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for work towards development of

McIDAS-eXplorer - A Version of McIDAS for Planetary Applications

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SUMMARY

This is the third quarterly report on McIDAS-eXplorer, a version of McIDAS for planetary applications under USRA/CESDIS contract No.5555-08 for the period January 16, 1994 - March 15, 1994. A prime highlight of this period is the demonstration of the eXplorer software at the 25th Lunar and Planetary Science Conference in Houston, Texas, March 14-18th, 1994.

With the end of the software development near, much of the effort has been spent towards validating the code on different platforms, testing with different datasets and getting user feedback on the functionality and useability of the code.

An article submitted to the Information Systems Newsletter describing McIDAS-eXplorer was published in the February 1994 issue.

In the remaining quarter we expect to concentrate on the delivery of the software and future support. We expect that a copy will be installed at the Software Support Laboratory at the University of Colorado in Boulder in the next quarter. It is likely that we will be able to demonstrate the final product at the Fourth Annual AISRP Workshop in Boulder likely to held this summer.

1. INTRODUCTION

This is the third quarterly report on McIDAS-eXplorer, a version of McIDAS for planetary applications under USRA/CESDIS contract No. 5555-08 for the period January 16, 1994 - March 15, 1994. 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 second quarter of the final year of development of McIDAS-eXplorer.

A major highlight of this quarter is the successful demonstration of the eXplorer software environment at the 25th Lunar and Planetary Science Conference held in Houston, March 14-18, 1994. An abstract was submitted to the Educational Activities session as a poster presentation. We demonstrated the software on a Silicon Graphics Indigo Extreme workstation which was set up in the exhibit area at the Lunar and Planetary Science Institute adjacent to the Johnson Space Center in Houston for the duration of the meeting. A number of conference attendees were able to sit down and try using the system themselves. As the meeting is primarily attracts geoscientists, the focus of the eXplorer demonstration was on access, browsing, display and analysis of the Magellan radar data collected at Venus. The Graphical User Interface used was received well by the audience.

The operability of McIDAS-eXplorer on different platforms has been a goal of this project from the beginning. Besides the SGI and IBM RS-6000 workstations, the core McIDAS-X software has been ported to HP and Sun workstations and hence the explorer portion can also be used on those workstations. The port to the UNIX on a PC platform, UNIXWARE from UNIVEL has been somewhat of a disappointment in terms of operating system peculiarities and support of graphics cards. The effort required to support this particular operating system has been considerable and is now deemed to be unaffordable, at least in the short run, until either the operating system itself matures and more support is available from the vendor. We have briefly looked into the use of an alternate UNIX implementation on a PC platform, the LINUX operating system which is in the public domain. Some portions of the PC-McIDAS have been ported, but once again the support of high end graphics cards is minimal and it is not known whether the eXplorer software could be effortless ported. For lack of sufficient resources, the work has on porting the software to the UNIX on Intel chips based machines has been at least temporarily halted.

Some progress has been made in the use of the other 32-bit operating system on Intel chip based computers, the OS 2 Version 2.1. Previously running McIDAS under OS/2 required the use of a special video display card which was available only for the microchannel bus. Under OS 2/2.1, the Presentation Manager is now used as the display environment. Thus any high end graphics card that has drivers for OS/2 2.1 can be used for running McIDAS on any bus- microchannel, ISA, EISA or the local bus variants, VL and PCI. The only remaining tasks is the porting of the GUI's which require Tk-Tcl to be available for the OS/2 2.1 operating system.

A brief article describing McIDAS-eXplorer previously submitted to the Information Science Newsletter has been published in the February 1994 issue. A copy is attached in the Appendix.

SOFTWARE DEVELOPMENT

A few new applications are being added to the eXplorer suite. One application allows an eXPlorer image data file to be exported in a PDS compatible format, e.g. with a fixed length record text header followed by the image data. One only need to ensure that the fieldnames used to describe the data belong to the PDS Data Dictionary.

A frequent need is to be able to print an image being processed or analyzed directly to a post script printer or convert it to another graphics format for post processing such as annotation or cosmetic editing. There are many public domain programs available to accomplish the latter. A utility is being provided to export the image data directly from disk into a commonly recognized format so that it could be converted to any desired format without having to display it within eXplorer. Previously the only ability to produce graphical image files was with the SAVGIF command which translates a displayed frame into a .gif format file.

Improvements are being made to the suite of image navigation commands. One of the strengths of eXplorer is to be able to handle multiple navigation types for a given image type simultaneously. Thus one can determine the spacecraft based celestial coordinates (Right Ascension and Declination) of any point in the image (assuming the proper pointing information is available of course), and with a change of navigation type also access the planet centered coordinates for the same point if the image contains for example a full disk view of an object and some space around it. This can be useful in determining the celestial positions of an object such as a moon or a satellite in the same frame that contains a portion of the parent object. Another application is for ringed planets where the navigation type can be switched from ring navigation (not yet implemented) to planet based navigation frame.

Along with the navigation frame choice, the user also has a choice of how to perform the image navigation. If the SPICE kernels are available, they are usually the default means to navigate the image. For other images lacking these kernels, the SEDR or other pointing data can be used along with the limb information to determine the planet center and to determine the equivalent kernels. The tutorial section accessible on-line from within eXplorer is being enhanced to show the different choices available.

One of the more often used applications is a data base creation, editing and listing utility command for tabular numeric or character based data. Typical databases of interest are the indices for the Planetary Data System CD-ROM volumes. These typically can also be imported into some common PC based database programs. However, for UNIX platforms such programs are not very common. The DBU and DBL commands provide the capability to take a database and its associated index or template file and create import the database into eXplore and to browse/search it based on the specific fieldnames.

This ability allows a user to select the images from the index prior to using a command to import specific images from the CD-ROM into the eXplorer environment. As the data could be of any type, as long as it is tabular, the same structure and commands can be used to select images based on SEDR or pointing data. An example using the Voyager 1 catalog from one of the PDS CD-ROM volumes is shown below.

HELP DBL to learn about the usage of how to make a query from a data base file

```
DBL - data base listing
DBL file KEYS= "sort

PARAMETERS:
         file  | file to access data from
KEYWORDS:
         KEYS  | list of keys to print values for.
                     To get a list of the keys available type:
                DBU KEYS 'file'.
        "sort  |list of sort conditions
```

HELP DBU to learn about how to obtain the fieldnames

```
DBU - data base utility

DBU option file
PARAMETERS:
OPTIONS:
LIST  - list file configuration information
       KEYS  - print list of valid key names for the db file file    - file to operate on
```

DBU LIST voyager1.mdb to list information about a database file

```
DB FILE: voyager1.mdb
----------------------------------------
VERSION NUMBER
NUMBER OF RECORDS                                          2500
CREATION YEAR                                              1994
CREATION MONTH                                                4
CREATION DAY                                                 26
CREATION TIME                                            203351
LAST UPDATED YEAR                                          1994
LAST UPDATED MONTH                                            4
LAST UPDATED DAY                                              6
LAST UPDATED TIME                                         03355
NUMBER OF BYTES PER RECORD                                   75
NUMBER OF KEYS PER RECORD                                     2
NUMBER OF GLOBAL VARIABLES
OFFSET TO BEGINNING OF KEYS                                  12
OFFSET TO BEGINNING OF GLOBALS                             1776
OFFSET TO BEGINNING OF DATA                                2800
MEMO FILE:                                     Voyager1.mdb.mmo
ARRAY FILE:                                    voyager1.mdb.arr

DBU:  DONE
```

DBU KEYS voyager1.mdb to list the fieldnames associated withe the database file

```
DB FILE: voyager1.mdb
GLOBAL VARIABLES
-------------------------------------------
CDROMNAME                CDROM name
CDROMNUM                 CDROM number
VARIABLES
-------------------------------------------
SCNAME                                  Space Craft Name
MSNPHSNM                                Mission Phase Name
TARGETNAME                              Target Name
IMAGEID                                 Image ID
IMAGENUM                                Image Number
IMAGETIME                               Image Time
EARTHRCDTM                              Earth Received Time
INSTRNAME                               Instrument Name
SCANMODEID                              Scan Mode ID
SHTRMODEID                              Shutter Mode ID
GAINMODEID                              Gain Mode ID
EDITMODEID                              Edit Mode ID
FILTERNAME                              Filter Name
FILTERNUM                               Filter Number
EXPOSUREDU                              Exposure Duration
NOTE                                    NoteSMPLBITMSK   Sample Bit Mask
DATAANMTYP                              Data Anomaly Type
IMAGEVOLID                              Image Volume ID
IMAGEFILNM                              Image File Name
BROWSVOLID                              Browse Volume ID
BROWSFILNM               Browse File Name
DBU:  DONE
```

DBL voyager1.mdb KEYS=TARGETNAME IMAGEID IMAGETIME FILTERNAME EXPOSUREDU "TARGETNAME=EUROPA to list images of Europa, and the time when they were taken

```
EUROPA    1445J1-059  1979-01-06T07:21:22Z  CLEAR  0.960000
EUROPA    0797J1-055  1979-01-09T22:42:59Z  CLEAR  0.960000
EUROPA    0850J1-048  1979-01-16T23:25:23Z  CLEAR  0.960000
EUROPA    0229J1-035  1979-01-29T15:08:35Z  CLEAR  0.960000
DBL: done
```

DBL voyager1.mdb KEYS=IMAGEVOLID IMAGEFILNM IMAGEID IMAGETIME FILTERNAME EXPOSUREDU "TARGETNAME=EUROPA to also list the CD-ROM volume name and the directory in which these images can be found on that CD-ROM volume

```
VG_0013    [EUROPA.C1464XXX]C1464330.IMQ 1445J1-059  1979-01-06T07:21
VG_0013    [EUROPA.C1475XXX]C1475242.IMQ 0797J1-055  1979-01-09T22:42
VG_0013    [EUROPA.C1496XXX]C1496335.IMQ 0850J1-048  1979-01-16T23:25
VG_0013    [EUROPA.C1534XXX]C1534314.IMQ 0229J1-035  1979-01-29T15:08
DBL: done
```

APPENDIX

Copy of an article published in the February 1994 issue of the Science Information Systems Newsletter

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FEATURES

The Earth Data System and the National Information Infrastructure Testbed

Carol A. Christian, Center for EUVE Astrophysics, University of California, Berkeley and Stephen S. Murray, Smithsonian Astrophysical Observatory and CM Science Innovations

The National Information Infrastructure Testbed

The National Information Infrastructure Testbed (NIIT) is an industry-led consortium of commercial, academic and government institutions formed expressly to develop a prototype, nationwide infrastructure to study and demonstrate distributed computing applications. NIIT testbeds will address actual applications specifically to gain and share experience in creating, and operating such infrastructure.

NIIT participants are primarily motivated to enhance the competitiveness of industry specifically related to distributed computing and information access and use through this cooperative effort. The knowledge gained through the NIIT is expected to enhance the U.S. role in the rapidly developing field of information systems. The NIIT distinguishes itself from other groups related to the NII by integrating existing technologies to deploy and study real infrastructure applications. Note that by including users in the development of the NIIT infrastructure, the feasibility of creating and marketing high-performance networking and distributed computing resources can be evaluated. The formation of the NIIT cooperation arose out of the expression of common interests in high-performance distributed computing environments demonstrated at Supercomputing '92.

The Earth Data System

The first reference application identified for a demonstration by NIIT addresses the problem of global environmental change. Environmental researchers must consider the interplay between various complex systems that comprise the environment, which affect changes in the biosphere.

Earth data research is specifically founded on the location of, acquisition of and analysis of large, heterogeneous datasets. These data are stored in many different archives that are geographically distributed, ranging from large, government archives of satellite imagery with full data management and access services to small, field datasets under the control of an individual scientist. Examples include the Landsat imagery at the University of New Hampshire, ocean data (color and temperature product. The position of objects relative to each other or within the frame can be edited along with the object's size and surface properties (e.g., color, shininess, and transparency). Components that affect the whole scene can also be edited such as lighting and viewpoint (camera position).

In addition to the above features, any of the possible adjustments to the scene can be animated, including the parameters that generate the visualizations. Animation is specified by setting what are called keyframes. Keyframes specify what certain "key"frames of the animation should look like. The tool uses interpolation methods to generate the frames in between the keyframes. A keyframe is set at the beginning of an animation specifying how everything should appear initially. Another keyframe is then set at some later time specifying how things should look then. For example, an object might be shown from the front in the first frame and then from behind in a later frame. The viewing position in between keyframes is then automatically interpolated. When all the frames are played, the object would appear to rotate. More complex animations would involve the use of a number of keyframes.

Obtaining the software

The general Explorer modules and the GEMVIS modules for Explorer or AVS mentioned above may be freely obtained from the anonymous ftp server at the National Center for Supercomputing Applications. The address is ftp.ncsa.uiuc.edu and the directory is /SGI/PATHFINDER. Please see the README files there for additional information. For additional information the Mosaic URL is: http://redrock.ncsa.uiuc.edu/PATHFINDER/aisrp93/talk.title.html.

For other questions contact Robert Wilhelmson at: (217) 244-6833.

McIDAS-eXplorer: A Tool for Analyzing Solar System Data

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McIDAS-eXplorer is an extension of McIDAS—the Man Computer Interactive Data Access System, an environment for analyzing weather data. Besides the eXplorer version, McIDAS currently exists in three different flavors—McIDAS-X (for X-Windows under UNIX, the version upon which the eXplorer has been primarily developed), McIDAS-OS/2 (for the OS/2 operating system, largely compatible with the UNIX version) and McIDAS-MVS (for older mainframe computers using the MVS operating system). Here, when only the term "McIDAS" is used, the reference is to capabilities in all flavors of McIDAS, and when a suffix is used, the text refers to the capabilities of that specific version only.

The objective of McIDAS-eXplorer is to bring to the planetary community the tools that the terrestrial meteorological community has been using to analyze weather data and model output. While planetary data published by the Planetary Data System (PDS) on CD-ROM volumes are the primary source of solar system data acquired from spacecraft missions, ground-based and telescopic images of the planets are also accessible and manipulable via McIDAS-eXplorer.

McIDAS was inspired by the need to have better means of analyzing the torrent of data from the geosynchronous weather satellites and to measure cloud drift winds. McIDAS has been ported to UNIX and OS/2 operating environments and can be used on IBM RISC 6000, Silicon Graphics, Sun and Hewlett Packard workstations running the respective vendor's version of UNIX.

The software implementation of the McIDAS control program allows use of McIDAS in field experiments wherever and whenever some means of communication link to a McIDAS host site is feasible. For example, McIDAS was used to chart the flight paths of the research aircraft based in Bahrain to sample the smoke from the oil well fires in Kuwait. McIDAS is currently used by the National Meteorological Center for routine weather operations and is at the heart of weather-related activities for the space shuttle operations. It is also used by weather services in Australia, Spain, and China and provides real-time weather support to one of the most remote sites in the world—McMurdo station in the Antarctic—over an Internet link to Madison, Wisc. The National Science Foundation/National Center for Atmospheric Research-sponsored UNIDATA project uses McIDAS for educational programs in nearly 100 atmospheric science departments of colleges and universities in the U.S.

McIDAS-eXplorer

McIDAS-eXplorer is an extension of McIDAS capabilities for use with data obtained by NASA's missions to solar system targets. The principal goals are to provide target-specific tools to analyze planetary data and to use the SPICE library developed by the Navigation and Ancillary Information Facility (NAIF) team at JPL for image navigation.

Planetary data span a large range in terms of quantity, type and global coverage. The strength of McIDAS is in its ability to interact with satellite data for geophysical applications such as multispectral imagery, surface network data, and atmospheric soundings. One of the goals of McIDAS-eXplorer has been to provide a unified approach to the analysis of target-dependent data by accounting for the differences in their physical characteristics such as size and shape. To this end, the NAIF approach of assigning a unique identification tag to each object (and spacecraft) is adopted within McIDAS-eXplorer with some enhancements for atmosphere-bearing bodies. These enhancements allow use of different radii for solid surfaces and various levels in the atmosphere and are important in dealing with objects such as Venus or Titan.

Although McIDAS-eXplorer is general enough to be utilized for most types of data, its strength lies in its ability to manipulate and analyze multispectral images or data that can be visualized as a two-dimensional image. Other data such as from station observations from irregularly spaced sites or numerical model output can also be manipulated conveniently within McIDAS. Atmospheric vertical profiles, spectra, and Magellan altimeter profiles are examples of different data that can be analyzed within the McIDAS environment.

Implementation

McIDAS differs from most other image display and analysis environments in that it is a multiprocessing, multiframe intelligent display environment. In fact, to the user, McIDAS functions as a pseudo operating system, providing some of the basic functions of an operating system. Further, it provides the user with a pass-through connection to the operating system to send and execute native (operating system) commands. McIDAS allows for multiprocessing, such that while one user application is being executed, others can be invoked as needed; it is limited only by the hardware capabilities and resources available. The frame intelligence derives from the fact that the system "knows" the key data attributes of the data (navigation, calibration and physical location in the system's database) displayed in different frames, and this information is available to the application programs and the user.

McIDAS is designed as a dynamic environment so that new applications can be developed and released for use even in operational situations (e.g. mission support). McIDAS uses a unified approach to data calibration, navigation, and display with a common interface both to the user and to the software applications for different data and different solar system objects. The approach it takes and the capabilities enabled are summarized below.

McIDAS-eXplorer enables use of the SPICE kernels for image navigation and also provides tools to determine the navigation transforms when the kernels are not available but the basic image geometry information, namely the trajectory and pointing information, are available. In this case, full or partial disk images containing at least some portion of the bright limb can be navigated by finding the limb points, the image center, and the navigation transform from the supplementary data. Images from the older missions, such as Viking Orbiter, and the bulk of Voyager imagery fall in this category.

Most spacecraft data undergo several specific processing steps; some are mandatory such as radiometric or geometric calibration, and many others are optional such as creating a map projection or multispectral classification. For post-processing analysis, it is useful to maintain a processing history record for the data that contain enough information to inform the user of what was done to the data. For image data, McIDAS-eXplorer maintains an audit trail in which applications programs append an entry containing all the command parameters that were invoked in

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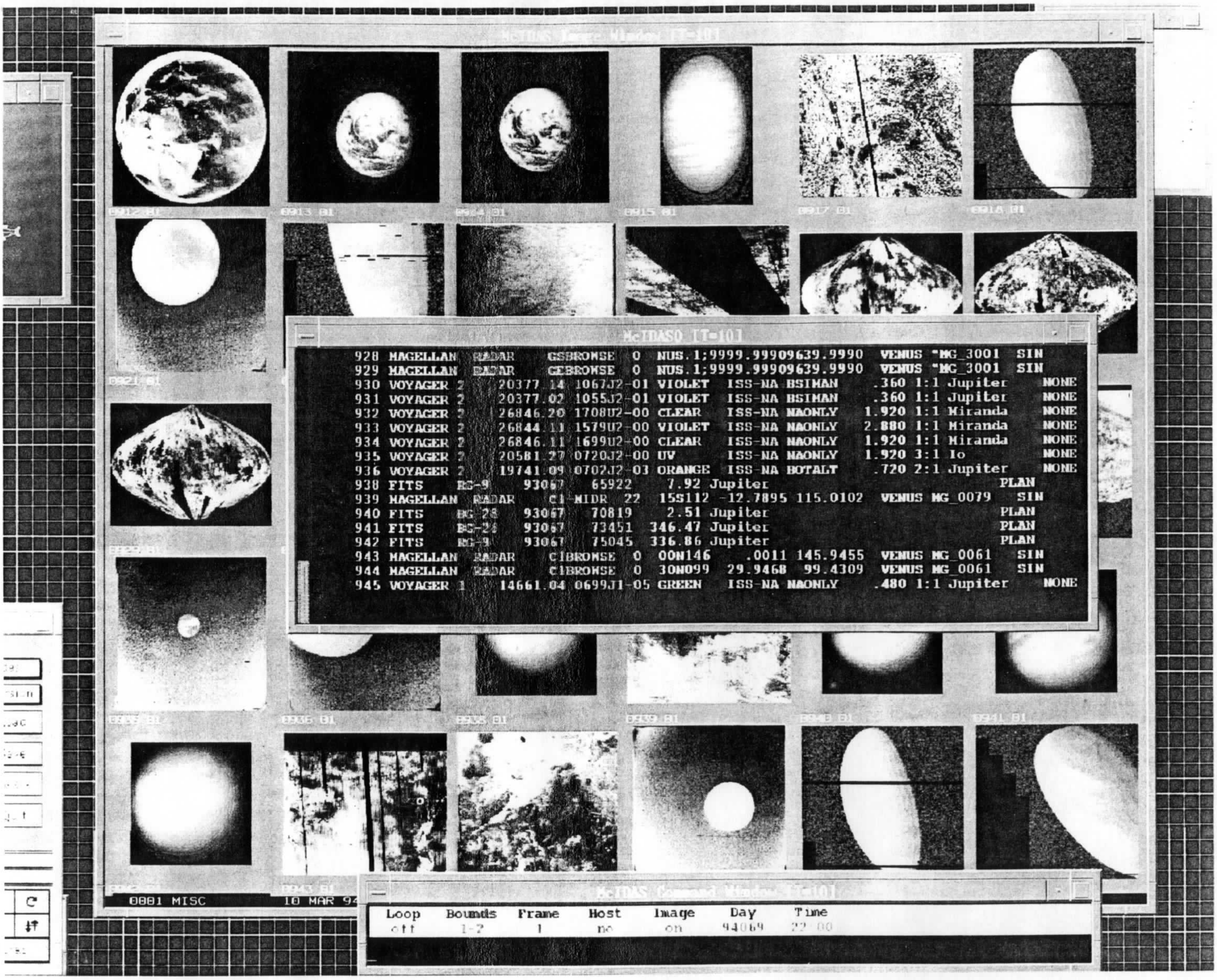

Figure 1. McIDAS image display window

that particular processing step. This processing history can be queried either by the user or by other programs to determine the processing status.

McIDAS display screen

The display frame contains much more information than just the visible image in the McIDAS environment. For each frame that contains an image, McIDAS keeps track of the image source, its calibration, and, most important, the navigation. Overlay graphics can be drawn that can also be dynamically saved in independent graphics files for redisplay later. The overlay graphics can be either merged with the image data or drawn as "peelable" graphics or transparency overlays, allowing the user to peel off and on the graphics with a single key stroke. Figure 1 shows a view of the McIDAS display illustrating the image display window with overlaid graphics, a command window, and a text output window. The figure shows a browse view of some of the data imported into a workstation in a single frame. More information about the data can be obtained by using other McIDAS tools by clicking on each of the thumbnail images in the overview frame.

McIDAS-eXplorer user interface

At its core, McIDAS and McIDAS-eXplorer are command-driven and not menu-driven. A certain familiarity with the command syntax is thus necessary until users become proficient. To eliminate the need to learn the syntax of different commands, a graphical user interface (GUI) has been developed for McIDAS-eXplorer so that both text or command line and a GUI are available.

The command line and the GUI are supplemented by function keys and single letter key strokes to communicate with McIDAS-eXplorer. The function keys are user-programmable to fit

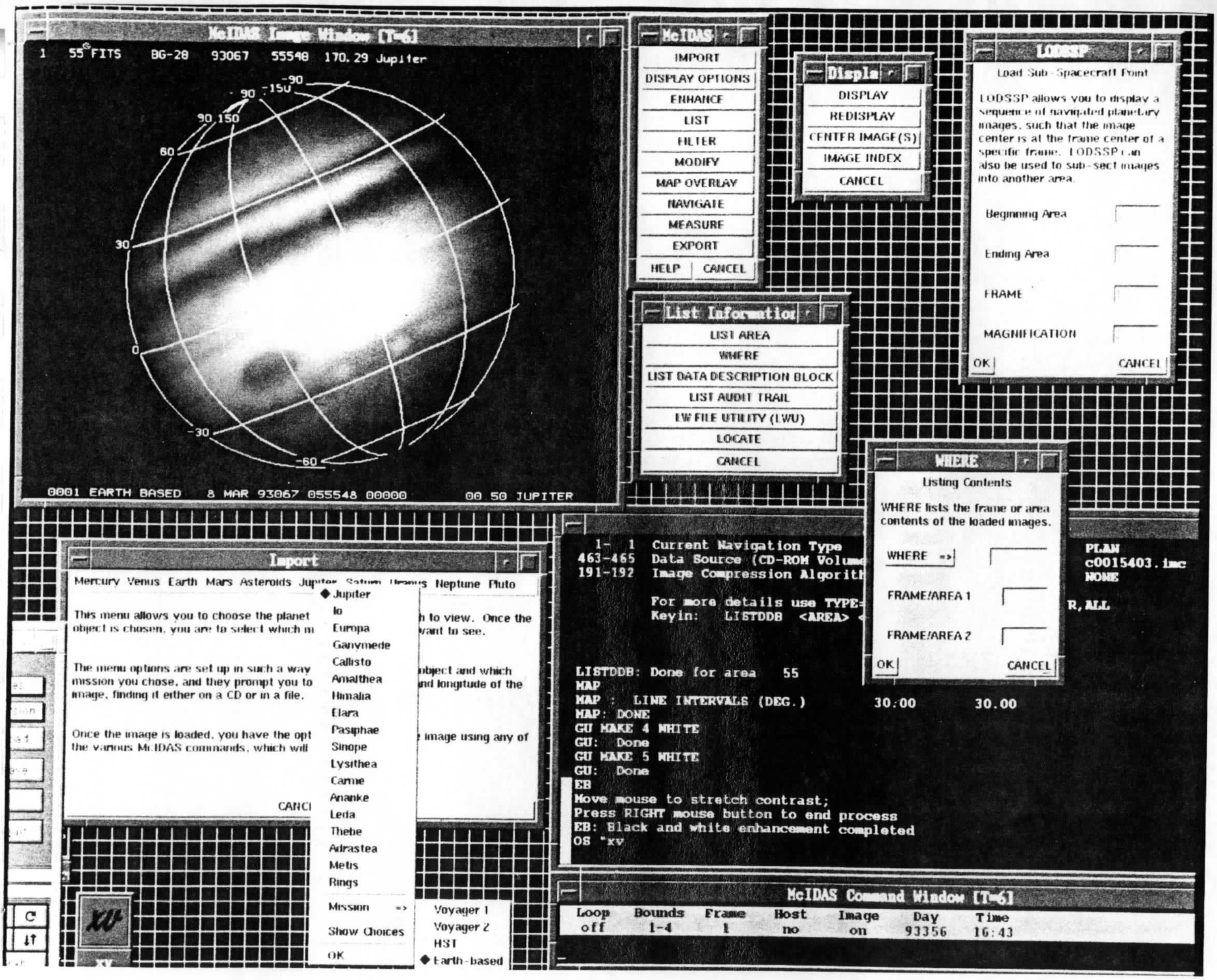

Figure 2. An Earth-based telescopic image of Jupiter with an overlay latitude/longitude grid and a view of available GUIs

context-specific application needs and can be saved and restored via "string tables" that characterize the workstation context. A specific function key menu can also be created by the end user for a specific purpose.

Pipeline processing of data can be accomplished directly as well. A McIDAS application program can start the execution of another existing application, either synchronously or asynchronously as desired. Implementation of such an application by the end user is possible if the user is comfortable writing a FORTRAN or C language program with the benefit of the McIDAS applications programming manual and some knowledge of McIDAS.

Tools

A variety of tools are available to manipulate the data within McIDAS-eXplorer. For solar system image data, these include geometric and radiometric calibration, filters of various types, navigation and cartographic projections, image enhancement, multispectral classification, time series analysis, area and distance measurements, and cross sections. Map outlines and gazetteer files provide the ability to visually identify the geographic features. General-purpose utility applications provide housekeeping functions and data migration.

Two-dimensional irregularly spaced data can be objectively analyzed onto grids, and gridded data themselves can be graphically displayed via contour plots and cross-section plots, as well as rendered into images. A basic spread sheet capability allows arithmetic operations on the gridded data to compute other derived quantities. Spectral data can be displayed, averaged, and staged for further processing as desired for temperature retrievals or other analysis.

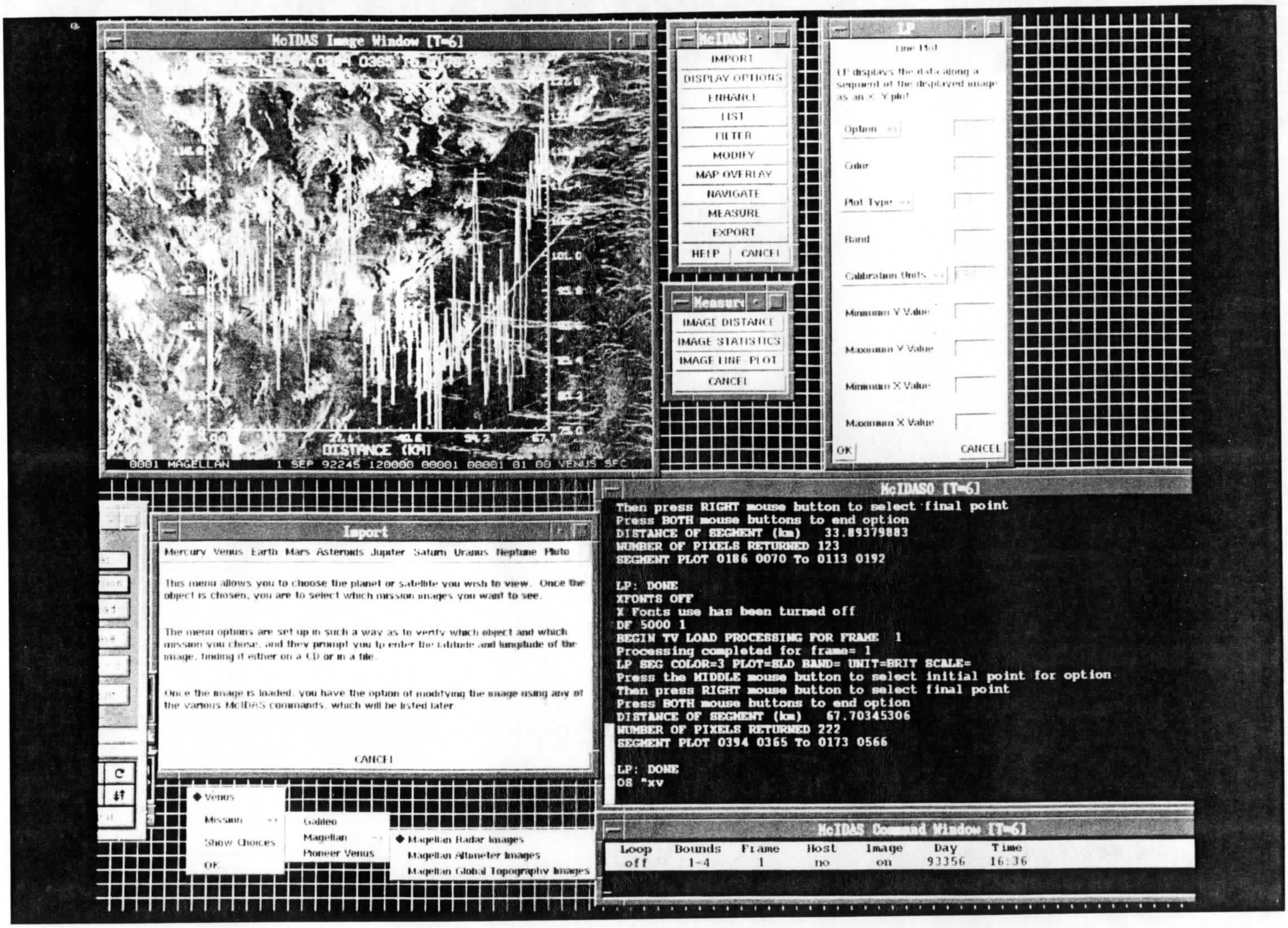

Figure 3. A line plot between two arbitrary points in a Magellan SAR frame

Currently McIDAS-eXplorer is able to import, process and analyze planetary images from PDS CD-ROM volumes, as well as images from most routinely available weather satellite images and Earth-based telescopic images in the Flexible Image Transport System (FITS) format. These include Voyager images of the giant planets and their satellites and Magellan SAR images of Venus' surface; the Pioneer Venus Orbiter Cloud Photopolarimeter and Galileo images of Venus can be calibrated (shading and geometry) and navigated. Support for other data products such as those from the Clementine, Mars '94 and Cassini missions should also be possible once the data are available. Support for navigation of irregular objects, such as asteroids and the smaller moons and ring systems will be added as resources permit. Once these data are imported within McIDAS-eXplorer, they can be gridded, map projected, animated, brightness normalized and filtered. Three-color composites and multispectral classifications of up to six bands are possible. Calibrated and navigated image data can be used for areal cloud motion and other measurements using general tools.

Figure 2 shows an example of an Earth-based telescopic image of Jupiter with an overlay latitude-longitude grid and a view of some of the GUIs available. Figure 3 shows a line plot between two arbitrary points in a Magellan SAR frame that shows the variation of the radar reflectivity (dB) along the path between those two points.

McIDAS-eXplorer requires a copy of McIDAS-X, which is licensed by the Space Science and Engineering Center at the University of Wisconsin- Madison. For further information contact the author at: (608) 262-9541; sanjayl@ssec.wisc.edu