealed several areas in the code where operating system differences were relevant and required modification of the code.

McIDAS-eXplorer was demonstrated at the Third Annual Applied Information Systems Workshop held in Boulder Colorado during August 1993. Plans are being made to demonstrate McIDAS-eXplorer at the 25th Annual meeting of the Division of Planetary Sciences, also being held in Boulder, Colorado during October 1993.

A brief article describing McIDAS-eXplorer has been submitted for publication in the NASA/AISRP newsletter.

Finally, an image created using McIDAS-eXplorer tools was highlighted in the November 1993 issue of the Earth magazine. The image was a color composite created from an earth orbiting weather satellite data (NOAA 11).

1. INTRODUCTION

This is the first quarterly report on McIDAS-eXplorer, a version of McIDAS for planetary applications under USRA/CESDIS contract No.5555-08. USRA is supported by NASA under contract # NAS5-32337. Prior work under the effort has been described in progress reports under USRA/CESDIS Contract 550-80 and NASA/GSFC Contract NAS5-31347 for the preceding two years respectively. This report summarizes the accomplishments of the first quarter of the final year of development of McIDAS-eXplorer.

Major accomplishments of this quarter include a first successful port McIDAS-eXplorer to a new operating system/workstation, the Silicon Graphics Indigo running IRIX. In order to validate the portability to other PC platforms a workstation capable of running UNIXWARE on an Intel based PC is being acquired. The code as developed should be capable of running under the OS/2 operating system (Versions 1.3 and 2.1) for IBM compatible personal computers as well, although the graphics display capability is currently limited to a proprietary display card capable of up to 16 frames of 256 colors in the 480 x 640 mode or the VGA/EGA display only.

We have received a fix for the CD-ROM drivers for the AIX operating system that finally enable us to read all of the PDS CD-ROM volumes. Prior to that CD's which utilized Extended Attribute Records (XAR's) could not be read under the AIX operating system on IBM RISC 6000 workstations, even though the CD-ROM volumes adhered to the ISO 9660 standard. Consequently access to the Magellan Global Altimetry, Radiometry and Topography datasets on the GxDR CD's was not possible until the corrective action. As a result, we have been able to develop new applications to provide access to these valuable data.

McIDAS-eXplorer was successfully demonstrated at the Third Annual Applied Information Systems Workshop held in Boulder Colorado during August 1993. Plans are being made to demonstrate McIDAS-eXplorer at the 25th Annual meeting of the Division of Planetary Sciences, also being held in Boulder, Colorado during October 1993.

Work performed using McIDAS-eXplorer received some media exposure recently as well. An image created using McIDAS-eXplorer tools was highlighted in the November 1993 issue of the Earth magazine. The image was a color composite created from an earth orbiting weather satellite data (NOAA 11). Figure 1 is a copy of the published picture in (black and white).

Also under consideration are plans for the distribution and support of the developed software for the user community. The target audience is NASA's planetary science community, and a probable distribution mechanism is through a site license to the Software Testing Laboratory expected to be set up at the University of Colorado, Boulder. The details on the transfere mechanism will be worked out in the next few months.

An abstract has been submitted for a NASA sponsored Workshop on Planetary Data Visualization to be held in San Juan Capistrano during November 1993. Tentative plans are being made to demonstrate McIDAS-eXplorer at this workshop.

Progress in specific areas is described below. Attached as Appendix I and II are abstracts of a paper submitted to the Division of Planetary Sciences Meeting to be held in Boulder, Colorado during October 1993 and for the NASA Workshop on Planetary Data Visualization.

Figure 1. A color composite image created using McIDAS-eXplorer depicting the floods in the midwest during July 1993 was published in ***Earth*** magazine in the November 1993 issue and is reproduced here in black and white.

Courtesy Sanjay Limaye, University of Wisconsin

On July 12, the Mississippi River was about to reach a 32.2-foot crest at Quincy, Ill. But flooding extended from southern Minnesota to St. Louis, as is clearly visible in this false-color image taken that day by the Advanced Very High-Resolution Radiometer aboard the satellite NOAA-11. Ordinarily, the river "would show up much thinner," according to Sanjay Limaye, the University of Wisconsin researcher who processed the image. Even parts of the river that do not look especially wide are about twice their normal width, he says.

The land surrounding the rivers also shows signs of the wet summer. "The ground is very green, which means there is a lot of greenery" despite the fact that the colors were chosen arbitrarily to represent both visible-light and infrared information, Limaye says. A spectral analysis of the image also shows that the ground in southern Minnesota and much of Iowa is covered with water. The yellow in the west represents low clouds. The yellow shape in Missouri is either mud or fog hanging low in river valleys. This was one of the few days in mid-July when the satellite's view of the river was not obscured by clouds.

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2. NEW SOFTWARE DEVELOPMENT

Several new applications have been developed for such tasks as providing access to the calibrated global data sets for altimetry, topography (surface slope and rms slope), radiometry (emissivity) that are found on the GxDR CD-ROM volumes MG_3001 and MG_3002. To provide access to the data collected from ground based telescopes, an application to import solar system planetary images and navigate them has been developed. Another application allows

the user to build a quick-look index for the data imported into a McIDAS-eXplorer workstation so that can be easily located and queried. These are described below.

GETGXDR

Some of the more valuable data compilations from the Magellan mission are the composite global datasets for surface elevation and slope and rms slope and emissivity data. GETGXDR allows importing these data a frame (1024 x 1024) at a time and to attach calibration and navigation data with it. The data inquiry options within McIDAS-eXplorer directly provide the user with values in calibrated physical units rather than just the raw data values.

GETFITS

GETFITS is patterned after the other McIDAS-eXplorer applications that allow a user to import data from PDS CD-ROM volumes for which the supplementary data is found in a FITS format header. Like other GETxxx applications the object is to provide access to the calibration and navigation to the end user. Unlike most of the planetary images the supplementary navigation data is not always available for the ground based images in a fixed format as the format varies with each observer. The key aspect of this application is the ability to link the ephemeris data such as the sub-earth and sub-solar point locations on the target object to the image under investigation using NAIF/SPICELIB toolkit. The only unknown for the navigation then is the orientation of the acquiring instrument itself that tells about the orientation of the spin direction of the target object as projected into the image plane. It is assumed that the data are preceded by a header that conforms to the FITS format and standards.

The source image can be either 1 byte, 2 byte or 4-bytes per pixel and the 2-byte data can be either unsigned or signed. Traditionally the 1-byte data is treated as unsigned integer data. The use of 2-byte real or 4-byte real data is discouraged as it requires conversion based on the native format and is not suitable for mixed mode data as is possible in the FITS format (label).

IMGINDEX

McIDAS and McIDAS-eXplorer store images in "numbered" files that minimizes the key-strokes required to enter a long file name. To browse through the acquired database of the images, a utility has been developed that allows the user to visually examine each image by creating a composite of thumbnail images of the areas into a new area that can be displayed on a single frame. The mouse and a programmable command are used to perform a user specified action on each of the images such as listing the contents of the image directory or its processing history or displaying it at full resolution on another frame. Typically up to 300 images from as many areas can be viewed at once in a 15 rows x 20 column grid on a frame size of 1024 lines x 1200 elements. Figure 2 shows an example. Such a display of the image contents of the workstations data sub-directories is useful index in locating a specific image for further analysis.

A separate command allows the user to determine which area a given browse image corresponds to and to initiate an application pertaining to that area such as a display on another frame, listing the directory, the Data Description Block, etc.

SUBPNT

This utility command computes the sub-observer and sub-solar points on a target solar system object (Valid NAIF id) from another observing solar system object (Valid NAIF id) for a given time in the target object's reference frame. The range between the two bodies is also computed. This is useful to compute the navigation geometry for an earth based telescopic image when the observation time (UT) is known. The only other quantity required for

navigation other than camera parameters is the orientation of the image with respect to the target object's spin axis (or more accurately, its projection in the image plane). For importing earth based telescopic images into McIDAS-eXplorer, a subroutine version of this application is called to compute the ephemeris for navigation purposes, and the command version can be used to plan observations.

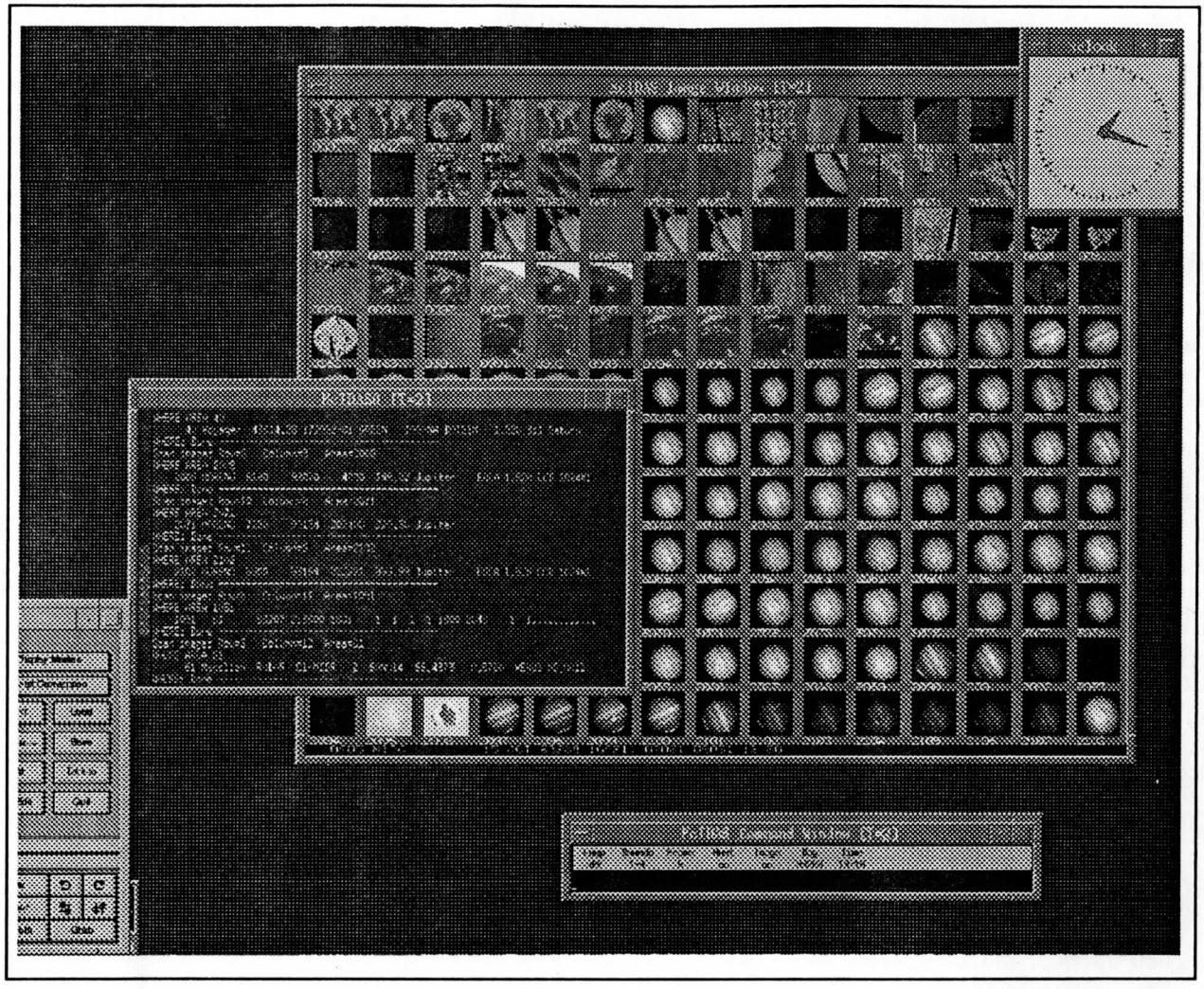

Figure 2. An illustration of the image index created from an inventory of solar system data imported into McIDAS-eXplorer using the IMGINDEX command.

LISZEN

This application allows the user to list the spacecraft or observer zenith angle and the solar zenith angle at a given location in a single navigated image or a consecutive sequence of images stored in McIDAS-eXplorer areas. The application can also be used to convert image co-ordinates into the target's native latitude-longitude system and vice versa. For Pioneer Venus images however the values may be obtained for only one image at a time from the command. However, the command can be used repetitively via the **REPEAT** command to list the values for a range of areas.

LODSSP

This is a macro command that is sequentially combines different McIDAS-eXplorer applications to perform the task of co-locating a sequence of frames at the center of the visible disk of a solar system target (sub-spacecraft point). The image location of this point is first obtained from the navigation information stored with each image and then issues the **DF** command to actually display the image on a user specified frame.

A keyword option allows the image to be centered in a new digital area instead of being displayed on a frame.

3. TESTING and PORTING of ALREADY DEVELOPED SOFTWARE

Testing of other application programs developed previously continues to ensure use with different datasets and on different versions of UNIX and for different end objectives. They are also being evaluated for consistency in terms of the user interface, use of keywords, and sufficiency of the user help text, both on-line and hard-copy. Current plans also include various tutorial sections in the user manual for processing of different planetary data.

Exercising the applications with different kinds of data and on different workstations is very useful in exposing any deficiencies in the working code and thus instrumental in making the code more useable, robust or portable as the case may be. Examples are the wide variety of targets or different source spacecraft for a given target such as Venus (Mariner 10, Pioneer Venus, Galileo, Magellan and ground based), and to ensure that the McIDAS-eXplorer applications and navigation and calibration work in the same manner despite the differences in the source sensors, imaging geometry and source data formats. Frequently any anomalies appear when an existing application is utilized on a new data type in a manner that may not have been fully anticipated.

4. GRAPHICAL USER INTERFACE DEVELOPMENT

As indicated in the previous report, we were evaluating three different approaches to developing a user interface as an additional means of user-system interaction besides the default command window. The primary motivation being to simplify the use of McIDAS-eXplorer for the benefit of novice users and also to improve the on-line user help facility. Based on criteria that include ease of use, ease of development and maintenance and visual appeal, the Tk-Tcl toolkit is being used as the main tool for creating the Graphical User Interface (GUI) for McIDAS-eXplorer.

The objective of the GUI is to present the user with a choice of actions or processes that can be performed on the data or the display merely by using the mouse/pointer motions and mouse clicks to make a choice from cascading menus. The interface in effect builds a McIDAS command from the user specified choice and transmits that to the McIDAS control program for execution. The command window is always active even while the GUI is being utilized. There are thus two means of interaction which cater to both the novice and advanced users.

One of the items in the selection offered to the user is to obtain help information about specific applications commands or to browse a glossary of terms. In future a tutorial section will be added to provide the users with on-line information and illustrations of how to proceed to attain specific data analysis objectives.

Figure 3 shows an example of a screen view showing several GUI windows created by clicking on corresponding buttons. One of the decisions to be made yet is exactly how and when to remove the windows created by the buttons when the corresponding task has been

completed--whether to close the GUI task window automatically upon completion of the task or leave it on in case the user may wish to repeat the task, and let the user close the GUI window.

5. DOCUMENTATION

There are primarily two areas of documentation--first is the documentation for the benefit of the end user and the second one for software engineers for the purpose of maintaining, modifying and adapting the code for future needs. So far the effort has been focussed only on the first objective with a view to enable as much of the end-user oriented documentation as practical and possible within the McIDAS context on-line. To achieve this the help for each of the commands is being evaluated for completeness, accuracy and clarity. For some of the more complicated applications some illustrative examples will be added. A separate text manual that could be used as a how-to guide is being written and will also be accessible on-line through the GUI.

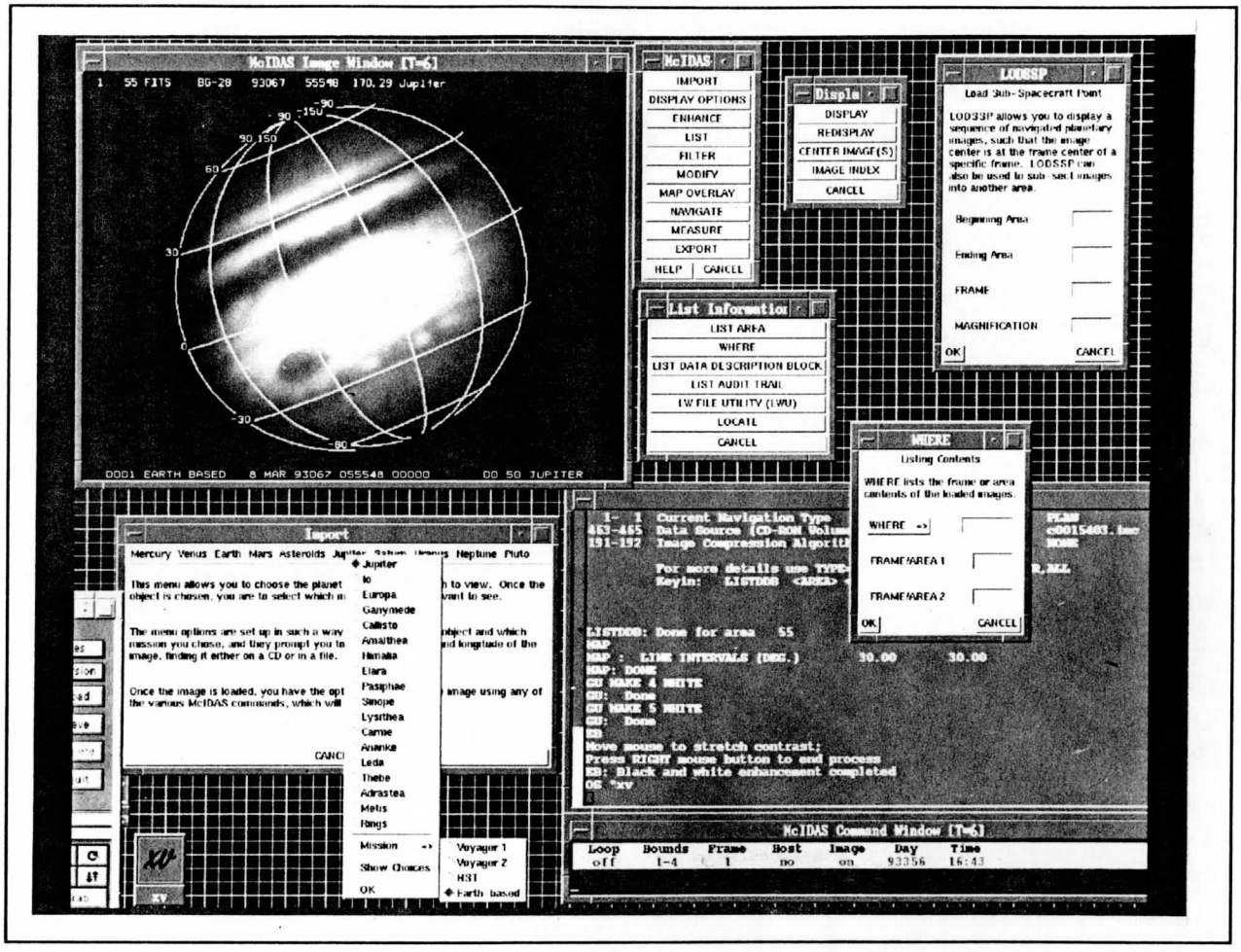

Figure 3. An illustration of McIDAS-eXplorer screen with command entry windows activated through the GUI.

As the new code development tapers off, a manual describing the developed code as well as some notes for future extensions will be created. This manual will not targeted at the end user, but only at software engineers responsible for maintaining the code once the project support is over.

In the coming months, the overall integrity of the product will be evaluated in terms of data access, analysis tools, user help, documentation. Finally, we will proceed to arrive at a workable distribution and support mechanism.

We anticipate a need for exercising the eXplorer software at an external site before general release to reveal any improvements that can be incorporated before the end of the project. A more significant consideration is how to provide a mechanism for continuing support for furure data products from new missions.

APPENDIX I

Abstract of the poster presentation on McIDAS-eXplorer for the Division of Planetary Sciences Meeting, Boulder, October 18-22, 1993 (Bull. Amer. Astron. Soc., **25**, 1063, 1993).

11.15-P

McIDAS-eXplorer: A Vehicle for Analysis of Solar System Data

S.S. Limaye, L.A. Sromovsky, R. Krauss, E. Wright, D. Santek, P. Fry (Space Sci. & Eng. Ctr, Univ. of Wisconsin-Madison) and R.S. Saunders (JPL)

McIDAS-eXplorer is a software environment being developed to provide access to and enable efficient analysis of geophysical data acquired about solar system objects. It is an enhancement of McIDAS-X (a toolkit directed at the terrestrial meteorological community for analysis of real-time weather satellite, conventional and forecast model output. McIDAS-eXplorer provides access to and enables investigation of data from the CD-ROM volumes published by the Planetary Data System from NASA's solar system missions and incorporates the SPICE subroutine library developed by the Navigation and Ancillary Information Facility (NAIF) at the Jet Propulsion Laboratory for the display, navigation, animation and analysis of planetary data on most UNIX workstations with X-windows support. Primarily intended for analysis of image data, the user extensible environment provided by McIDAS-eXplorer allows analysis of a wide variety of data with minimal effort in a multiframe (with overlay graphics), multitasking environment. Currently, tools are available for calibration, navigation and analysis of Voyager images of the giant planets and their satellites, Magellan radar and altimeter data, Viking Orbiter, Mars Mosaicked Digital Image Model data, and Galileo images. Tools are being added for access to and analysis of atmospheric profiles as well as spectral data such as Mariner-9 IRIS and Voyager IRIS observations.

This work is funded by Contract# NAS5-31347 from NASA's Applied Information Systems Research Program.

APPENDIX II

Copy of an abstract submitted to the NASA Workshop on Planetary Data Visualization to be held in San Juan Capistrano, California during November 1993.

MCIDAS-EXPLORER - A SOFTWARE ENVIRONMENT FOR VISUALIZATION OF SOLAR SYSTEM DATA; S.S. Limaye, D. Santek, L.A. Sromovsky, U. of Wisconsin-Madison, and R.S. Saunders, Jet Propulsion Laboratory.

McIDAS-eXplorer is a software environment designed to provide a capable means of accessing, analyzing, displaying and visualizing the data collected by missions to solar system targets as well as the earth[1]. Built as an extension to the X-windows version of McIDAS, the eXplorer environment is user extensible and is implemented on many different flavors of UNIX. McIDAS has been developed by the Space Science and Engineering Center of the University of Wisconsin-Madison with primary focus on providing an integrated interactive access to the meteorological data and model output collected by the weather satellites and conventional means, as well as to numerical model output[2]. It currently exists in three different versions- McIDAS-MVS for the mainframe system, McIDAS-OS2 for the OS/2 operating system for personal computers, and McIDAS-X for the UNIX workstations. The eXplorer version is compatible with both the X and OS/2 versions of McIDAS.

A prime objective of McIDAS-eXplorer is to provide access to the planetary data now available on nearly 200 CD-ROM volumes published by the Planetary Data System (PDS) and the US Geological Survey. These CD-ROM volumes contain image data collected by missions such as the Viking 1 and 2 Orbiters Voyager 1 and 2, Magellan Radar mission to Venus and the Galileo Orbiter still in transit to Jupiter. These data comprise all the planets except Mercury and Pluto as well as many of the planetary satellites and ring systems and soon, two asteroids. McIDAS-eXplorer provides a common approach to the access, analysis and display of the data on these different targets in terms of data manipulation and navigation.

McIDAS provides tools for three data categories- (i) graphic or image data (ii) gridded data and (iii) station data. The image data can be multispectral and have either 1 or 2-byte depth. The gridded data are distinguished from the image data in that the data values may be real (4 or 8-byte) and generally have dimensions smaller than the image data and may have missing elements. The station data are generally a single geographical location data vector with as many components as necessary. For the solar system targets, the first data type is the most prevalent form illustrated by nearly 60 gigabytes of solar system images contained on nearly 100 CD-ROM volumes and most McIDAS-eXplorer tools. These data are imported into the McIDAS environment and stored in files called 'Digital Areas' with an data block containing the particulars of the contents. The second data type is illustrated by low spatial resolution topography, gravity field data or numerical model output data and is stored within McIDAS in the form of Grid Files. Each Grid File can contain multiple grids of different quantities, and a Grid File Directory provides the access roadmap for the contents of the file. Simple arithmetic or 'spread-sheet' operations are possible with the grids from within McIDAS.

The third and the simplest data type is illustrated on the Earth by surface weather station observations or for solar system targets by infrared spectra acquired for a specific location. These types of data are optionally stored as Meteorological Data ('MD') files with data tagged by keywords or as a simple flat file with a directory structure. The MD file format allows database search and retrieval, as well as data editing functions.

These different data types can generally be visualized in a variety of ways, either as a two dimensional image, as a pseudo 3-D image in a perspective view, or even a stereoscopic display. In all cases, looping and animation helps the user in many respects immensely. Typically the atmospheric data is quite variable in the time domain so that time lapse observations are a key aspect of any analysis. McIDAS provides a means of displaying such time lapse data in a sequence of user controlled animated loops with each component frame providing full access to the original data in calibrated or uncalibrated units and navigation.

Users interact with McIDAS through a variety of means. A Graphical User Interface (GUI) is available that can be customized for specific tasks and is independent of the underlying program structure in the sense that the GUI can be changed without usually having to redesign the process itself. Experienced users usually prefer to interact with the system directly through a command window. McIDAS commands accept both positional parameters, as well as keyword oriented parameters.

The task of entering a sequence of commands that is used repetitively can be simplified through three different methods. The first method is to set up a string name with the commands to be used with the replaceable parameters identified explicitly. Then a single command can execute that sequence for the range of parameter values specified for the replaceable parameters. A second and more explicit method is to record the sequence of commands to be executed in a "batch" text file and then issuing the command to execute the batch file. A third means is to compile a macro command that can accept both standard FORTRAN statements for flow control and McIDAS commands and then execute that macro command.

McIDAS is a multiprocessing environment on all platforms with the number of processes limited only by the available resources. A typical UNIX workstation with 32 Mbytes of and a capable video board memory can run a McIDAS session with 16 frames of 1024 x 1024 in the full color mode. A high end workstation can support multiple McIDAS sessions either on the same workstation or via X-terminals. It is even possible to network a number of workstations in a ring and share the data. At the low end we have recently ported McIDAS to an Intel 486 DX2/66 MHz based PC equipped with a local bus video display card and a CD-ROM drive and running the UNIXWARE operating system. Except for the number of concurrent users supported, such a workstation is capable of being a satisfactory workstation for the individual scientist.

McIDAS-eXplorer has been developed under support from NASA's Applied Information Systems Branch.

[1] Limaye, S.S., L.A. Sromovsky, R. Krauss, E. Wright, D. Santek, S. Gorski, and R.S. Saunders: *A Vehicle for a Analysis of Solar System Data*, NASA Science Information Systems Newsletter, Issue 30, October 1993, *in press.*

[2] Suomi, V.E., R.J. Fox, S.S. Limaye, and W.L. Smith, 1983: A Modern Interactive Data Access and Analysis System: McIDAS III: *J. Clim. Appl. Meteor.*, **22**, 766-778.