Annual Report on CESDIS Contract SL 550-80

McIDAS-eXplorer: A Planetary Version of McIDAS

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SUMMARY

This annual report summarizes the progress made towards a planetary version of McIDAS, the interactive data access system developed at the Space Science and Engineering Center of University of Wisconsin-Madison. The second year of development marks completion of major development towards providing access to the solar system data collected by space missions for scientific analysis and visualization. An appropriate name for this software environment, which has been primarily developed under the X-windows environment on UNIX workstations is McIDAS-eXplorer.

The basic goals set early in the effort, those of providing access and tools for the data published on CD-ROM volumes by the Planetary Data System (PDS) and devising a flexible graphical user interface are now nearly achieved, at least in terms of the infrastructure. The next years' effort is directed towards completion of the documentation of the applications, the software libraries, the Graphical User Interface, and delivery mechanisms.

McIDAS-eXplorer will be demonstrated at the Third Annual Applied Information Systems Research Program Workshop in Boulder, Colorado to be held in early August 1993. Plans are also being made to present McIDAS-eXplorer at the 25th Annual Meeting of the Division of Planetary Sciences also to be held in Boulder during October 1993.

1. INTRODUCTION

The basic goal of the effort is to develop a portable software environment for the access, analysis and visualization of planetary data collected by NASA's space missions and published by the Planetary Data System (PDS) on CD-ROM volumes. Nearly one hundred and fifty such volumes containing nearly 100 Gbytes of data are now available containing data on solar system objects such as planets from the Earth to Neptune, most planetary satellites and ring systems, and soon, two asteroids (Gaspra and Ida). These data have been collected by the Viking, Voyager, Magellan and Galileo missions, and for the most part represent image data. While some tools to display the images on most computer systems are available, the tools to access the navigation and calibration data and for manipulation of the data are generally not available in a single integrated system. The result has been that almost every planetary scientist has had to develop software as needed. The result has been that the software is very data and usually mission specific and generally not very portable or easily maintainable. McIDAS-eXplorer, offers the planetary community a capable, user extensible system that is portable, has a graphical user interface for ease of use and yet the convenience of a direct command interface, provides access to calibrated and navigated data that can be displayed on a workstation and animated with or without overlaid graphics.

We have made progress in accessing some of the newer Magellan CD-ROM volumes that contain Extended Attribute Records (XAR's). These CD-ROM volumes were supposed to be readable on most operating systems. Unfortunately in the AIX environment on IBM RISC 6000 workstations this is not the case and the data cannot be accessed. We have reported the problem to the vendor and made our CD-ROM reader accessible to the cognizant IBM office in Austin, Texas for debugging use over Internet. We have also sent that office one of the CD-ROM volumes with the XAR's and a fix to the operating system is expected soon from IBM very shortly.

The progress made in the last year in specific areas such as basic system software development, application program development, Graphical User Interface development and documentation is described below. A short article has been submitted to the Applied Information Systems Newsletter for publication in the August 1993 issue. As part of the documentation a user guide is being prepared and attached as an Appendix.

2. BASIC SYSTEM SOFTWARE DEVELOPMENT

A key feature of McIDAS is the use of a flexible data directory structure. McIDAS-eXplorer exploits this flexibility for solar system data by extending the directory structure to a Data Description Block (DDB) for each specific data type. The DDB has some commonalty with instrument type across missions, especially for framing cameras. The DDB also allows McIDAS-eXplorer to convert the raw data to calibrated units and to be aware of the specifics of the relevant particulars of the data such as not only the date and time of acquisition, but camera filter, exposure, data mode etc. The DDB structure is now defined for all the major data published by PDS as well as for some other data not available through the PDS such as Pioneer Venus Orbiter images and earth based telescopic images. Figure 1 shows some examples of the DDB contents for Magellan radar, Voyager, Viking and Pioneer Venus images.

Figure 1. Examples of the Data Description Block (DDB) attached to each area containing a planetary image. Pioneer Venus and a Magellan image particulars are illustrated in these two examples.

```
McIDASO [T=6]
LISTDDB ——> Listing of McIDAS-eXp Data Description Block for Area 5000
========================================================================

Spacecraft and Instrument Block:
--------------------------------
129-130  Data Description Block Type/Version              DDBOMGN
131-132  Data Type (S/C Image, Data, Map Proj)            MAGELLAN
133      Spacecraft ID (DSN/NAIF Code)                    -18
           (Spacecraft is Magellan Orbiter)
135-136  Instrument ID (Name)                             RADAR
137-138  Image Type                                       C1-MIDR
139-140  Picture Location                                 15S077
141      Tile or Framelet Number                          1
142      Number of First Orbit                            2658
143      Number of Last Orbit                             2752
147-148  First Orbit Ascending Node Time (hh:mm:ss)
149      Frame Size (in scan direction)                   1024
150      Frame Size (in cross-scan direction)             1024
151-152  Side Looking Direction (L,R,X,S,M)               RIGHT
153-184  Spare
191-192  Image Compression Algorithm                          NONE

Central & Picture Body Block:
-----------------------------
193-195  Central Body Name                                    VENUS
196      Central Body (NAIF Code)                         299
197-199  Picture Body Name                                VENUS
200      Picture Body (NAIF Code)                         299
201      Picture Body Rotational Period (hrs.)            5835.84
204      Nominal Picture Body Eq. Radius (km)             6051.90
205      Nominal Picture Body Pol. Radius (km)            6051.90
206      Nominal Picture Body Cross-Eq. Radius (km)       6051.90
207-209  Spare
210      Picture Body Eccentricity  SQRT(e2-p2)/p         .300000E-08
211-256  Spare

Imaging Geometry Block:
-----------------------
257-257  Map Projection Type                              SIN
260      Image Scale Factor (km/pixel)                    .225000
```

```
McIDASO [T=6]
Imaging Geometry Block:
-----------------------
257-257  Map Projection Type                              SIN
260      Image Scale Factor (km/pixel)                    .225000
261      PROJSAMP                                         4096
262-263  Projection Longitude                             77.3689
264-265  Image Center Latitude                            -8.42695
266-267  Image Center Longitude                           69.6484
268-269  Image LAT_UL                                     -7.33720
270-271  Image LAT_UR                                     -7.33720
272-273  Image LAT_LL                                     -9.51670
274-275  Image LAT_LR                                     -9.51670
276-277  Image LON_UL                                     68.5714
278-279  Image LON_UR                                     70.7689
280-281  Image LON_LL                                     68.5217
282-283  Image LON_LR                                     70.7316
284-352  Spare
```

```
McIDASO [T=6]
LISTDDB 1005 ALL


LISTDDB ——> Listing of McIDAS-eXp Data Description Block for Area 1005
========================================================================

Spacecraft and Instrument Block:
--------------------------------
129-130  Data Description Block Type/Version              DDBOCPP
131-132  Data Type (S/C Image, Data, Map Proj)            RAW S/C
133      Spacecraft ID (DSN/NAIF Code)                    -12
         (Spacecraft is Pioneer Venus Orbiter)
135-136  Instrument Mode ID                               OCPP
137-138  Image Type
139      Number of Scan Lines                             814
140-141  Scan Sample Rate                                 .610352E-03
143-181  Spare
182      Eccentricity of Orbit                            .820014
183      Inclination of Orbit to Ecliptic                 104.781
184      Ecliptic Longitude of Ascending Node             23.7390
185      Argument of Periapsis                            167.132
186      Orbital Period                                   23.9980
187      Semi-Major Axis of Orbit                         39455.0
188      Ecliptic Latitude of Periapsis                   12.4352
189      Ecliptic Longitude of Periapsis                  207.075
190      Altitude from Target Center at Periapsis         7101.35
191-192  Image Compression Algorithm                      NONE

Central & Picture Body Block:
-----------------------------
193-195  Central Body Name                                Venus
196      Central Body (NAIF Code)                         299
197-199  Picture Body Name                                Venus-C1
200      Picture Body (NAIF Code)                         2999
201      Picture Body Rotational Period (hrs.)            108.000
204      Nominal Picture Body Eq. Radius (km)             6120.00
205      Nominal Picture Body Pol. Radius (km)            6120.00
206      Nominal Picture Body Cross-Eq. Radius (km)       6120.00
207-209  Spare
211-256  Spare
```

```
McIDASO [T=6]
Imaging & Map Projection Geometry Block:
----------------------------------------
257-258  Map Projection Type (Roll-by-Roll, Proj)         RL-BY-RL
259      Date Scan Begins                                 82037
260      Time Scan Begins                                 44300
261      Orbit Number                                     1158
262      Date of Last Periapsis                           82037
263      Time of Last Periapsis                           14149
264      Ecliptic Latitude of S/C Spin Axis               -88.2240
265      Ecliptic Longitude of S/C Spin Axis              223.718
266      Navigation Spin Period Default from File         12.9683
267      R.M.S. Deviation of Spin Periods                 .573723E-01
268      Length of Scan (sec)                             10556.2
269      Commanded Look Angle                             124.000
270      True Look Angle                                  123.944
273      Roll Angle Code 1 (Position at Beginning)        67
274-275  Contact Time 1 (sec)                             16380.6
276      Roll Angle Code 2                                68
277-278  Contact Time 2 (sec)                             18136.3
279      Roll Angle Code 3                                69
280-281  Contact Time 3 (sec)                             19330.8
282      Roll Angle Code 4                                70
283-284  Contact Time 4 (sec)                             20538.4
285      Roll Angle Code 5                                71
286-287  Contact Time 5 (sec)                             22330.2
291      Contact Code (First or Last)                     2
292      Contact Sector                                   732
293      Roll Contact Mode                                71
294      High/Low Mode Code                               1
295      Gain State (HIGH or LOW)                         9
298      Roll Pixel Correction                            -11
306-352  Spare

User Computed Quantities Block:
-------------------------------
353-354  User Block Type                                  MEXP-CPP
355-435  Spare
436      Minnaert Fit Max DN Value                        148
437      Minnaert Fit Slope Constant                      .665762
438      Minnaert Fit Intercept Constant                  119.672
439      Minnaert Fit Mean Absolute Deviation.            .476869E-01
440-460  Spare
```

Figure 2 shows how the DDB structure allows querying the system to determine the data inventory in a context sensitive manner.

```
AREA#       Identification of the Image imported into the area
____
   52 Pioneer 12  1462  2291     0    110.8090      .0000      7.0608      13.129
   53 Magellan  RADAR     C1-MIDR   1   15S077  -8.4270  69.6484  VENUS MG_0078
   54 Magellan  RADAR     C1BROWSE  0   15S077 -14.9716  77.3688  VENUS MG_0078
   55 FITS     BG-28   93067   55548  170.29 Jupiter
   69 FITS                 1       0  196.04 Neptune
   88 MORENO  3700     93069   22750  230.75 Jupiter     EOCA 1.52M CCD 1024X1
   89 MORENO  6350     93069   24423  220.74 Jupiter     EOCA 1.52M CCD 1024X1
   90 FITS             93067   55654  170.29 Jupiter
   96 Pioneer 12     0  1211     0     97.6684      .0000     11.5447      13.184
   97 Pioneer 12     0  1182     0     97.6497      .0000     11.8578      13.060
   98 Pioneer 12     0  1185     0     97.6259      .0000     11.8547      13.073
  101 Magellan  RADAR     F-BROWSE  0  35N077  35.0003  76.7801  VENUS MG_0080
  102 Magellan  RADAR     C1BROWSE  0  30S117 -29.9445 117.4310  VENUS MG_0079
  104 Magellan  RADAR     F-BROWSE  0  35N077  35.0003  76.7801  VENUS MG_0080
  105 Magellan  RADAR     C2BROWSE  0  60N15323 24.62502022.0250  VENUS MG_0061
  125 Magellan  RADAR     F-MIDR.  19  05N070   5.7276  69.3144  VENUS MG_0009
  141 Magellan  RADAR     C2-MIDR  19  60N033  66.1411   7.9239  VENUS MG_0061
  142 Magellan  RADAR     C1BROWSE  0  30N099  29.9468  99.4309  VENUS MG_0061
  145 Viking 1 Orb54276386     462S33        CLEAR
  147 Viking 1 Orb54276365     462S12        CLEAR
  166 FITS     7250    93120  212236  141.64 Jupiter
  168 FITS     6190      238   12228  999.99 Jupiter
  193 Magellan  RADAR     C1-MIDR  34  15N077  12.7922  71.7747  VENUS MG_0078
  201 FITS     BG-28   93067   55548  170.29 Jupiter
  202 FITS     BG-28   93067   55654  170.29 Jupiter
  203 FITS     RG-9    93067   61201  170.29 Jupiter
  204 FITS     RG-9    93067   61255  170.29 Jupiter
  211 FITS     BG-28   93067   70615    3.76 Jupiter
 1615 Pioneer 12  1462  2291     0    110.8090      .0000      7.0608      13.129
 1616 Pioneer 12  1462  2291     0    110.8450      .0000      7.0608      13.129
 1617 Pioneer 12  1461  2291     0    127.5848      .0000      2.8811      13.129
 2100 MORENO  8900    93134  202900  170.29 Jupiter
 2101 MORENO  8900    93153  233158  170.29 Jupiter     EOCA 1.52M CCD 1024X1
 2102 MORENO  8900    93154  222221  170.29 Jupiter     EOCA 1.52M CCD 1024X1
 2103 MORENO  8900    93154  234100  170.29 Jupiter     EOCA 1.52M CCD 1024X1
 5000 Magellan  RADAR     C1-MIDR   1   15S077  -8.4270  69.6484  VENUS MG_0078
 5001 Magellan  RADAR     C1BROWSE  0   15S077 -14.9716  77.3688  VENUS MG_0078
 5002 Magellan  RADAR     C1-MIDR   2   15S077  -8.4270  71.8542  VENUS MG_0078
 5003 Magellan  RADAR     C1-MIDR   4   15S077  -8.4270  76.2659  VENUS MG_0078
```

Figure 2. An illustration of a listing of the variety of images imported into McIDAS-eXplorer that provides quick location of the different data available for analysis. Each line lists some pertinent information about the image such as the source, wavelength, date and time of acquisition, exposure, source CD-ROM volume identification, etc.

3. APPLICATION PROGRAM DEVELOPMENT

New application programs have been added to the eXplorer toolbox for applications such as distance measurements, determination of the Minnaert photometric function, removal of the limb darkening, ephemeris computation, image navigation and filters and dynamic display of data at the cursor. These are described below.

BRTCEN

BRTCEN accomplishes two tasks. First, it finds a guess object center by determining the center of brightness, and second, it determines the locations of the limb points by locating the points where the radial brightness gradient from the guess center is maximum between two azimuths at a given angular spacing. For full disk, full phase images the center of brightness is a fairly good guess for the target image center. The agreement worsens as the phase angle increases or when the image contains only a partial view of the target. The sky brightness is estimated from the brightness histogram and is not used for the brightness center calculations. The line and element sampling and the brightness range to use for the center of brightness can be specified on the command line to override the default values.

DSTNCE

This application allows the user to measure distances in physical units on any displayed image which has been navigated between multiple pairs of points in the image or along a multi-segment path. The target identification is based on the Data Description Block (DDB) attached to the image area. The physical parameters for the object are obtained from a call to eXplorer subroutine BODCON and allows for differentiating between radii for solid surface and different atmospheric levels for objects bearing extended atmospheres.

FILTER

A general application program to digitally manipulate the spatial frequencies in an image by means of a variety of digital filtering options has been developed. The object is to provide access to all The options to apply filters to images include the ones more commonly used such as High Pass, Low Pass, Laplacian, Sobel Edge detection, Smoothing and Median frequency filters. Other options such as Fourier, Kalman and Wiener are being added.

IMGCTR

In most planetary analysis the planetary images needs to be navigated first. The first step in image navigation is to locate the center of the target object in the image space. **IMGCTR** is an application that facilitates this task by determining the center from the bright limb locations which have been previously recorded in a limb points file (LIMBxxxx, where xxxx is the area number). The limb locations themselves can be determined from one of two distinct methods-- using **LIMBPT** to locate the limb by the method of the maximum rate of change of brightness along a line or a column of the image, or, by using **BRTCEN** to determine the limb location by determining the location where the derivative along a radial direction from a guess center location. The guess center location is found as the center of brightness and works well for full disk images. For partial disk images the guess center can be specified manually or found iteratively using **BRTCEN** and **IMGCTR** commands in sequence.

IMGNAV

Once the image center has been found from the bright limb, or by other means and entered into the DDB for that image/area, the navigation transform can be completed by attaching the ephemeris data to it. For earth based images this essentially means that the location of the sub-earth and the sub-solar point on the target object and the distance to the sun and the earth be known to the navigation utility programs. These quantities are computed using the NAIF/SPICE library routines for the observation date and time attached to the image (and stored in words 5 & 6 of the image/area directory).

For spacecraft images it is the spacecraft-target geometry at the time of the image acquisition that is required and this information is usually provided as part of the mission's data. For the new missions such as Galileo, this data can be found in the PDS label on the CD-ROM volume itself. For the older images the SEDR data is found in SEDR files also provided by the flight project. For the Voyager images (all Uranus and Neptune images and for a limited number of images of Jupiter and Saturn and their moons) the pointing information is available as SPICE kernels. For such images **IMGNAV** is not required as other commands read the SEDR or SPICE kernels and provide the required information to the navigation programs within McIDAS-eXplorer.

LIMBPT

LIMBPT command allows the edge points for an image to be determined interactively from a displayed image and stored in a limb points file (LIMBxxxx, where xxxx is the area number). The edge points are determined as local maximum directional derivative locations for the brightness distribution in the image in a 3 x 3 neighborhood about point. If the bright limb is located within each image then this algorithm will find the limb location. In the original version of this command the points were found within the cursor dimensions as located on the image display. In the eXplorer version the size of the cursor is limited to 63 x 63 due to X window restrictions. Consequently the edge points are now determined for the entire area or within a box specified by LIN and ELE keywords. The command is meant to be used interactively and allows for addition, deletion and listing/plotting of the found points. The file format is the same as that used by **BRTCEN** command and recognized by the **IMGNAV** and **IMGCTR** commands.

LINPLT

LINPLT allows the data along any two arbitrary points in the displayed image to be extracted and plotted as a line plot of distance vs. data value on the displayed frame. The data is plot in the native units except if the image displayed is a Magellan MIDR product image, in which case the raw DN's are shown unless the unit is specified explicitly (UNIT=DB) when the command is entered. The reason for this exception is that the calibration of MIDR data from raw DN to calibrated radar brightness is somewhat time consuming.

If the image displayed is navigated, then the physical distance along the path is expressed in km, otherwise in image pixels and is formatted according to the resolution of the image data.

LODSSP

For animation or other purposes it is desired to display a registered sequence of images in a loop. For most imaging systems the pointing of the camera is such that the target image is seldom at precisely the location in the image coordinates. Thus if a sequence of images is displayed with the same image coordinates for all the frames, the target image will in general move from frame to frame. To discern any change in the images the human eye requires that the target image be "frozen" in the frame. This can be done when the coordinates of the target image center (which is coincident with the sub-observer point on the target for far encounter observations) for each frame are known. LODSSP is a macro command that obtains the image center (or more specifically the sub-spacecraft point location) from the DDB for each image and displays each image on successive frames such that this point is always at the same frame coordinate. The default location is the frame center. Optionally, the images can be permanently registered in this manner by exporting them to new areas using LODSSP. The images can be either magnified or scaled down by an integer factor either for display or for exporting to a new area.

MINFIT

The gross brightness variation in a full or partial disk planetary image obtained in reflected sunlight is due to the variation of the scattering geometry-- the incidence and viewing angles, also called "limb darkening". This variation masks the variation in the reflectivity distribution over the planet. On occasion it is desired to visualize these reflectivity variations alone, devoid of the scattering geometry variation. TO accomplish this the contribution due to the scattering geometry can be removed if the scattering function is known. There are several theoretical and empirical models of the scattering from planetary surfaces. Chandrasekhar H-functions, Hapke function, Buratti function and Minanert law are a few of the models that are generally used for this purpose. The Minnaert law is an empirical model based on symmetry of incidence and reflection directions and can be used for most applications:

$$I\mu = I_0 \, \mu\mu^{\beta} \text{ or:}$$
$$\ln(I\mu) = \ln(I_0) + \beta * \ln(\mu\mu_0), \text{ where:}$$

I: Observed intensity
I_0: A constant, called normal albedo,
μ: cosine of observer zenith angle,
μ_0: cosine of solar zenith angle, and
β: a constant.

If the actual target behaves as a Minnaert surface, then the plot of $I\mu$ vs. $\mu\mu_0$ on a log-log scale should be a straight line, with I_0 determined from the intercept and β being the slope of the linear fit. The applicability of the law is thus self evident over the $\mu\mu_0$ limits by the linearity of the distribution and can be determined from the image either by least squares regression or by a robust fit. The quality of the linear fit is given by the regression coefficient or of the robust fit. MINFIT uses this scheme to determine the Minnaert coefficients (intercept, slope and measure of the quality of the fit) by both methods.

If the image data is "perfect", devoid of any noise, then the regression and the robust fits will generally be very close. Most imaging instruments however contain sufficient "noise", both systematic and random. To the degree that such noise is present in the image data, the regression and robust fits will differ somewhat, and generally the robust fit being superior.

MINFIT stores the Minnaert coefficients in the DDB for that image for later use for removal of the brightness variation using **NRMIMG**.

NRMIMG

NRMIMG removes the limb darkening due to scattering geometry variations using the Minnaert law. Ideally the "normalization" of brightness should be done as a multiplicative process. However, the inadequacies of a good scattering model lead to some anomalies in the output brightness at high zenith angles. For cosmetic reasons an additive correction is applied in **NRMIMG** such that the departure from the predicted intensity in the original image is added back to a constant brightness. The output image can be contrast stretched linearly during this process. The Minnaert coefficients are picked up from the DDB for the source area and can be overridden by specifying them on the command line.

PIXVAL

PIXVAL is an experimental command that constantly runs in the background once started and displays the digital data value at the cursor center location in the displayed image constantly. The data display is constantly updated as the cursor is moved or when a new frame is brought into foreground. The cursor coordinates and the calibrated data value is also displayed so that this process accomplishes the same purpose as the "E" and the "D" key commands.

SUBPNT

SUBPNT computes observing geometry (the sub-earth and sub-solar coordinates and ranges) for a given image assuming the time attached to the image is the correct UT when the image was originally acquired. The NAIF planetary constants file and ephemeris files must be available for this command (leapseconds.ker, pck3mod.tpc and de118cd.bsp files must exist in the ~mcidas/data sub-directory). The values are stored in the DDB slots for those quantities and the navigation transform is computed so that the image navigation is accessible to the McIDAS-eXplorer applications. The image must be displayed after the IMGNAV command has been executed so that the frame directory contains the latest navigation state.

4. USER GUIDE DEVELOPMENT

The User Guide being written has been expanded to include not McIDAS-eXplorer command summaries that expand on the on-line help available to the user. Eventually the Guide would include short tutorials on analysis of different planetary data. Initially this guide is intended to be available as a hard copy in the development phase and later, when most of the development is near completion, on-line. A copy of the current draft version is attached as Appendix II in this report.

5. GRAPHICAL USER INTERFACE

Previously a function key-based and a Motif based GUI has been considered to make McIDAS-eXplorer more amenable to novice users. Further development has been deferred until a more portable and easy to maintain environment has been identified. Specifically, we based GUI that should be easy to maintain and be portable. Figure 4 shows an example of a screen visible to the user when importing Voyager images from PDS CD-ROM volumes. Once the user has made the appropriate choices a command structure is created and transmitted to the McIDAS control program for executtion.

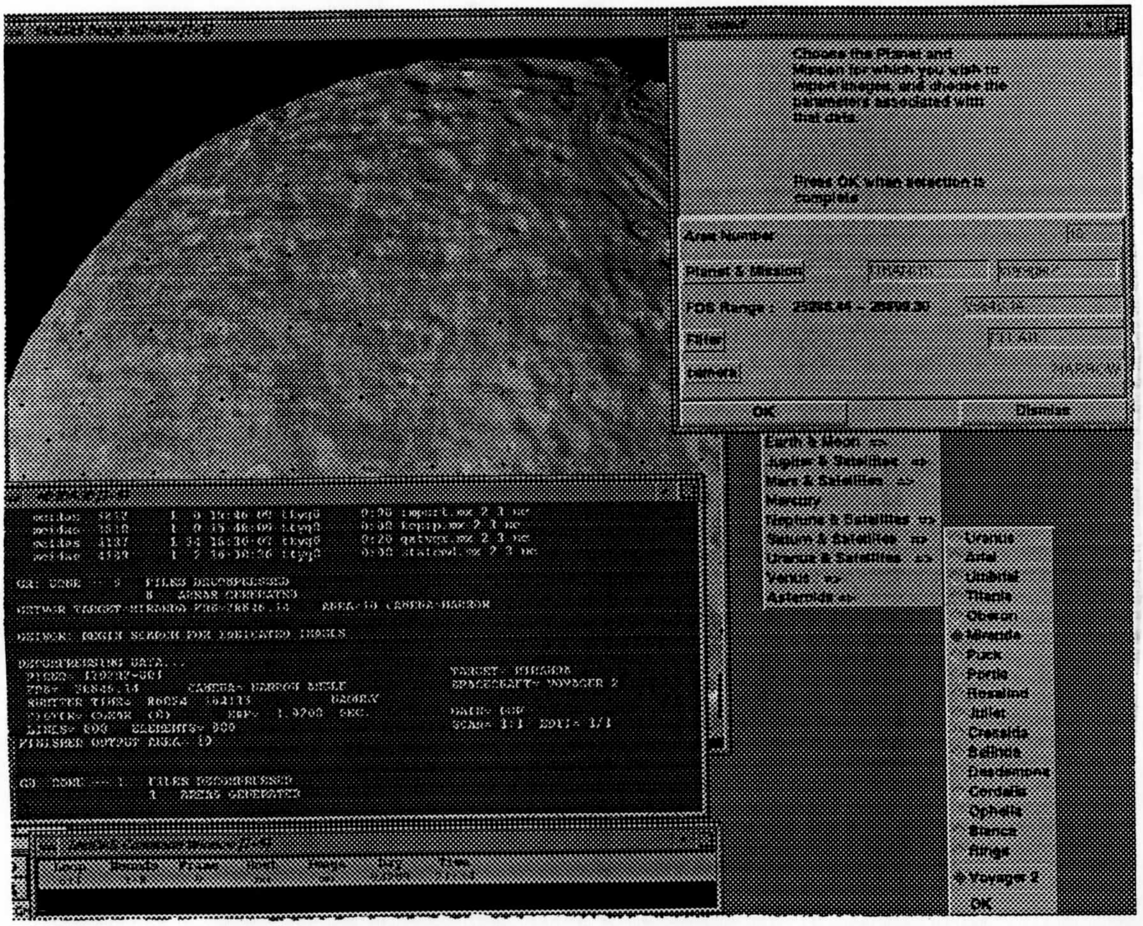

Figure 4. An example of a GUI created for assisting importing of images from PDS CD-ROM volumes. The user makes selections through mouse movements and mouse clicks which builds a specific McIDAS-eXplorer command which is then executed.

6. PORTING TO SILICON GRAPHICS WORKSTATIONS (IRIX)

All of the new development has been focussed on the AIX operating system using the IBM RISC-6000 workstation. As McIDAS-eXplorer is meant to be portable to different UNIX workstations, we have begun porting and testing of the code under the IRIX operating system using the Silicon Graphics Indigo Workstation (XZ4000) equipped with the XZ buffer. The graphics card on this workstation allows full 24-bit display enabling three color composites.

Initial experience has been that the basic code is portable although compiler and linker differences in the two operating systems require that some of the code could use some improvements in terms of portability. In future we expect to test new code simultaneously under the two different operating systems.

There has been one advantage of the IRIX operating system over the AIX in that the drivers for the CD-ROM volumes published by PDS are compatible with the extended attribute records (XAR's) that have posed a problem with the AIX operating systems. Consequently we are able to access data from all the PDS CD-ROM volumes on the SGI workstations, for which a fix is expected from IBM soon. To speed up the access to the CD-ROM data a Pioneer DRM604X 6 CD changer is being utilized which has a 600 kb/s transfer rate which is 4 times the normal rate. We have been able to modify the SCSI drivers for the IRIX to be able to access this changer.

7. SUMMARY

This annual report has summarized the progress during the second year of development of the planetary version of McIDAS, now being called McIDAS-eXplorer version. We have accomplished the basic goal of developing and adapting core McIDAS applications and tools to access, analyze and display/animate planetary data being published by the Planetary Data System (PDS) on CD-ROM volumes. The code is expected to be useable on UNIX and OS/2 workstations from different vendors such as IBM, Silicon Graphics, Sun and Hewlett Packard at the end of the development phase. One more year of work is planned to (i) complete the access to most of the planetary data, including some earth based and other spacecraft data such as Pioneer Venus and newer missions such as Galileo and Mars Observer, (ii) develop a better GUI (iii) completion of the User Guide (both hard copy and on-line), (iv) documentation of the code developed, and (v) prepare a release package.

It is anticipated that the next year's funding may be under a different contract number and the progress reports will be submitted accordingly.

APPENDIX

Draft of the McIDAS-eXplorer User Guide

Scanner's note:

There are no more pages in this document.