CR-189382

Final Report for work performed under

USRA Contract No. 5555-08

towards the development of

MCIDAS-eXplorer - A Version of MCIDAS for Planetary Applications

Sanjay S. Limaye
Principal Investigator

Co-Investigators:

R. Stephen Saunders (JPL)
Lawrence A. Sromovsky (SSEC)
Michael Martin (JPL)

Space Science and Engineering Center
University of Wisconsin-Madison
1225 West Dayton Street
Madison, Wisconsin 53706

(608)262-9541
sanjayl@ssec.wisc.edu

July 1994

APPENDIX I

Abstracts of presentations at the Division of Planetary Science Meetings in 1993 and 1994, at the Lunar and Planetary Science Meeting, 1994, and the Planetary Data Visualization Workshop in 1993.

SUMMARY

This is the final report on the development of McIDAS-eXplorer, an extension of McIDAS for solar system applications. This work has been supported under the Applied Information Systems Research Program funded by NASA under USRA contracts 5555-08 and S.C. 550-08, and NASA Contract NAS5-31347.

The initial goals of this effort were to bring to the planetary community the tools used by the terrestrial meteorological community for the access, display and analysis of weather satellite data. An additional consideration of the use of UNIX workstations and PC's as software platforms. The primary target data for this endeavor are the imaging data from NASA's solar system missions are the CD-ROM volumes published by the Planetary Data System (PDS). Another goal of the proposed effort was the facilitation of a graphical user interface for user interaction.

These goals have been met. McIDAS-eXplorer allows the user to access the full calibration and navigation data attached in the PDS labels. The data can be manipulated, displayed, animated using the developed tools. The user manual and help are accessible on-line from within an eXplorer session. These capabilities have been achieved in the last three years by the development of over 160,000 lines of code (mostly FORTRAN and C). These are based on about 150,000 lines of "core" McIDAS-X and McIDAS-OS2 versions. McIDAS-eXplorer is now able to access the PDS solar system data, including the attached navigation and calibration information. For images that do not have the SPICE kernels attached, new image navigation tools based on the NAIF SPICE toolkit have been incorporated within the eXplorer suite.

To expose the planetary community to the capabilities, McIDAS-eXplorer has been demonstrated at Division of Planetary Sciences Meeting in Boulder (October 1993), and at the 25th Lunar and Planetary Sciences Meeting in Houston in March 1994. It is also being demonstrated at the 26th Meeting of the Division of Planetary Sciences Meeting in November 1994 at Washington D.C. (Limaye et al., 1994). McIDAS-eXplorer has been demonstrated at the AISRP Workshops in Boulder in 1992 and 1993.

The eXplorer binaries for AIX, IRIX, HP-OS and SunOS and OS/2 2.1 operating systems can be obtained from the Space Science and Engineer Center. It is likely that the Software Support Laboratory at University of Colorado, Boulder will also be an avenue for access to McIDAS-eXplorer. This final report describes the eXplorer software capabilities and includes a printed copy of the User Guide

ray impact parameter, both of which are directly obtainable from the frequency data and trajectory information (Fjeldbo, Kliore, and Eshleman 1971, ASTRON. J. 76, 123-140.)

Occultation studies of the giant planets have demonstrated that departures from spherical symmetry, if not accounted for, can result in serious errors (Eshleman 1975, SCIENCE 189, 876-878.) In the present study, we have analyzed and quantified errors in temperature and pressure profiles due to large scale atmospheric 'tilts' in an otherwise spherical atmosphere, including the role of occultation geometry in enhancing or suppressing this error.

The effect of atmospheric tilt is to introduce an approximately constant bias in the temperature profile. For example, a horizontal tilt of 0.6 mrad in the Martian atmosphere can bias temperature profiles by up to 0.3 Kelvins, depending on the occultation geometry and on the orientation of the tilt. A much more severe slope of 4.8 mrad, which might exist in the upper atmosphere at the boundary of the polar caps (Pollack et. al. 1990, J. GEOPHYS. RES., 95, 1447-1473) and where most occultations of Mars Observer are expected to occur, could bias the temperature profiles by up to 3.2 Kelvins for an orbit opening of 30 degrees, if such effects were neglected.

Our approach in modeling the tilts has been to assume the local atmosphere to be spherically symmetric but with a different center of symmetry. This approach is satisfactory for the case in which the ray periapsis does not vary too much in latitude and longitude during the course of an occultation. Results from the NASA-Ames GCM for Mars suggest that horizontal variations in pressure are much more severe across latitude than they are across longitude. An axially symmetric figure of revolution should be a better model for the shape of the Martian polar atmosphere than is a large scale tilt.

The current approach incorporates errors due to imprecise knowledge about the location of the transmitter, the receiver and the center of the occulting planet, and is not restricted to any specific occultation geometry.

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.

Session 12: 1992 Urey Prize Lecture
C. Pieters, Moderator
1:30–2:20 pm, Grand Ballroom

12.01-INV

Harold C. Urey Prize Lecture

On the Diversity of Plausible Planetary Systems

Jack J. Lissauer

Session 13: Invited Talk
C. Pieters, Moderator
2:20–3:00 pm, Grand Ballroom

13.01-INV

Breakthroughs in Ground-Based Infrared Spectroscopy of Planets

C. de Bergh (Observatoire de Paris)

Recent progress in infrared detector technology and instrumentation and the development of infrared arrays have strongly benefited the study of planetary atmospheres and surfaces using ground-based spectroscopy. We will review the most recent of these studies. Three important breakthroughs will be more particularly discussed:

1) the new study of the deep atmosphere of Venus by measuring near-infrared radiation of the dark side of the planet,

2) the monitoring of processes occurring in the ionosphere of Jupiter using H_3^+ infrared emissions,

3) the detection of nitrogen ice at the surface of Pluto.

Poster Presentation
Posters from Sessions 14–15
3:00–3:30 pm

Session 14: Comets III
S. Hoban and J. Crovisier, Moderators
3:30–5:30 pm, South Ballroom

14.01

No, We Are Not in a Cometary Shower

Paul R. Weissman (Jet Propulsion Laboratory)

The flux of long-period comets through the planetary region will vary as a result of the magnitude and rate of external perturbations on the Oort cloud. In extreme cases, star passages through the Oort cloud or encounters with GMC's can cause showers of 10^9 or more comets to enter the planetary system (Hills, J. G., Astron. J. 86, 1730, 1981). In order to correctly estimate the population of comets in the Oort cloud, it is necessary to know whether or not the solar system is currently experiencing an enhanced cometary flux. In addition, cometary showers have been invoked to try and explain the enhanced cratering rate currently estimated for the Earth over the past 250 Myr, which is about twice that estimated for the Moon over the past 3 Gyr. Using computer-based dynamical simulation models, it is shown that the current distributions of long-period comet orbital elements are inconsistent with a cometary shower. Two different dynamical tests are employed. First, it is shown that the predicted orbit element distributions from a cometary shower are highly non-random, in contrast with the random distributions of the long-period comets. Second, the 1/a, distribution for the long-period comets shows no evidence of a perturbation of the inner Oort cloud, as would be expected for a major cometary shower. Taken together, these two tests allow one to set an upper limit on the magnitude of any recent major perturbations on the Oort cloud. This work was
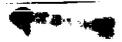
INTRODUCTION

This is the final report for work performed for the development of McIDAS-eXplorer, a version of McIDAS for planetary applications under USRA/CESDIS contract No. 5555-08 for the period July 15, 1994 - July 14, 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. A McIDAS-eXplorer User Guide has been produced that is the culmination of the work performed under NASA support and is attached to this report. This User Guide is intended as a companion volume to the McIDAS-X and McIDAS-OS/2 Guides.

The third and final year of McIDAS-eXplorer development has concentrated on porting eXplorer code to different operating systems, streamlining the installation procedure, identifying the operating system and version specific items, implementing software revision control for the source code and adding support for some remaining Planetary Data System data products. The progress in the last quarter is described below. To provide a comprehensive overview, the capabilities of the McIDAS-eXplorer software are also summarized below. McIDAS-eXplorer User Guide is attached in Appendix I.

McIDAS-eXplorer Overview

McIDAS eXplorer consists of FORTRAN and C routines that conform to the McIDAS environment in terms of data structures, user interface, data navigation and calibration implementation. For reasons of portability and software maintenance, the new code developed strives to adhere to the modern programming practices which have been amply described in Fortran Programming Standards and Guidelines* (JPL D-6613) and also to the standards followed by the NAIF toolkit. McIDAS and eXplorer applications to accomplish specific tasks are developed as modules that are callable from a control program. A module that would be traditionally a "main" program is a "key-in" within the McIDAS environment. The size statistics are as follows.

McIDAS-X library modules:	939 (Core McIDAS core)
eXplorer library modules:	1291 (This effort)
NAIF-Spice library modules:	515 (developed at JPL)

Lines of code:

	McIDAS-X:	148,761 (Core, Version 2.0)
	eXplorer:	161,872 (New code, thios effort)
For comparion,	NAIF library:	138,570 (Developed at JPL)

Number of Keyins:

	Core McIDAS-X:	119 (including single letter commands)
	eXplorer:	82 (New)

Total eXplorer object library size is about 9 Mbytes.

Space required for binaries (both McIDAS-X and Explorer):

IRIX 4.5:	200 Mbytes
IRIX 5.2:	10 Mbytes (shared object library, requires larger swap space)
AIX3.2.5:	130 Mbytes
HP-UX 9.03:	230 Mbytes

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* Produced by the Telecomminucations and Data Acquisition Office and the Space Flight Operations Center, Jet Propulsion Laboratory, Pasadena, California, September 1989 (TDS Document No. 890-218, SFOC Document SFOC0095-00-01).

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 (SunOS 4.1.3, SunOS 5.3, and Solaris 2.3) and and hence the explorer portion can also be used on those workstations. The port to the UNIX on a PC platform, UNIXWARE from UNIVEL was 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 chip based machines ihas been at least temporarily halted, pending future support.

McIDAS and McIDAS-eXplorer can be used under the IBM OS/2 Version 2.1 operating system except for the GUI available on X-window platforms. Previously running McIDAS under OS/2 required the use of a special video display card which was available only for the microchannel bus. We supported the development of the Presentation Manager for the graphical display environment under OS 2/2.1. 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.

HIGHLIGHTS

Nicolle Zellner demonstrating McIDAS-eXplorer to Nancy Chanover (NMSU), A. Sanchez La Vega (Spain) and K. Rages (NASA/Ames) at the 25th DPS Meeting in Boulder, October 1993. Co-Investigator L. Sromovsky is at right.

Major highlights of this last year include the successful demonstration of the eXplorer software environment at the 25th Lunar and Planetary Science Conference held in Houston, March 14-18, 1994 and at the 25th Meeting of the Division of Planetary Sciences in Boulder,

Colorado during November 1993. An abstract describing eXplorer software has been submitted for the DPS meeting to be held in November 1994 in Washington D.C. where it is anticipated that a workstation demonstration will also be held.

We demonstrated McIDAS-eXplorer capabilities on a Silicon Graphics Indigo Extreme at both the meetings. At LPSC the 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. Previously McIDAS-eXplorer was demonstrated at the AISRP Workshop in Boulder, Colorado during August, 1993. An article describing eXplorer was published in the NASA Information Systems Newsletter (February, 1994)

McIDAS-eXplorer being demonstrated to Jim Dodge of NASA's Office of Mission to Planet Earth at the AISRP Workshop held in Boulder, August 3-6, 1993 by Sanjay Limaye (PI). Onlookers include Bob Krauss and David Santek of SSEC (left and front center) who participated in the eXplorer development. (Photograph by Sandy Dueck, JPL)


David Santek explains eXplorer capabilities at the LPSC conference in Houston using the poster display set-up adjacent to the workstation in the exhibit area at LPI

Co-Investigator Steve Saunders looks on while
eXplorer capabilities for Magellan data are
demonstrated on the SGI workstation at the LPSC
conference (above).

McIDAS-eXplorer at the 25th LPSC
Meeting
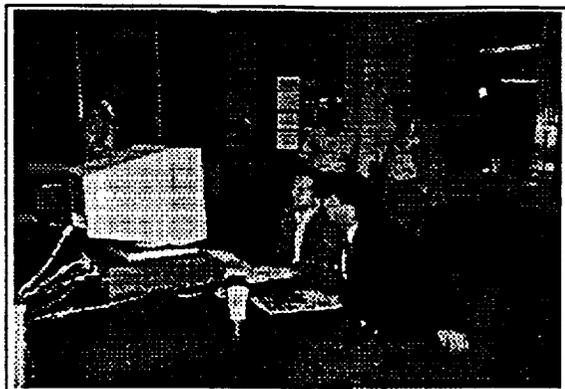
Copies of the abstracts of papers describing McIDAS-eXplorer are attached in Appendix I. A
copy of the article that describes McIDAS-eXplorer is attached in Appendix II. Finally, the
final version of the McIDAS-eXplorer User Manual is attached separately as part of this
report.

Acknowledgements

Many individuals contirbuted to the development of McIDAS-eXplorer. Mr. Robert
Krauss, Mr. Edward Wright wrote a significant amount of code. System support was provided
by Mr. Patrick Fry and Mr. Steven rader. Mr. David Santek and Ms. Sue Gorski assisted
with core McIDAS-X system related issues. Mr. Ken Bywaters, Mr. Russel Dengel and Mr.
Gerry Peltzer developed several new applications. Much needed other support was also
provided by the Space Science and Engineering Center.

Planetary Data Visualization Workshop

Report of a workshop sponsored by
NASA's Solar System Exploration Division and held at
San Juan Capistrano Research Institute Nov. 15-17, 1993
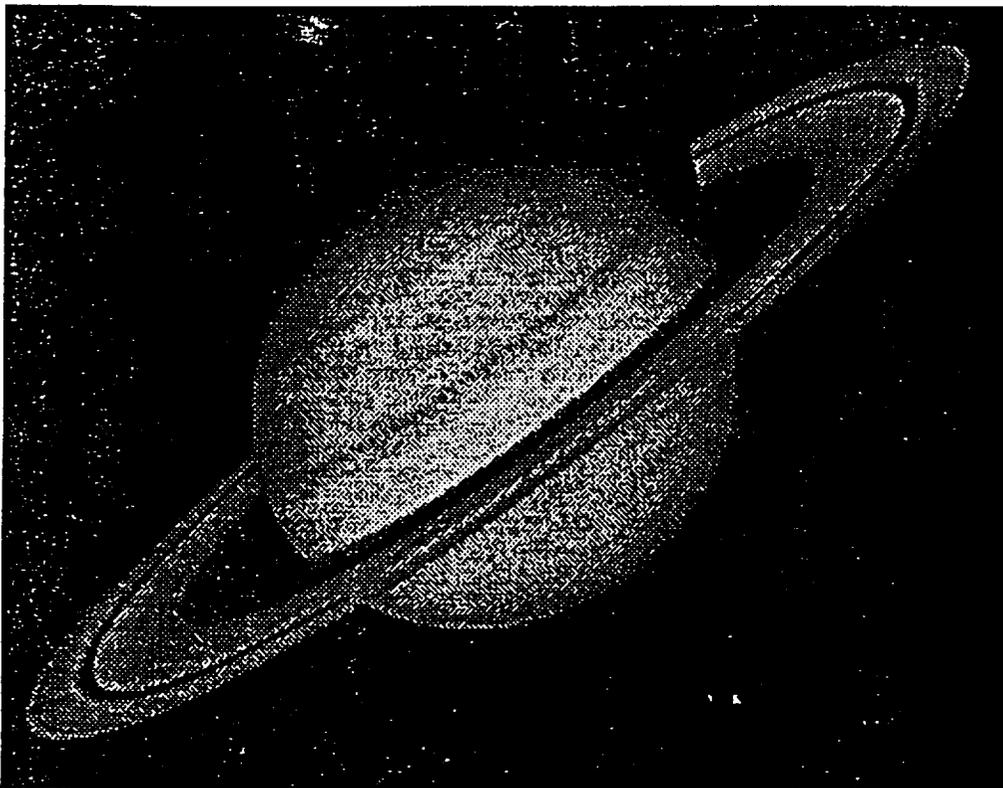
SJI
Prepared by Doug Nash
San Juan Capistrano Research Institute
San Juan Capistrano, California
April 26, 1994

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.

Access, Analysis and Display of Magellan Data with McIDAS-eXplorer

R.S. Saunders

The compilation of radar observations of the Venus surface from tge Magellan mission data has been resulted in over 70 giga bytes of radar reflectivity and radiometry images and altimetry profiles along the spacecraft track. The imagery data are available from the Planetary Data System on 80 CD-ROM volumes, the altimetry data on 15 CD-ROM volumes and the global topography, radiometry and surface slope compisites are available on a set of 2 CD-ROM volumes. To facilitate access, analysis and display of these data, a software environment, McIDAS-eXplorer has been developed. It is based on a mature system that is used extensively for earth weather satellite observations and the extensions actually allow analysis of most solar system targets for which spacecraft and ground based telescopic data are available in recognizable formats. Navigation, registration and calibration of the planetary data are an integral part of the environment. Designed to run on most UNIX workstations supporting X-windows, the environment is user extensible allowing addition of end-user developed applications and includes both a Graphical User Interface and a command line interface, multi-frame display and animation capability and tools for most image processing applications such as digital enhancements, filters, cartographic projections, graphical overlays, color composites.

McIDAS-eXplorer is a multi-processing environment and can run as many applications or user sessions as practical under the computing, memory and peripheral storage resources availble. Batch processing is supported as is the ability to create or use different user interfaces such as a function key template, a graphical user interface or the command window. A simple macro facility allows quick creation of specific command sequences that are used repititively.

In order to fully exploit the navigation, calibration, display and animation capabilities of McIDAS-eXplorer, the data are first imported into McIDAS-eXplorer along with all available navigation and calibration data and stored in the workstation in a specific format. Processing history records are kept for each image imported along with the entire text label that the image was tagged with (e.g. the PDS or the VICAR label). The supplementary calibration information for the radar images to convert raw data numbers into radar reflectivity is accessible to the system, such that while roaming (with the use of a mouse controllec cursor) in a displayed image, the full calibrated and navigated data can be retrieved at the cursor location.
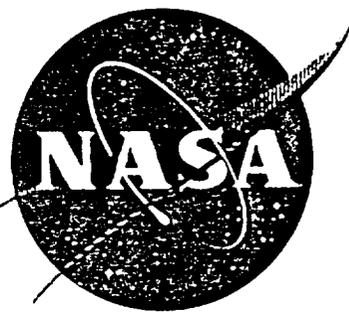
These capabilities will be demonstrated on Magellan data at the conference.

APPENDIX II

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

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

Sanjay Limaye, Space Science & Engineering Center (SSEC), University of Wisconsin-Madison

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
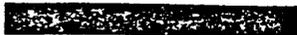
The objective of McIDAS-eXplorer is to bring to the planetary community the tools that the terrestrial meteorological community has been using to analyze weather data and model output.
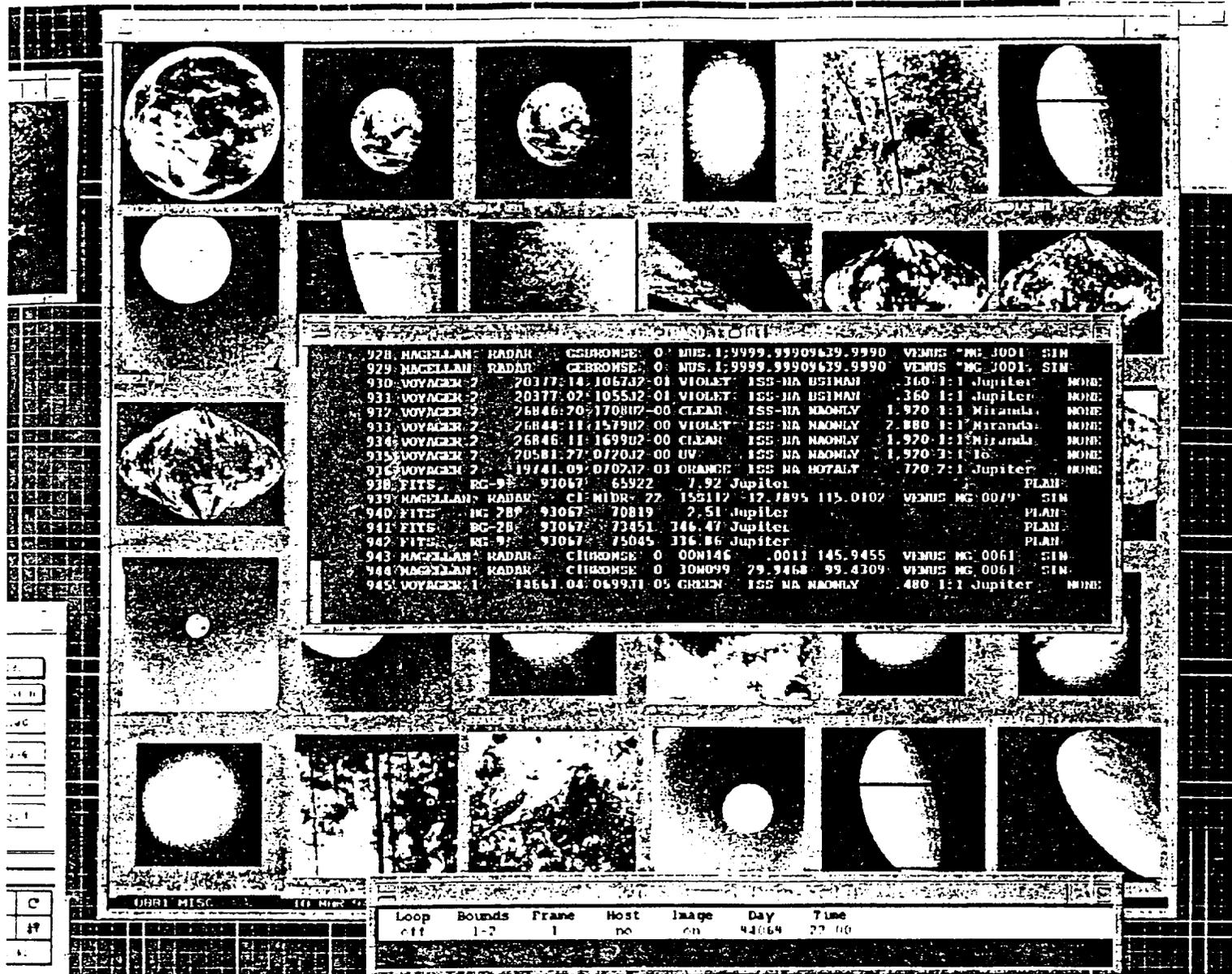
Figure 1. McIDAS image display window

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

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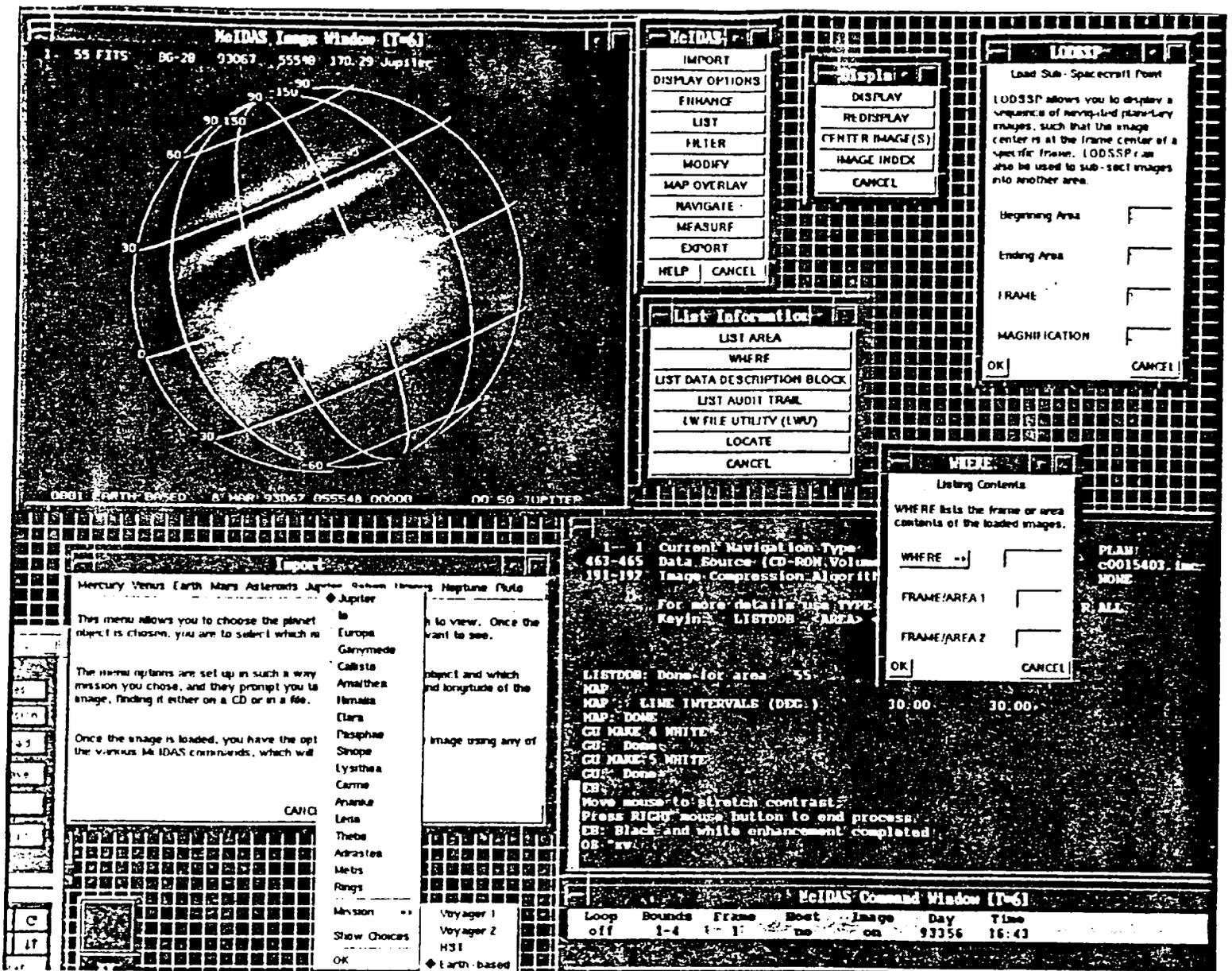
Figure 2. An Earth-based telescopic image of Jupiter with an overlay latitude/longitude grid and a view of available GUIs

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
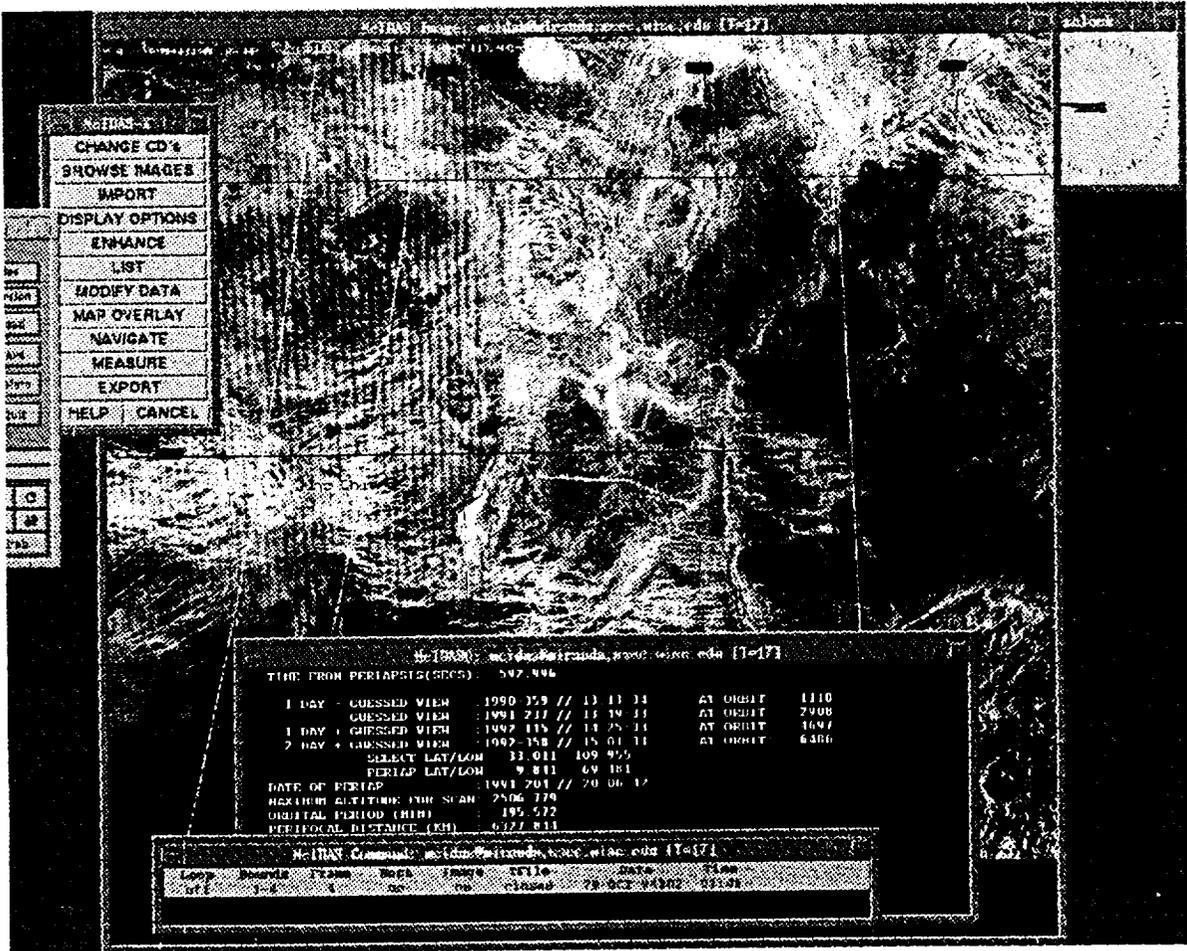
McIDAS-eXplorer

A Planetary Analysis and Display System

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Space Science & Engineering Center
University of Wisconsin-Madison
1225 West Dayton Street
Madison, Wisconsin 53706

(608)262-9541
sanjay1@ssecmail.ssec.wisc.edu

September, 1994

McIDAS-X is a licensed product available from the
Space Science and Engineering Center. For licensing information Contact:
S.S. Limaye, SSEC/UW-Madison
1225 West Dayton Street
Madison, Wisconsin 53706
(608)262-3755
sanjayl@ssec.wisc.edu

Table of Contents

1.0 INTRODUCTION

This document describes **McIDAS-eXplorer**, a set of planetary analysis tools designed for the McIDAS environment. McIDAS is Man Computer Interactive Data Access System developed by the Space Science & Engineering Center (SSEC) of the University of Wisconsin-Madison (Suomi et al., 1983). Somewhat earlier, in late 1960's a similar facility was being born at the Jet Propulsion Laboratory (JPL) called Video Information Communication and Retrieval (VICAR) for analysis of the data being returned from the space probes such as the Mariner 6 mission to Mars (Castleman, 1979). McIDAS originated as a tool for providing interactive access to the earth weather satellite data during the 1970's when there was a dearth of adequate hardware and software tools. While specific hardware elements are a key part of McIDAS, it is primarily the suite of software tools that has made it particularly useful in national and international operational weather facilities for integrating vastly different data weather sources and providing a coherent access to the user. Many of these capabilities are also applicable to the analysis of the planetary data returned by NASA's solar system missions of the past (Viking, Voyager, Magellan), current such as Galileo and Mars Observer and future such as and Cassini or the Pluto Fast Flyby. However, because of the different nature of the data and target objects, many adaptations or modifications are necessary. McIDAS-eXplorer constitutes these adaptations and includes other specific tools for analysis of the planetary data.

This document is intended as a companion document to the McIDAS-X or McIDAS-OS2 User Guides. For the most part however, the need for documents is rare as majority of planetary data manipulation needs are addressed in this volume.

1.1 Planetary Image Data

While it may appear that the remote sensing data such as images returned from LANDSAT or SPOT satellites and data from weather satellites have much in common, and hence the same analysis tools (e.g. many of the Geographic Information Systems packages) can suffice, the differences between the two are apparent in the way these data are utilized as well as in their content. These differences can be illustrated by the presence of clouds in the satellite data-- for geographic remote sensing applications the presence of clouds is a hindrance to the analysis of the underlying surface data, yet the presence of the same clouds in weather applications is used for determining the atmospheric flow and radiation budget or storm development. Further, the information for geographic applications is concentrated in the spatial and spectral domain whereas for meteorological applications the information is contained primarily in the time domain and in spatial and spectral domain for climate applications. The spatial resolution of the data as well as coverage is also a distinguishing factor. For geographic and geologic applications highest achievable spatial resolution is desirable whereas for weather and climate applications *global* and *temporal* coverage is more important than high spatial resolution.

Planetary data in general differ from both the geographic satellite remote sensing data and the terrestrial weather satellite data in several key aspects. First of all while some data is analyzed in near real time for mission sequencing and public affairs reasons, much of the scientific analysis is carried out later. The data is usually acquired over a limited period of time and is often unique. Thus while we have global weather satellite data for nearly two decades, we have less than two days worth of images of Venus from Galileo and for several weeks each year from the Pioneer Venus Orbiter. At the other extreme we have the radar investigation of the surface of Venus from Magellan at a resolution of 120 meters providing mapping of a planet that is unmatched even by the data available about our own planet due to difficulties of mapping the ocean bottom.

1.2   What is McIDAS?

Very briefly, McIDAS provides a multiprocessing software and hardware environment for multiframe display and analysis of and interactive access to any multi-dimensional data. Data are rendered onto the two-dimensional display device of the user workstation on as many frames as the hardware capabilities allow. A user interface allows as many analysis tasks as practical (limited by the workstation resources) and animation.

Currently three different flavors of McIDAS are supported by SSEC. They are McIDAS-MVS that runs on mainframe computers capable of running the MVS operating system (IBM or compatibles), McIDAS-OS2 for IBM compatible personal computers capable of running the OS/2 operating system, and McIDAS-X for UNIX workstations that support the X-windows environment. The MVS environment also typically includes satellite data ingestors for earth weather satellite data and a variety of inputs through other communication networks to ingest other types of data such as weather forecast model outputs, conventional surface and upper air station data, surface radar data, lightning data etc. These ingestion capabilities are of course not required for analysis of planetary data. The other hardware element of McIDAS-MVS and McIDAS-OS2 versions is a SSEC designed workstation called the "Wide Word Workstation" (WWW). This workstation is controlled by an IBM PS/2 personal computer and is capable of storing and displaying up to 1500 image/graphic frames in its video memory allowing animation at video refresh rates. The interface to this workstation does not yet exist for the RISC-6000 series computers although it is technically possible.

For reasons of technology and price vs. performance, the UNIX workstations from different vendors such as Silicon Graphics, IBM (RISC-6000 series), Sun Microsystems and Hewlett Packard, McIDAS software has been ported to the X-Window environment which is supported by these workstations. At the moment all of the new planetary code has been developed for the McIDAS-X environment, however, it can be easily ported to the OS2 environment.

Finally, a general observation about McIDAS is in order. By comparison with many of the commercial applications, particularly in the McIntosh and Windows 3.1 domains, the user interface used by McIDAS may seem dated. The primary reason why the interface has not yet changed is that McIDAS is used at many operational meteorological facilities throughout the world as well as colleges and universities in the US. The hardware environment McIDAS is used under ranges from IBM compatible personal computers based on Intel 80386 (or later processors), UNIX workstations and mainframe computers running MVS operating system (with SSEC designed and built workstations). The existence of a diverse user community implies user support and performance across platforms. As the port to the X-environment matures the interface is being modernized as more users move to the X-Windows environment.

1.3   What is McIDAS-eXplorer?

McIDAS-eXplorer is a software enhancement package for McIDAS (currently only for the X-version). This is intended to provide support for analysis of planetary data acquired by NASA's numerous solar system missions. As the missions to different planets have different instrument systems, the planetary data span a large range in terms of data quantity, type and global coverage. It is neither possible nor desirable to provide support for all types of data. 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. To that extent the enhancements described here provide support for planetary image data from missions such as Mariners, Vikings, Pioneer, Voyagers and Magellan as well as from Hubble

Space Telescope. In addition, other planetary data such as Magellan altimetry data, Pioneer and Mariner 9 Mars occultation profiles, Voyager IRIS can also be accessed and processed.

The tools developed to ingest the different data into McIDAS and specific planetary applications are described herein. Thus the user also needs access to the McIDAS-X User handbook to be able to utilize the standard McIDAS capabilities.

In the past the different missions usually provided the data in the form of Experiment Data Record (EDR) tapes. Supplementary navigation data required to analyze these data were provided as Supplementary Experiment Data Record (SEDR) tapes. The process of using these data for analysis required custom software for each mission and each instrument. Fortunately the situation is much improved now with the advent of the CD-ROMs. Much of the planetary data are now being made available through the Planetary Data System on CD-ROMS which allows some commonality to accessing these data. However, the SEDR data such as trajectory, pointing etc. are not yet available for all the CD-ROMS although limited data are available as SPICE kernels.

There are many capable software products available which unfortunately can be used only with specific data, particularly terrestrial data. With many successful missions to the solar system targets we now have an immense amount data collected at numerous objects that are as diverse as the airless moon or Mercury to rings of Neptune as well as comets and asteroids. The only thing common about these objects is that they have vastly different physical properties besides the fact that the opportunities to collect data on these targets from space probes are limited. One of the goals of the development of McIDAS-eXplorer has been to provide a unified approach to the analysis of the target dependent data by accounting for the differences in their physical characteristics such as size, shape, etc. To this end, the Navigation Ancillary Information Facility's (NAIF, at JPL) approach of assigning a unique identification tag to each object (and spacecraft for that matter) is adopted within McIDAS-eXplorer with some enhancements.

Although McIDAS-eXplorer is general enough to be utilized for most types of data, its strength is in analysis of multispectral images or data that can be visualized as a two dimensional image. McIDAS-eXplorer also has tools for analysis of atmospheric data such as temperature profiles which although are one-dimensional individually, are typically available globally for planets such as Mars, Venus, and of course, earth. The Infrared Radiometer Interferometer Spectrometer (IRIS) instrument on Voyager 1 and 2 provides spectra for the giant planets from which temperature profiles have been derived.

Object Identification

The (NAIF) software developed at JPL uses an identification number for each solar system object for ephemeris purposes. This same number is used within McIDAS-eXplorer but with a small modification. This identification process serves another purpose besides naming the object in the image-- it is used to retrieve the object's physical constants (radii, length of day etc.). In most cases the planetary data refer to a single target object such as a planet or its satellite or ring system. Occasionally, however, there can be multiple objects in a single frame such as the images of a planet and its ring system or a satellite in the same frame. In such cases the decision on which NAIF identification number to use within McIDAS-eXplorer is made on the basis of which single object is being analyzed in that frame.

Another complication arises in investigating images of bodies with extended atmospheres such as Venus or Titan. The visible or infrared images of these planets do not "see" the surface but only the cloud-top level, which is about 65-70 km above the surface for Venus

and nearly 300 km for Titan. Thus the effective radius for such objects needs to be different for the purpose of not only image navigation (the process of relating the image co-ordinates to the planet's co-ordinates and vice-versa), but also for measuring distances etc. For this reason McIDAS-eXplorer distinguishes between the solid surface and the cloud level. Further, this level can be different at different imaging wavelengths such as for Saturn, therefor allowance is made for having as many as 9 separate radii for different levels for objects with atmospheres. The NAIF identification code for an object is entered as a four-digit number rather than as a three digit number. with the rightmost digit denoting the level for which the radius is defined. Thus, for Venus, the NAIFID value of 299 is modified to 2990 for the solid surface, and 2991 for the cloud level at the first wavelength, 2992 at the second wavelength etc. The mnemonic identification is also suitably modified as appropriate, for example, to Venus_sfc or Venus_atm.

Object specific physical constants that are required for analysis or navigation of the data are obtained through a single subroutine. The physical constants for each solar system target that are incorporated within McIDAS-eXplorer can be listed with the **PHYSCON** command. This subroutine contains the most-recent published values of the triaxial radii and the length of the day for solar system objects. If any of the data need to be updated, then this subroutine needs to be recompiled after the required changes, and all of the planetary code needs to be relinked as well. This is done as a matter of precaution to ensure that the fundamental constants are not changed inadvertently (as is possible if the constants were loaded from a data file-- there is no simple accountability if the file gets modified).

McIDAS-eXplorer allows use of the SPICE kernels for the navigation of images and also provides tools to determine the navigation transforms when the kernels are not available but the basic trajectory and pointing information are available. Data from the older missions such as Viking Orbiter and bulk of Voyager imagery fall in this category.

Digital Areas or Image Files

Although the CD's offer a convenient means of archival of image data, the speed of access is less than desirable. For this reason and for reasons of compatibility with the McIDAS environment as well as efficiency, the image data is imported into the McIDAS environment as files. At the same time a Data Description Block is created that provides a road map to the navigation, calibration information for the image data. While there is some commonality between various formats, mission and science instrumentation differences result in mission specific variations. These are accommodated by classifying the DDB's into specific models such as one for framing cameras, one for spin scan imagery, one for nadir pointing scanning instruments etc. The Magellan SAR and altimetry data are exceptions in that the image products are available only as mapped products (various compressions achieved through sampling) while the latter is mostly available along orbit tracks.

The datafile structure is described in detail in Appendix III for the different models used. A brief overview of the files used by McIDAS for storing the imported image data is given below.

McIDAS-X stores image data in files called "areas" all of which have names of the form "AREAxxxx" where xxxx is a four-digit number. Each "area" contains one single image which can be multibanded. As many as 9999 areas can be accessed by McIDAS from the "/u1/mcidas/data" sub-directory, and more can be allocated by using a second sub-directory. This sub-directory can be thought of as workspace for McIDAS-X, and needs to be large enough to accept the data to be accessed as well as for any output created, and typically this is the largest sub-directory. With each area basic information about the data contents regarding acquisition time, source instrument, calibration, navigation, and format is stored in a carried

along the processing chain. Standard McIDAS-X file format for multidimensional spectral images includes a directory block (64 words) as well as a 128-word block containing the navigation information for the data.

Data Description Block

McIDAS-eXplorer extends the data directory concept by using an additional Data Description Block (DDB) in as many multiples of 64-words as needed. The DDB allows access to detailed descriptors of the data about the target object, the source instrument, data acquisition geometry, calibration and other ancillary information that is potentially useful. The exact definition of a DDB is dependent on the instrument type that returned the data. Thus the Voyager images have a specific DDB type defined which is different from the Magellan radar images of the Venus surface which are available only in map format.

At present the DDB concept has been implemented only for the image data. The PDS has adopted a standard for labels for the datasets produced on CD-ROM's. These PDS labels usually include information present on other labels such as VICAR labels as well as processing history and other mission specific labels or information. McIDAS-eXplorer tools to import the PDS data from CD-ROM's in general will include the complete text label associated with each image file and also extract a set to encode into the DDB so that McIDAS-eXplorer commands can use that information easily. As work proceeds, this approach will be adapted for other data types.

McIDAS-eXplorer adheres to the general McIDAS-X conventions for the file system. Thus the data ingested normally reside in the /mcidas/data directory and the source is in /mcidas/src directory, etc. Specific formats for storing and accessing the data are specified under McIDAS-X such as image data (two or three dimensional), gridded data (two dimensional gridded data sets e.g. output of numerical models) which is usually coarser than the image data, and other single dimension data types such as time series, etc. The exact implementation of the different formats is dependent on the native operating system, but McIDAS-X provides a transparent and a common interface between the applications software and the native operating system. The basic file system is called the Large Word array or LW format. Both the digital image data and the grid-data formats are based on the LW file system. For both the gridded and the image data sets a directory service is provided to query the contents of the file. McIDAS-eXplorer uses certain extensions for planetary applications which are compatible with McIDAS-X.

Processing History: Audit Trails

Most spacecraft data undergo several specific processing steps, some are mandatory such as radiometric or geometric calibration, many others are optional such as map projections or multispectral classification. In most instances wherein a large amount of data are being analyzed, it is useful to maintain a processing history record for the data. For the image data, McIDAS-eXplorer maintains an audit trail in which applications programs append an entry containing all the command parameters that were invoked in that particular processing step. This processing history can be queried either by the user or by other programs to determine the processing status.

McIDAS has been ported to the OS/2 operating systems as well as to several versions of UNIX. The primary application code is mostly written in FORTRAN with some C language code. To a large extent McIDAS acts as its own operating system and most housekeeping activities can be performed from within McIDAS itself. Nevertheless, experience with the native operating system is useful but proficiency is not necessary. As McIDAS predates most personal computers and certainly the windows environment, it is not surprising that the pri-

mary means of interaction with the user is through the command line. However other user interfaces are possible and have been developed and implemented within McIDAS in the past.

McIDAS differs from most other image display and analysis environments in that it is a multitasking, 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. McIDAS supports multitasking such that while one user application is being executed, others can be invoked as needed and limited only by the hardware capabilities. The intelligence derives from the fact that the system "knows" the key data attributes of the images as well as graphics displayed in different frames and this information is available to the application programs. This is crucial for quantitative analysis in a multitasking environment.

Execution of a profile file sets the display environment flags such as number of bits displayed, initial number of frames created at start-up, size of the display frames, default font for text and graphics windows, image display mode (24-bit three-color mode or 8-bit false color) etc. For example, on workstations with 24-bit graphics the session can be started as:

mcidas -bp 24 -ig y -fr 24 48 -imsiz 256 256

This starts a session with independent graphics ("W" key toggles the graphics on and off the image), with 3-color 256 lines x 256 elements sized display frames of which 24 are allocated initially and up to 24 more can be allocated dynamically from the McIDAS command window (using the MAKFRM command). The frames that are created dynamically can be of any size as limited by the available workstation memory.

McIDAS-eXplorer User Interface

McIDAS-X typically creates four "windows" on the workstation screen when a session is started. One of these is a "command" window which also includes a status line (Figure 1) and is the primary user interface to McIDAS. There are multiple text windows ("1" and "2") of which only one is active at any moment (selected by clicking on a mouse button in the particular window or from the numeric-keypad by pressing "1" or "2" key). The window active when a command is entered contains the output from that command. The fourth window is the image display which is sized according to the frame size specified in the start-up procedure.

McIDAS-eXplorer supports various forms of user input- text or command oriented, supplemented by function keys and single letter key-strokes and a Graphical User Interface (GUI). The function keys are user programmable to fit the particular application needs as well as utilized in a a menu system which is invoked with the ESC key (which prompts the user for the name of a menu file).

The user can communicate his input to eXplorer in two other ways besides the Command window. The GUI is based on the Tcl-Tk script and is user tailorable as well as a Function Key based menu system, which can also be adapted by the user as needed. These two interfaces make it unnecessary to know the syntax or even the command names and most tasks can be accomplished readily through the interface. The GUI does require some familiarity with the scripting language if it needs to be modified by the user (although in most cases it is unlikely) and is completely independent of the commands. It is a system of cascading menus that offer different tool-bars which can be chosen with mouse-button clicks. When needed, these will prompt the user for input.

The function key based interface is similar in operation in that it is also a set of cascading menus where the choice is made by pressing a specific function key. Only minimal user input is possible with this scheme. It is however much simpler to create and can be easily manipulated with a text editor. The details of how to write a function key based interface can be found in the McIDAS-X manual.
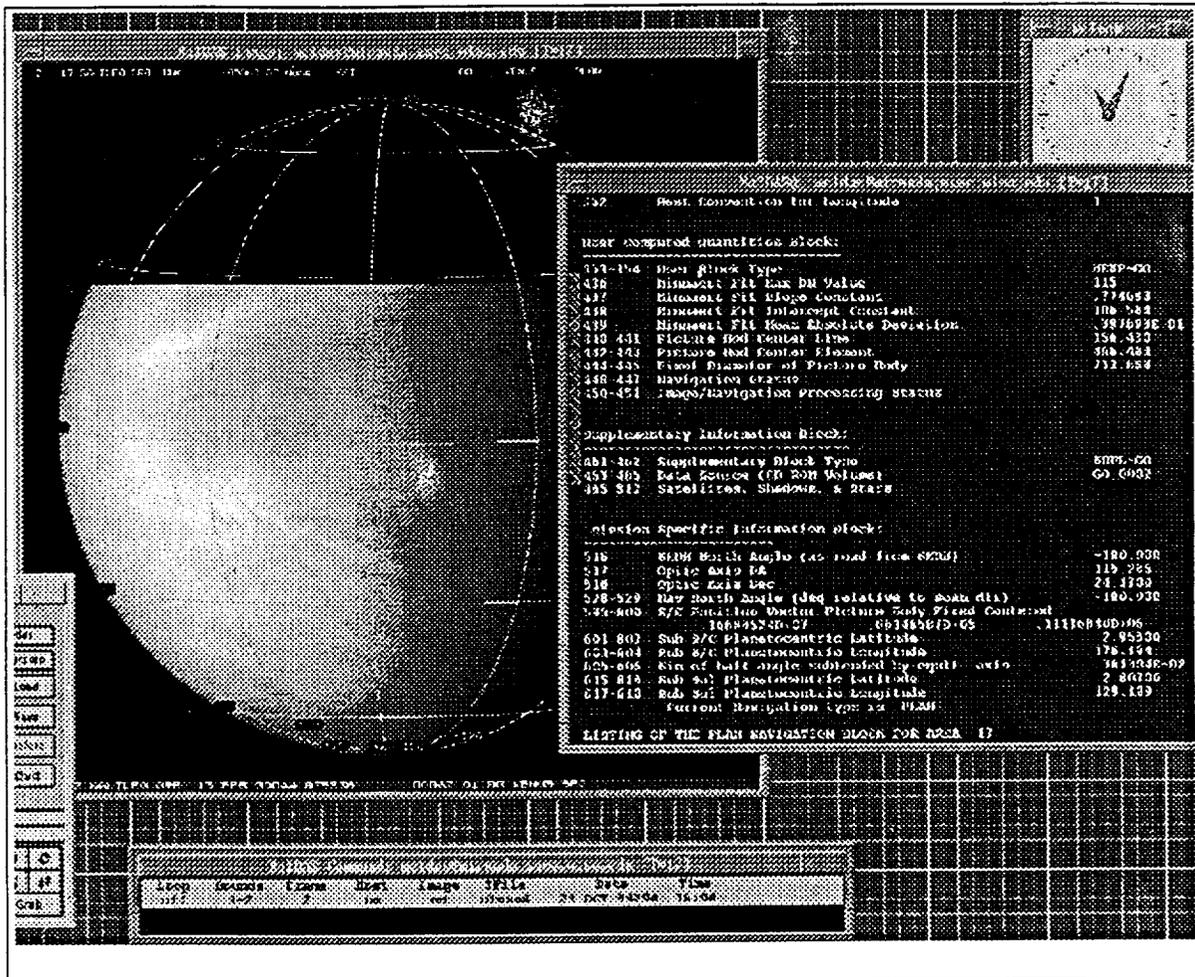
Figure 1.1. A view of the McIDAS-X screen. The Command window is at the bottom, the text message window to the upper right and the image window is on the left. The graphics in the image window can either be independent (either graphics or the underlying image can be toggled into view) or merged with the base image. The status line on the top of the Command Window indicates the current state of the display.

The GUI interface currently supported makes the use of McIDAS-eXplorer easy for novice users. An initial tool-bar window allows selection of a particular function supported by McIDAS-eXplorer. Clicking with the mouse-button (left) opens a newer window giving the user other choices that activate specific McIDAS commands and allow solicitation of input for command parameters. This interface allows the help to be made available in a context sensitive manner and is independently controllable separate from the command itself and is being developed using the Tk-Tcl scripting language. An example of this interface is shown in Figure 2.
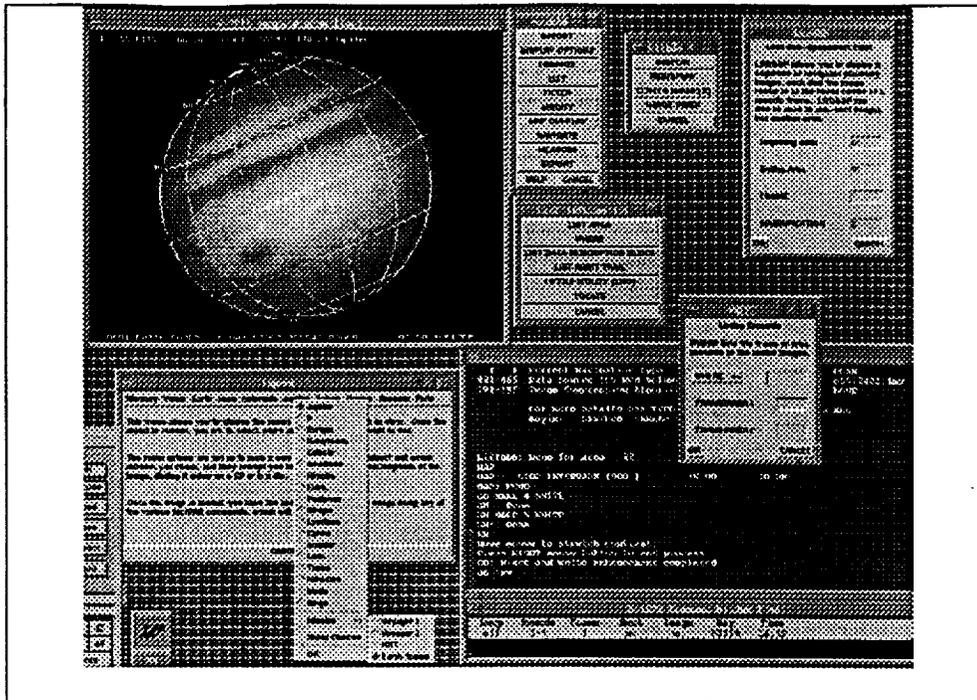
Figure 1.2. An illustration of the Graphical User Interface that cascades menus from which tasks can be chosen with mouse-button clicks.
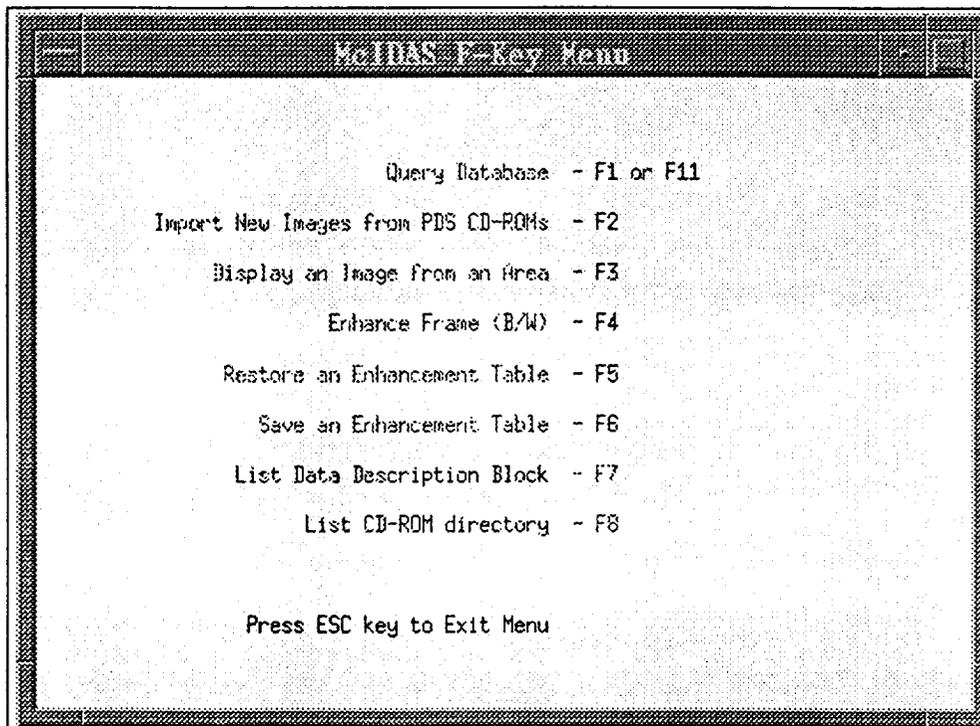
Figure 1.3. An illustration of the Function Key based User interface. This one is invoked from a text file containing the menu script with the ESC key. The user can create custom menus for different applications and invoke them as needed.

1.4   McIDAS-eXplorer Workstations

The foremost requirement for McIDAS-eXplorer is to have convenient access to the current and future planetary datasets. Data from missions such as Voyager (giant planets), Viking (Mars) , Galileo (Earth and Venus) and Magellan (SAR imagery of Venus and surface altimetry, reflectivity, emissivity) data are available on CD-ROM's through the Planetary Data System and the National Space Science Data Center (NSSDC). The workstations required to use McIDAS-eXplorer are the ones that can run McIDAS-X with the exception that a CD-ROM reader needs to be available either locally or over a Local Area Network (LAN). A typical configuration is a UNIX based workstation (SUN, SGI, IBM/RISC-6000, HP) with 32 mb or more memory, 1 Gb or larger capacity disk, and a DAT or an Exabyte tape drive in addition to the CD-ROM reader. A color display, preferably with 24-bit display capability is desired but 8-bit display support is adequate for many applications. Similarly, a CD changer such as the Pioneer DRM-604X can also be useful to provide access to as many as 6 CD's simultaneously (not synchronously of course), but not necessary, and of course can be expanded through the SCSI interface to handle as many as 48 CD's on-line, up to 8 of the minichangers (daisy-chained to the SCSI port) simultaneously.

1.5   Planetary Data supported under McIDAS-eXplorer

The following data are planned to be fully supported for analysis in terms of navigation and data calibration. In addition to the following, earth based telescopic images of solar system targets can also be readily imported and analyzed using McIDAS-eXplorer if the data are available in a standard format such as FITS or TIFF.

Earth and Moon

Data from all US civilian meteorological satellites (GOES, POES) as well as METEOSAT and GMS (European and Japanese geosynchronous satellites).

Galileo Orbiter SSI images during Earth 1 and Earth 2 encounters in December 1991 and December 1992.

Venus

Magellan Mosaicked Image Data (C- and F-MIDR's) on PDS CDs MIDRCD.01 - MIDRCD.120 and Altitude and Radiometry Data CDs on Volumes ARCDRCD.001 through ARCDRCD.015 and Composite Global topography and Radiometry Data, GxDR_3002

Pioneer Venus Orbiter Cloud Photopolarimeter (OCPP) images

Pioneer Venus OCPP Polarimetry Maps from NSSDC archive tapes

Galileo SSI images of Venus (GO_0002).

Mars

Mapped Image Data Model (USGS): MDIMS volume 1-6

Viking Orbiter Images: PDS Volumes VO_1001 through VO_1006.

Jupiter and Satellites

Voyager 1 and 2 images on EDR tapes and PDS CD-ROM Volumes 6-8 and Volumes 13-25 (Volume 17 is the last one published so far, more are forthcoming).

Hubble Space Telescope images of Jupiter.

Earth based telescopic images of planets with FITS headers.

Saturn and Satellites
Voyager 1 and 2 images on EDR tapes and PDS CD-ROM Volumes 4-5.

Hubble Space Telescope images of Saturn.

Uranus and Satellites
Voyager 2 images on EDR tapes and PDS CD-ROM Volumes 1-3.

Neptune, Rings and Satellites
Voyager 2 images on EDR tapes and PDS CD-ROM Volumes 9-12.

References

Castleman, K.R., 1979. **Digital Image Processing**, Prentice Hall, Englewood Cliffs, New Jersey, 429 pp.

Suomi, V.E., R.J. Fox, S.S. Limaye, and W.L. Smith, 1983. McIDAS III- a modern interactive data display system. J. Clim. Appl. Meteor.. 22, 766-778.

2.0   USING McIDAS-eXplorer

McIDAS-eXplorer is a set of specific commands or applications programs that can be run under McIDAS-X and familiarity with McIDAS-X workstation environment is useful. The current release of McIDAS-X and eXplorer also support a Graphical User Interface (GUI) based on the Tcl-Tk scripting language. This GUI provides access to many of the commands in an intuitive manner using toolbars. Help about specific commands, a glossary, a tutorial section on how to accomplish certain tasks is also accessible via this GUI. A completely GUI based version of McIDAS-X called MERLIN is also available via anonymous ftp. McIDAS-X capabilities, installation notes can be found in the Users Guide available from SSEC. For novice users a brief introduction to the McIDAS concepts is given here.

Starting and ending a McIDAS session

At the console login, enter the user ID and the password to log onto the workstation. The user ID and the password are created by the system administrator.

If the X-server is not running, start it with xinit. To start McIDAS, simply enter at the prompt:

mcidas -ig y

from your home directory. This initiates execution of the mcidas profile file which sets the display environment flags such as # of bits displayed, number of frames created at start-up, size of the display frames etc. The contents of the profile are described in the McIDAS-X User's Guide. Note that it is when starting a McIDAS session that the frame size and the number of gray levels displayed gets set (leave it at 128 unless the workstation has more than a single 8-bit display plane). Details of starting McIDAS with different numbers of frames and different sizes may be found in the McIDAS-X Users Guide.

Note that the frame size defined here is the McIDAS display frame size. The X-window within which this display appears is initially set to this size and should normally not be changed. Once the McIDAS session has started, expanding or shrinking the display window (or the "image" window for McIDAS) has no real effect on the amount of data displayed by McIDAS in that window. Thus the frame size should be set to the largest size of the image that needs to be seen at the full resolution since by integer sub-sampling larger images can be seen in a small display frame.

McIDAS-X creates several "windows" when a session is started, typically, four. One of these is a "command" window which also includes a status line (Figure 1) and is the primary user interface to McIDAS. There are two text windows ("1" and "2") which are made active by clicking in the particular window or from the numeric-keypad by pressing "1" or "2" key. These two text windows contain output from McIDAS commands. The fourth window is the image display which is sized according to the frame size specified in the start-up procedure.

To close a McIDAS session, simply enter EXIT in the command window which will end a session.

Starting the GUI

The eXplorer GUI can be started from your home directory with:

where *term_#* is a terminal number assigned by McIDAS to the session and can be found in the Title Bar for the McIDAS Text and Command windows. Alternately, the interface can also be started from the McIDAS session with the **GUI** key-in from the command window.

Figure 2.1 The initial screen for the GUI that allows the user to chose between different actions using the mouse-button clicks on the desired item.
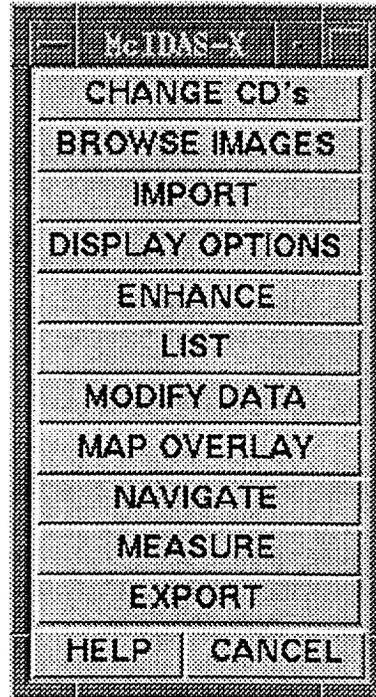
McIDAS Display

Since the prime motive behind McIDAS is the analysis of data acquired in the temporal domain, animation is a key feature, and thus McIDAS uses multiframe display capability. The image data are displayed on a "frame" which can contain either image or graphic data. The frames can be any size as desired and each one can be of a different size. If the frame size is larger than the screen size then the screen provides a scrollable window into the displayed frame and can be moved with the mouse. Frames can also be dynamically added to a session (as allowed by available system memory), but at present they can be unloaded to free up memory only by exiting the McIDAS session and re-starting McIDAS with the new parameters. On UNIX workstations the number of frames to configure and their sizes are specified by the user (in the profile) as constrained primarily by the amount of random access memory (RAM) available in the workstation.

The user controllable frame size is useful to optimize the number of display frames for the specific data being analyzed in that session. Even if animation may not be a desire, a large number of frames are still immensely useful in streamlining an analysis session by eliminating the need to erase and re-draw graphics as well as by keeping them around for reference. The planetary image data available on PDS CD-ROMs range in size from 800 x 800 for Voyager and Galileo to 1024 x 1024 or larger for Magellan products, a considerable difference in frame size and memory requirements.

The display frame contains much more information than just the visible image in McIDAS environment. For each frame that contains an image, McIDAS keeps track of the image source, its calibration, and, most important, the navigation. "C" single-letter command, **LF** and **WHERE** commands allow the user to query a frame's contents. **LISTDDB** provides more detailed information about the displayed frame.

Overlay graphics can be drawn which can also be dynamically saved in separate graphics files for re-display later. This is particularly useful in the X-environment wherein "peelable" graphics are not possible or implemented on some workstations. Thus, if any changes are required in the graphic frame, the entire contents have to be erased and re-displayed.

2.1	*McIDASese - Not quite a language but a syntax of its own*

At its core, McIDAS and McIDAS-eXplorer are command driven and not menu-driven. A certain familiarity with the command syntax is thus useful. A Graphical User Interface (GUI) and a function key-based interface are also available to execute most of commonly used McIDAS-eXplorer and core McIDAS-X applications. The GUI is based upon the Tcl-Tk scripting language. The function key-based interface is user programmable and allows creation of a function-key based menu system, and can be created using a text editor outside of McIDAS environment. More than one such menu can be created and used during a single session. The function key-based menu is invoked with the ESC key which then prompts the user for the name of the file containing the menu script.

Typically, a process can be performed with a command entered in the command window from the workstation key-board. Usually most commands are task oriented and execute an operation once. Since McIDAS is a multiprocessing environment in itself, user always has the option of starting other processes via the command window while one is executing, or via GUI or function keys. Some commands however are interactive and require user attention via mouse button clicks, or occasionally, key-board input. A few commands are memory resident, which remain active until the user either explicitly terminates them or they time-out.

A command may or may not have any arguments, have positional parameters or keywords or both. The positional parameters are generally restricted to certain "obvious" situations (but that is peculiar to the programmer!) while keywords are used to specify other specific inputs. Such keywords are used by typing the keyword exactly (ALWAYS in upper case) followed by a comma or the equality sign ("=") followed by the value. A keyword may accept as few as one or as many as 32 values entered consecutively on the command line. The McIDAS-eXplorer commands are expected to check the specified keywords for validity, if any are misspelled or extraneous to the command, an error message is printed out and the process is not executed. The keywords come in two varieties- global and command specific. The "global" keywords are generally recognized system-wide, and share some commonality in use. Examples are DAY= and TIME= or DEV*ice*=. Generally the global keywords require only the first three characters, but command specific keywords may check the entire keyword.

Caution: In McIDAS-X the commands name can be entered in lower case (although not recommended) but all keywords must be entered in UPPER CASE!

The positional parameter is most often used to indicate to an applications program the *area#* containing an image of interest. Often it is desired to modify one image by some process and retain the original as well. The syntax most often used (and almost invariably in

McIDASese) is to specify in input area# first and the output area# second. For example a command with a syntax given as:

REMAP *from_area to_area* and entered as
REMAP 101 102

will remap the image contained in the file specified by the positional parameter *from_area* (area# 101 in this example) and write the output in the file specified by the second positional parameter *to_area* (area# 102) using the navigation transforms defined for the two areas. The actual file names for the two areas are AREA0101 and AREA0102, but the user seldom needs to worry about the exact names except for system administration purposes.

A simpler example of the positional parameter is when only a single parameter is required, such as in the LA command to list the directory for a given area (so one can find out what the contents are!):

LA 101

which produces a single line of output in the text window like:

```
area   ss   yyddd hhmmss   lcor   ecor  lr er zr  lsiz  esiz z     bands
----  ----  ----- ------- ----- ----- -- -- -- ----- ----- -   -----
 101  48   89214 83159      1      1  1  1  1   800   800 1 1...............
```

If this is not sufficient, one can make use of the keywords for this command to produce additional output by keying in:

LA 101 FORM=AUDIT

which queries the area to produce the audit trail for the image contained in the Area 101 and the output may look like:

```
area   ss  yyddd hhmmss  lcor  ecor lr er zr  lsiz  esiz z    bands
----   ---- ----- ------ ----- ----- -- -- -- ----- ----- -   -----
 101   48  89214 83159    1     1  1  1  1   800   800 1 1...............
        proj:    0 created: 93048 191147  memo: ---CDROM DECOMPRESS---_____
        type:VISR    cal type:BRIT
        area offsets:  data= 9040 navigation=  256 calibration= 2816
        doc length:  36   cal length:   0   lev length:   0 PREFIX=  36
        valcod:         0 zcor:  1 band-8:  NA  reel#:*****
     -Audit Trail
        yyddd hhmmss
        ----- -------
        PICNO= 0338N2-023                         TARGET= NEPTUNE
        FDS=  10706.02      CAMERA= NARROW ANGLE   SPACECRAFT= VOYAGER
        SHUTTER TIME=  89214   83159        NAONLY
        FILTER= GREEN  (5)   EXP=  15.3600SEC.     GAIN=  LOW
        LINES= 800   ELEMENTS= 800                 SCAN=  5:1    EDIT=


        VCDROM: Internal Parameters and Defaults:
        SOURCE        = /cdrom/neptune/c1070xxx/c1070602.imq__
        FDS-START     = 1070600
        FDS-END       = 1070700
        TARGET        = neptune
        CAMERA        =
        FILTER        =
        SEARCH_INDEX= 0
        OUTPUT_AREA  = 101
        93048 191155 VCDROM FDS= 10706.00 10707.00 AREA= 101 TARGET= NEPTUNE
        93119 175624 RF 101
        93119 175657 FILLO 101
        93119 175727 RF 101
        93119 175813 SEDRIN 101
```

Some commands which require no arguments at all. One example is **EXIT** which shuts down an active McIDAS session and closes all active McIDAS windows. Then there are some single-letter commands which can be alternately entered using the ALT-key simultaneously with another key. These commands do not require a [CR] if entered using the ALT key, and generally control the display state. Examples are the 'A' and 'B' key commands which respectively advance or back-up the display to the next frame in the sequence.

McIDAS also makes use of user defined string tables to facilitate simpler input to application programs as well as argument passing between different application programs. These string tables are created by a simple string editor and stored in the user profile and can be saved and deleted. Multiple versions can be stored under different names for different applications and can be shared with other users Besides the single command execution or action of application tools, McIDAS applications can be executed in a sequence for repetitive tasks in one of two distinct ways. One of them is as a macro command that is precompiled. A McIDAS macro program accepts as input standard FORTRAN statements with some exceptions and can call other McIDAS applications. Once compiled, the application executes the sequence described within the macro.

The second way of simplifying repetitive tasks is to use the REPEAT command, which executes a command string a given number of times with any number of numeric arguments. For example:

> TE "MAPIT !1 !2 MERGE=YES; DF !2 1
>
> REPEAT MAPIT 100 TO 200 BY 1 300

will map images contained in areas 100 to 200 and map into a given projection and merge the output into a single output area (# 300) and display the result after the addition of each image on frame 2. This sequence is useful for making mosaics from Magellan framelets or tiles.

2.2   Hardcopy Text or Image output

There are several ways of obtaining hardcopy text and image (gray-scale or color) output from McIDAS-X. The simplest means of obtaining a print copy of the McIDAS command output is to use the redirect capability offered by the DEV keyword. The output can be directed either directly to the workstation printer, or to a file, simply by appending any command by **DEV = P**, or **DEV = F** *filename* respectively. The text file can then be printed from the X-window by any of the methods. Note that this file is an LW file (which really means that it lacks the carriage-return LineFeed sequence) and must be converted to a DOS or a text file by using **DOSTOLW** command and then sent to the printer. One possible is to use *enscript*:

(In the McIDAS Command Window):

> **DOSTOLW** *filename text_file*
> **OS** *"enscript -2rG filename*

which will print the file as facing pages in the landscape format.

If a complete log of the McIDAS work session is desired, user key-ins and the McIDAS output can be also be copied to a log file using the **TFILE** command to open and close the log files at appropriate times as desired:

> **TFILE OPEN** *"filename*
>
>   .
>   .
>   .
>
> **TFILE CLOSE**

The file can then be printed as before from the X-window using the operating system commands.

A third means is to use a screen capture device to print out the screen display which may or may not include gray-scale or color images using such as a TOYO printer which is connected to the display device of the workstation.

Finally, the image displayed on a McIDAS frame can be printed by saving it as a .GIF format file using the **SVGIF** command. The .GIF file can then be saved as a PostScript file using the **XV** utility from a X-Window session, either as a color image or as a black and white image. The PostScript file containing the image can then be sent to the system laser printer to get either a black and white gray-tone image, or to a color printer to obtain a color print:

The .GIF file can also be exported to other systems such as high resolution cameras or image editing programs to add annotation, change color balance etc.

Frequently an X-window is also required for direct interface to the operating system, although most commands can also be sent to the operating system from the McIDAS command window through the OS command followed by a string (i.e. preceded by the double quote symbol, ") containing the operating system command syntax. Exceptions are commands that require authentication, as the "su" command.

OS "pwd *(queries the system for the current directory).*

The output is directed to the current McIDAS text window:

/u1/mcidas/data

McIDAS-eXplorer adheres to the general McIDAS-X conventions for the file system. Thus the data ingested normally resides in the /mcidas/data directory and the source is in /mcidas/src directory, etc. Specific formats for storing and accessing the data are specified under McIDAS-X such as image data (two or three dimensional), gridded data (two dimensional gridded data sets e.g. output of numerical models) which is usually much more granular than the image data, and other single dimension data types such as time series, etc. The exact implementation of the different formats are dependent on the native operating system, but McIDAS-X provides a transparent and a common interface between the applications software and the native operating system. The basic file system is called the Large Word array or LW format. Both the digital image data and the grid-data formats are based on the LW file system. For both the gridded and the image data sets a directory service is provided to query the contents of the file. McIDAS-eXplorer uses certain extensions for planetary applications which are compatible with McIDAS-X.

| 2.3 System Status |

As McIDAS-X is a multiprocessing environment, several application programs can be executed simultaneously. The respective output can be directed to separate text windows or files. Some of the applications, such as multispectral classification of large images require significant processing time even on fastest workstations. It is useful in such instances to determine the active applications. A command (SHFT-?) provides a current snapshot of the processing load at any instance, and an abort mechanism also exists to abort a user process from within McIDAS-X (/ followed by the process identification number in the Command window).

An inventory of the data imported into McIDAS-eXplorer is obtainable using **WHERE** and **LA** commands in condensed, text form, and visually as thumbnail images using the **SCANA** command. **SCANM**, a memory resident command allows some limited operations to be performed on the data/areas displayed in a browse frame created by **SCANA** key-in interactively.

Figure 2.2 Example of a display for a browse area created using SCANA to depict the area contents. Practically as many as 400 images can be viewed in this format and used as an index to the eXplorer data contents.

2.4   Scheduler

McIDAS-X has a scheduler capability to execute a sequence of commands at a predetermined time in the future. Although this is most useful in real-time environments for acquisition of data, the facility is useful to schedule processing resources intensive tasks at times when the workstation may be otherwise idle or less stressed.

Figure 2.3 Another example of a display of a browse frame created from data stored in 180 areas which contained raw and mapped (polar stereographic) images from Pioneer Venus Orbiter Cloud Photopolarimeter. The areas may or may not be consecutively numbered.. Each thumbnail image can be annotated either with the date/time of acquisition, or the area and band number as desired. The browse area itself is tagged with day and time when the index was generated and can be seen on the frame annotation line at the bottom.

2.5 Batch processing of commands

A facility to execute commands from a file allows systematic, repetitive processing of data effortlessly. Any McIDAS command can be entered in a text file just as it would be entered from the key-board. The commands in the file can be executed using the scheduler capability or started from the key-board with the RUN *file_name* command. The file can be created using any text editor available on the workstation and should normally be in the /mcidas/data sub-directory. If a log of the processing is desired, each command should be appended with DEV=F *log_file_name*. Alternately, TFILE OPEN can be used to maintain a single log file record of the RUN output.

If any command aborts, i.e. is terminated due to some error, processing continues with the next command in the RUN file.

2.6   Keyboard

For compatibility reasons, McIDAS keyboard normally is in CAPS-LOCK state. All key-ins are KEYWORD names are expected in upper case only. Note that the McIDAS control program key-board state in the command window is not always indicated by workstation's CAPS-LOCK indicators. Usually this is not a problem unless a UNIX file name is being specified in the Command window, in which case the SHIFT key must be temporarily depressed. All default McIDAS internal file names are in upper case.

The ESC key serves two functions within McIDAS-X. If this key is pressed while typing a command in the Command window, the typed entry is cleared. If however the key is pressed at any other time, it prompts the user for a name of a file containing the script for a Function Key based menu interface. If hit accidentally, a simple ENTER will close that window (and indeed this is necessary to return control of the keyboard to the user).

The key-board state in other X windows is not affected and is consistent with the CAPS-LOCK indicator light if any on the workstation.

2.7   Programmable Function Keys

Often used commands can be invoked quicker with the capability of programmable function keys. The 12 function keys available on most workstations are named KEYF1 through KEYF12 and can be programmed using the **TE** command with a specific command, e.g.:

```
TE KEYF1 "WHERE FRAME 1 4
     KEYF1 = WHERE FRAME 1 4
```

Anytime the function key F1 is pressed, the programmed command is executed. It is also possible to assign multiple commands to a single key by separating them by a semi-colon:

TE KEYF10 "?;WHERE AREA 100 110;LISTDDB 10;OS "ls /cdrom

Pressing the F10 key will initiate the sequential execution of the four commands assigned to that key and will first provide the McIDAS processor status, list contents of areas 100 through 110, list the Data Description Block (DDB) for area 10 and send a command to the native operating system to list the directory of the /cdrom directory.

2.8   Environment Table

An environment table capability enables keyword parameters to be passed to commands that use that keyword. The environment table basically consists of keywords used by McIDAS commands which can be assigned values using the TE command. A McIDAS command will 'read' this table to scan if any of the keywords used in that command exist in the table and use the value assigned if the keyword exists in the table. If the keyword is also entered via the key-board as part of the command, then that value takes precedence over the environment table value.

TE DAY "79006

If the LA command is then entered from the keyboard with a certain range of area numbers to list, then only the ones that contain images acquired on day 6 of 1979 will be listed as DAY is a valid keyword for LA.

The environment table can be listed with the TL command and saved/restored in/from a named file with the TU command. Thus a user can create multiple environment tables for different types for data analysis.

2.9 McIDAS-eXplorer Commands

A variety of tools or commands 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, cross-sections etc. Map outlines and gazetteer files provide ability to visually identify the geographic features. General purpose utility applications provide housekeeping functions and for 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. Many of these commands are part of the core McIDAS-X on which eXplorer is built.

McIDAS commands are generally written in either FORTRAN or C and compiled. Users may write their own applications in the McIDAS environment making use of the subroutine libraries provided as part of the McIDAS-X license.

2.10 Right Tool for the Task

McIDAS-eXplorer has tools to import, process and analyze planetary images from PDS CD-ROM volumes. Currently Voyager images of the giant planets and their satellites and ring systems, Magellan SAR images of Venus surface, Pioneer Venus Orbiter Cloud Photopolarimeter images of Venus clouds can be calibrated (shading and geometry) and navigated. Support for other data products such as Galileo SSI images and hopefully Mars Observer will be added in the near future. Once these data are imported within McIDAS-eXplorer, they can be gridded, map projected, animated, brightness normalized and filtered. Three color composites and multispectral classification 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.

Although many of these commands are quite general in that they can be used for data from any solar system object or spacecraft mission, some of them are very specific to a particular mission and data. For example, there are a set of specific commands that are limited to data from Voyager 1 and 2 missions to perform tasks related to the analysis of the images

which have very specific properties requiring specific processing. Similarly the Magellan SAR and topography data have a set of commands that are not useful to any other data. Such mission specific commands are described in Section 4.

The commands available to import planetary image data currently are described in Section 4 in detail. These commands are supplemented by the core McIDAS commands to manipulate the image and other data. The core McIDAS commands are described in a separate volume which is available upon obtaining the basic McIDAS license from UW-Madison/SSEC.

2.11   IMPORTING DATA into McIDAS-eXplorer

Most of the planetary data analysis takes place from "archived" data as opposed to "real time" data which is more typical with earth meteorological satellite environments. The most common format now for the archived planetary data is the CD-ROM. Appendix I contains a list of the data available through PDS in this format. One notable exception is the HST WF/PC data which are so far available only on 9-track or Exabyte tapes, usually in FITS format.

There is another medium or format of data input/output from Digital Audio Tape (DAT) cartridges available from within McIDAS-X. If a DAT drive is available on the system, then McIDAS areas can be saved as individual files on these cartridges and restored later. This is a fairly attractive method for short/long term archiving of processed data as these cartridges can hold up-to 8 Gbytes (compressed) of data. Thus as the McIDAS work-space gets full, the image areas can be stored and restored as desired.

McIDAS-X stores image data in files called "areas" all of which have names of the form "AREAxxxx" where xxxx is a four-digit number. Each "area" contains one single image which can be multibanded. As many as 9999 areas can be accessed by McIDAS from the "/u1/mcidas/data" sub-directory. This sub-directory can be thought of as workspace for McIDAS-X, and needs to be large enough to accept the data to be accessed as well as for any output created, and typically this is the largest directory.

If another directory name is desired for the default data directory, it can be specified by the core **REDIRECT** command.

Reading data from PDS CD-ROM's
The first challenge is to know which particular CD-ROM volume to load into the CD-ROM drive to read the data. Some familiarity with the mission is useful to select a specific image and a CD-ROM volume for a given target object. This task can be accomplished in several means. One is to browse through the CD-ROM contents for a specific mission or a solar system target either directly (outside of McIDAS-eXplorer), or using the browse feature included in most data importing commands for the PDS data which allows to create a visual, thumbnail view of a number of images that can be viewed at once. Another is to use the database features included within McIDAS-eXplorer to select a certain image and the CD-ROM volume on which it can be found. There are two means of searching the database, one is a generic database program within McIDAS-eXplorer (DBL command) and another is to use a mission specific command (e.g. FINDVGR for Voyager images). More in information on how to use these commands can be found in the user guide (Chapter 4 and the command reference).

Assuming that a particular image has been located on a specific PDS CD-ROM volume, the user can proceed to import that image into McIDAS-eXplorer as described below.

Mounting and Unmounting CD's

Most versions of UNIX require that a CD-volume be mounted before it is recognized by the system, and McIDAS-X is no exception. Here is how to mount and unmount the CD's:

changecd

(physically remove the CD-ROM in the drive if there is any) and insert a new CD into the CD-ROM reader, and then click with the right mouse button in the active frame window to finish the mount process. The CD-drive light should go on to read the directory which indicates that the command has taken effect.

Note that the contents of the CD-ROM can be queried using the UNIX command ls via McIDAS-eXplorer by typing in the Command window:

OS "ls /cdrom

At this point the data from the particular CD inserted into the reader is accessible from within McIDAS-eXplorer though mission and data specific commands or via the GUI. These commands have a prefix GETabc where abc refers either to the specific mission or the mission specific data type. For example, GETMGN, GETALT and GETMGXDR all refer to different commands to import data from PDS CD-ROM volumes containing Magellan SAR mosaicked images, Altimeter data or Global composite data). Similarly, GETVGR imports Voyager 1 and 2 images of the outer planets and their satellites, and GETGO and GETVO are used for Galileo Orbiter and Viking Orbiters 1 and 2 images respectively.

The GUI also allows a means to mount and unmount CD-ROMs.

Importing Planetary Data from other than PDS CD-ROMs

Planetary data from other than PDS CD-ROM sources can be imported into McIDAS-eXplorer if the target data is in a FITS format file using the GETFITS command. This enables the attached FITS header to be decoded to use the calibration and navigation information if any. If the data do not come with a FITS header, then assuming the size of the header is known and the data are stored in a simple binary format (one or two bytes per pixel (signed integers only), MAKIMG can be used to import the data. Any supplementary information about the navigation can then be attached manually using commands such as DDBUTIL and NAVUTIL.

The different planetary data for which there is explicit support within McIDAS-eXplorer are described in the next section.

3. PLANETARY DATA SUPPORTED BY MCIDAS-eXPLORER

The primary data supported by McIDAS-eXplorer are the imaging data from NASA's various missions to solar system targets that have been published by the Planetary Data System (PDS) on CD-ROMs. To date the missions whose image data are available include the Voyager 1 and 2 missions to the outer planets, Viking 1 and 2 Orbiter missions to Mars, Magellan mission to Venus and Galileo Orbiter data collected during the Venus, Earth, and Moon encounters on its way to Jupiter. These data are described briefly below.

3.1 VOYAGER IMAGES OF THE GIANT PLANETS AND THEIR SATELLITES

The imaging system on each of the two spacecraft was nearly identical- each carried a wide and a narrow angle vidicon camera. Each camera was equipped with a filter wheel with eight filters. The filters on the two spacecraft were nearly the same with the exception of a methane band filter on the Voyager 2 wide angle camera that replaced the blue filter on the Voyager 1 filter wheel. The face plate of each of the cameras was etched with a pattern of 202 reseau marks that were nominally 3 x 3 pixels wide. Their positions were measured to a $\pm$ 0.001 mm accuracy on the ground. The details of the imaging system and the calibration of the data can be found in the report by Benesh and Jepson (1978). The camera characteristics are summarized in Table 1 for completeness.

Table 1

Voyager Imaging System Characteristics

Spacecraft Camera	VGR 1 Narrow Angle	VGR 1 Wide Angle	VGR 2 Narrow Angle	VGR 2 Wide Angle
Focal Length,mm	1502.38 ± 1.37	200.47 ± 0.39	1503.49 ± 0.39	200.77 ± 0.23
Frame Size	800 x 800	800 x 800	800 x 800	800 x 800
FOV*	0.44989x0.44989	3.34888x3.34986	0.45022x0.45022	3.36174x3.36745*
Pixel Size** (μrad)	9.12	68.34	9.11	68.23
Filters	6	5	6	5
	Clear	Clear	Clear	Clear
	Violet	Violet	Violet	Violet
	Blue	Blue	Blue	Blue
	Green	Green	Green	Green
	Orange	Orange	Orange	Orange
	UV	-	UV	-

*Average over the entire frame (measured from reseaus)
**Central 100 pixels only (after Danielson et al., 1981)

The vidicon images obtained from Voyager cameras suffer from geometric and radiometric distortions. Before much of the quantitative analysis can be carried out it is necessary to correct the data for these distortions. The removal of the geometric distortions requires the use of the geometric distortion indicated by the known locations of the reseaus and their image locations. The radiometric distortion removal requires the shading files that contain tables of the vidicon response at each pixel for a given exposure.

3.1.1 Pre-Processing of the Voyager 1 and 2 Images

The images acquired from the Voyager vidicons suffer from two kinds of distortions: (a) photometric, and (b) geometric. The photometric distortions correspond* to the non-linear response of the brightness read-out across the image for a uniform incident illumination. This nonlinearity actually is from two distinct sources- (i) non-linear response of the vidicon itself, and (ii) the development of dark current on the vidicon as soon as the image is shuttered. The geometric distortion arises from optical distortions due to the magnetic focusing used in the vidicon system for reading out the image brightness data and results primarily in a barrel type distortion. It is possible to remove both of these distortions to a large degree as described below.

The systematic processing of Voyager images can be streamlined by using a macro command that daisy chains the steps described below as the processing steps need to be sequential. See the macro **DOVGR** for example which will begin with a either Wide or Narrow angle camera images acquired with a specific filter and will sequentially process it to fill the data compression gaps, determine reseau locations, correct for shading including dark noise subtraction using an appropriate dark noise file, perform geometric rectification, and determine a preliminary set of limb points for interactive navigation, all in a single command. Optionally, multiple images can be processed in exact same manner, sequentially.

Within McIDAS-eXplorer environment, whenever the original data are being modified in some form, the application program will always retain the original area and create a new version of the data in another area and will copy the accompanying directory and DDB information as well as make an entry in the audit trail. The original can then be deleted if no longer necessary. Thus if an error is made at any step, the process can be repeated as desired. The individual steps are described below.

3.1.2 Removal of Geometric Distortion

To account for this distortion a network of 202 3x3 reseau marks is etched on the face plate of the each of the vidicons and their positions on the face plate were carefully measured (to a thousandth of a mm) on the ground before launch (Benesh and Jepsen, 1977). The locations of these marks are first measured in the images (using key-in **RF**) and their ground measured locations used to compute the transformation between the observed and expected object space locations. The coordinates for other points in the image are then obtained by bi-linear interpolation. The nominal and found locations of the reseaus in the raw image, and the object space locations in the geometry corrected image can be displayed on using the **RESEAU** key-in. Finally, after the image has been geometrically corrected, there is no need to retain the reseau marks in the image and are generally removed for cosmetic purposes by replacing their image signature with brightness values from the surrounding region. This is also recommended prior to determining photometric function parameters for the image (e.g. with **MINFIT**), so that the reseaus themselves do not anomalously contribute to the photometric function fit.

In order to minimize the effect of round off or truncation error, the output images size is set to 1000 x 1000 pixels, 25% larger than the original size in either dimension. The **GEOM** command accomplishes this latter task.

The required key-ins are as follows:

RF source_area_#   *to measure and store the image locations of the reseaux marks. The spacecraft and camera information as well*

as the nominal reseau locations are retrieved within the
program from the area DDB.

*(If the data are also to be corrected for radiometric distortion, then the command SHADE9
should be used before removing the geometric distortion.)*

GEOM source_area_# output_area# SMOOTH = YES or NO
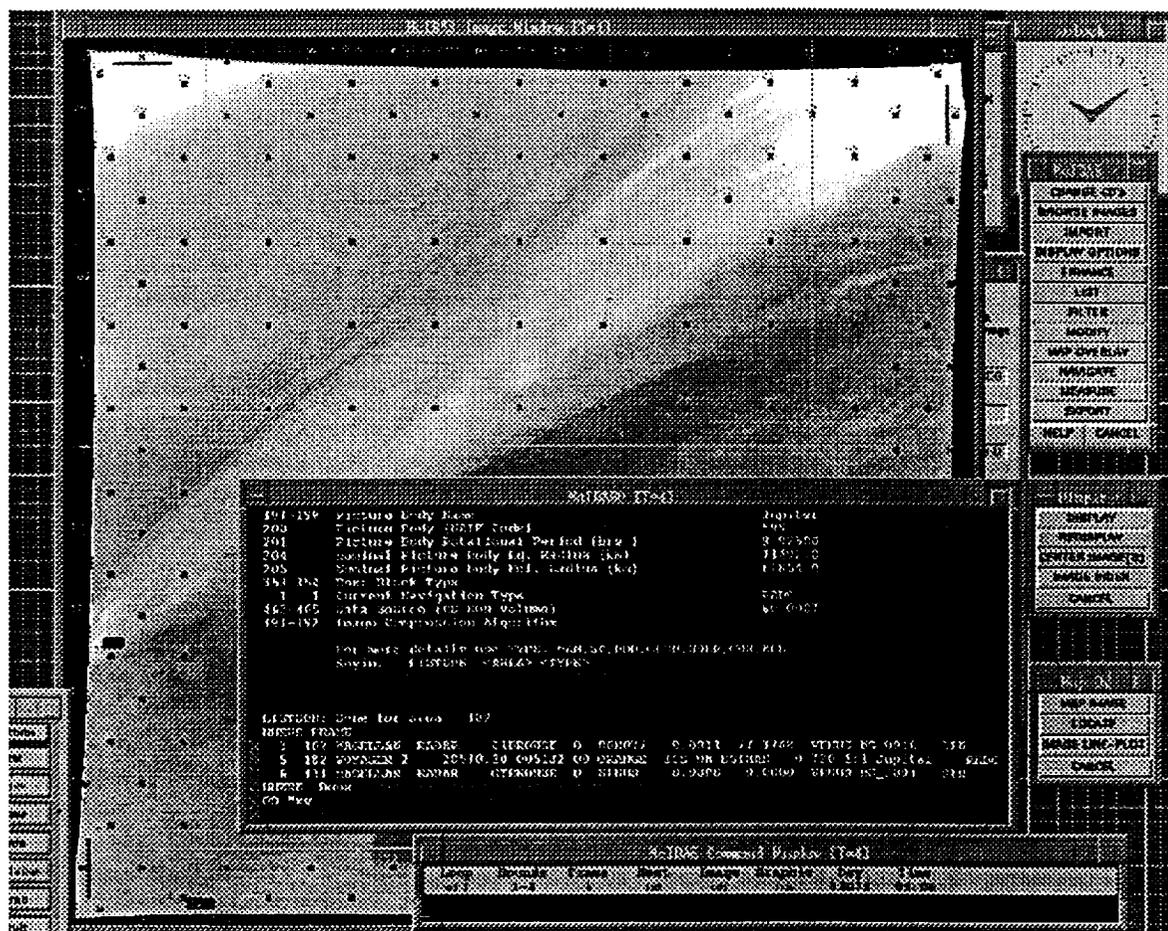
Figure 3.1 Example of a Voyager GEOMed image with the reseau locations displayed
on the image prior to filling them in with the RESREM key-in

*The GEOM step uses the measured locations of the reseaux marks and their
object space locations to remap the input image into another area that has the
distortion removed. The SMOOTH=YES option smoothes the output image by
performing a local average of the immediate neighbors (2/3, 1/3 weighted).
Note that typically the radiometric distortion is removed BEFORE this step as
the shading correction files are usable only in the original (i.e. distorted)
image. Further, the averaging is speeded up through the use of a look-up table
that will currently handle DN values between 0-4095 only. The output of the
shading correction program is generally 2-bytes and is within this range if the
data are normalized using the IOF=1 default option. If the data are
radiometrically calibrated to a greater dynamic range, then the SMOOTH
option should be turned off as it will not produce proper averaging. If the*

resultant image is visually too granular, then it can be smoothed by running a
low-pass filter with a small filter radius (e.g. 2x2).

3.1.3 Removal of Photometric Distortion

Photometric correction requires removal of the dark current signal or dark noise, and correction of the non-linear response of the vidicon. Both of these are image position as well as exposure time dependent. The dark current however has another cause and that is dependent on the rate at which the image is read out by the data system- the current starts building as soon as the image is exposed and keeps on increasing until the image is read out by the vidicon electronics. Thus, the lower the data rate the longer it takes to read out an image and the greater the dark current build up.

| *Dark Current Removal* |

The dark noise begins to build up on the vidicon face plate as soon as the exposure begins, and is thus a function of the exposure time and the image readout time. The image readout time is determined by the data transmission rate. The rates used for transmission of data during the Voyager 1 and 2 encounters with the Saturn system typically used a 3:1 scan rate. The background brightness thus increases from the top of the image to the bottom and from the left to right. As may be expected, the dark noise has quantization noise, so that there is a slight variation from frame to frame and from pixel to pixel. Usually the dark noise frame is therefore generated from average of several frames and/or also low-pass averaged to reduce the noise in the output image

Typically the dark current is subtracted during the radiometric correction step (**SHADE9** command). Occasionally the dark current subtraction alone is desirable for quick-look analysis, in which case the McIDAS **MC** command can be used to subtract the dark noise frame from the Voyager image of interest. The reseau marks should also be generally located in an image prior to dark noise removal and or shading correction.

| *Shading Correction* |

The non-linear vidicon response to uniform incident light manifests itself in differing output brightness levels across the image. The non-linearity of the cameras was determined by measuring the output brightness level in terms of data numbers (DN's) for nine exposures for each filter, and a coefficient determined for each pixel of the image that describes the response of the vidicon for the input brightness at for a given filter at that pixel and saved as a "shading file". Thus, given an image that is exposed at an exposure within the bounds of the shading files, the expected brightness at each pixel of the image can be interpolated from the actual vidicon response and the shading coefficients.
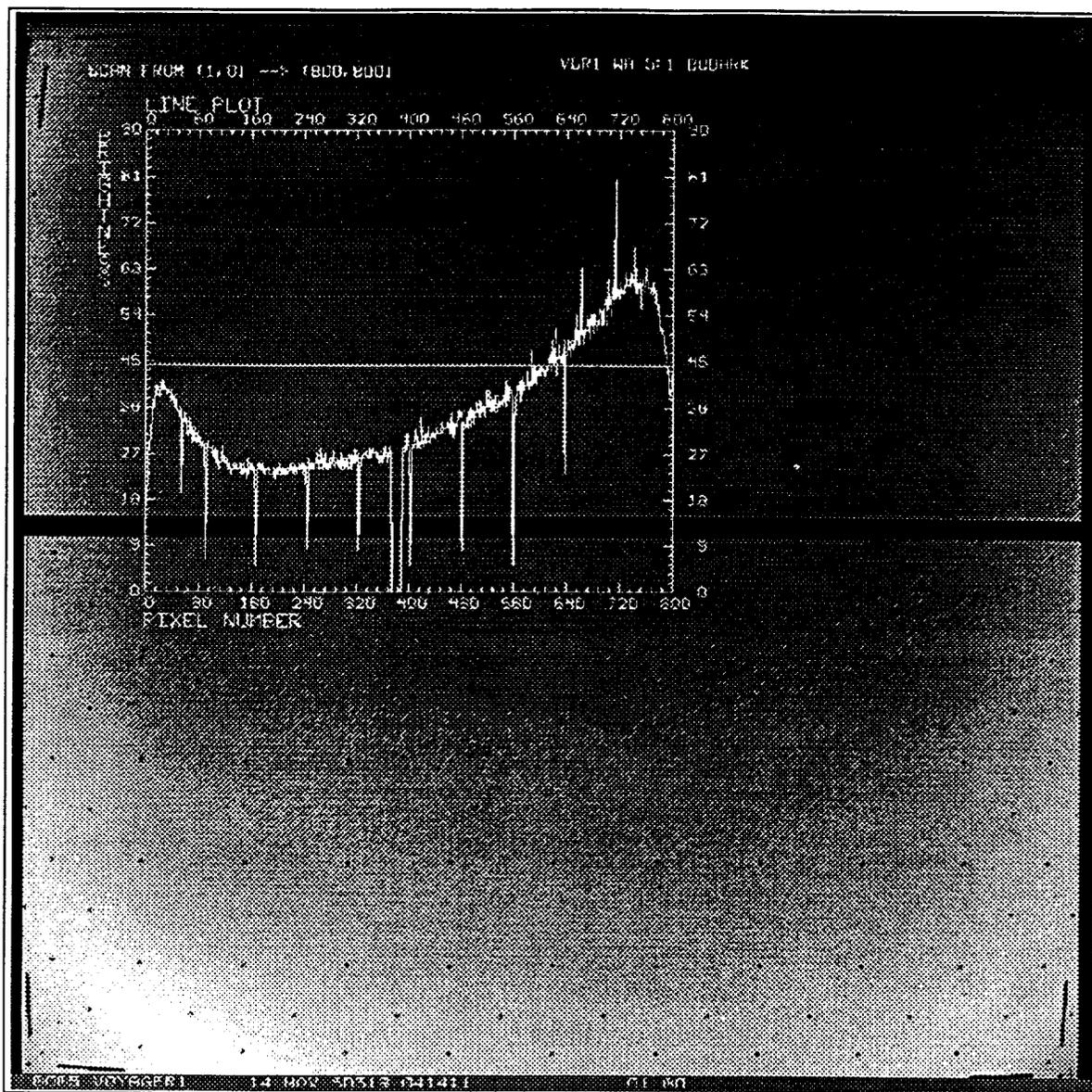
Figure 3.2 An example of a Voyager 2 Wide Angle camera dark frame. A line plot across the image along line 800 shows the variation of the background brightness level. The signature of the reseau marks is readily apparent.

The shading correction files are voluminous, occupying nearly 12 mbytes per filter. Their names are of type VGRnXm, where n is 1 or 2 indicating Voyager 1 or 2 spacecraft, X is the camera identifier, N for narrow angle camera and W for wide angle camera, and m denotes the filter number on that camera (between 0 and 7). These files are normally expected in the default data sub-directory. They may be compressed to only about 24% of their original size using a loss-less compression scheme when not in use.

3.1.4 Image Navigation

Image navigation is the process of relating the image co-ordinates of a feature to their planetary coordinates or vice versa. For the Voyager images this step does not have the potential to add photometric "noise" to the image. However, the procedures to bring out subtle

image features such as color composites or image normalization require a precise navigation. Thus navigation can indirectly add photometric noise to the processed image if the scattering angles are imprecisely or incorrectly computed. There are two separate means of accomplishing the image navigation. The simplest is to use the NAIF SPICE kernels, if available. The second is to utilize the SEDR information and determine the image center using constrained or unconstrained fit(s) to the bright limb as described below.

3.1.5 Center Finding

For objects whose surface is obscured by clouds, such as Titan, or the gaseous planets with no "fixed" surface features, the navigation process relies on the observing geometry, the camera characteristics and the physical shape of the object. The first task is to determine the location of the center of apparent disk of the target object. This is readily done for a spherical object by determining the position of the distinct periphery of the object, the "bright limb". Since the solid surface is not being imaged for most of Voyager data, the visible limb does not have a sharp edge characterized by sudden change in the brightness in a scan across the disk, but a gradual one and requires the use of an edge detection technique to locate the limb. The technique usually employed is the maximum brightness gradient one which usually is assumed to reflect the location of the level where the slant optical depth equals unity.

In the case of Venus and Titan this limb is a considerable distance above the solid surface (determined from radar and radio occultation data respectively). Further, the height of the detectable limb of Titan has been measured to be different at different wavelengths from both Pioneer 11 observations (Tomasko and Smith, 1982) and from an analysis of Voyager images. There is also evidence that the height of the detectable limb is considerably different at low (i.e. backward scattering) and high solar phase angles (i.e. forward scattering) for Titan. To enable use of different radii at different wavelengths, eXplorer uses a modified NAIF Object Identification code that allows a wavelength dependent radius to be used seamlessly for objects with extended atmospheres.

3.1.6 Use of SPICE kernels

If available, the NAIF-SPICE kernels for an image can be utilized to attach navigation transform using the GETSPICE command. These kernels are available for a limited number of Voyager Jupiter and Saturn images from Voyager 1 and 2, and for all of Uranus and Neptune system images from Voyager 2. Note that with SPICE kernels, some of the information that is provided in the Voyager SEDR record is not available directly and hence the DDB entries for those quantities will not be filled unless GETSEDR is also used for that area.

Sometimes it is desirable to improve upon the SPICE-kernel navigation, either to update the planet image center location or the north angle. NAVUTIL can be used to update the navigation. In future a utility to output the SPICE kernels in the NAIF compatible format from any eXplorer image navigation would be useful.

3.2   VENUS IMAGES: MAGELLAN, GALILEO and PIONEER VENUS MISSIONS

There are four US space missions which have returned a significant amount of VEnus images and most of which is available on PDS CD-ROM volumes. Mariner 10 obtained nearly 5o00 images using two vidicon cameras over a period of about 8 days on a fly-by trajectory to Mercury, its ultimate target. These data are not yet available on PDS CD-ROMs. In 1978 the Pioneer Venus Orbiter began acquiring images of Venus from orbit using a spin scan technique. The Orbiter Cloud Photopolarimeter (OCPP) instrument acquired nearly 4000 images of Venus' cloud cover over a time approximately 7 years in reflected sunlight and filtered through a narrow band 365-nm filter. It also acquired many full disk polarimetry maps at 270, 365, 550 and 935 nm over a longer duration. As Venus is completely covered with clouds, images in reflected solar light acquired by Mariner 10 and Pioneer Venus reveal only the cloud features of Venus. Magellan mission has returned synthetic aperture radar images of the surface and high vertical resolution topography data over nadir footprints along the Magellan orbit tracks. The surface imagery from Magellan is available on PDS-CD-ROM volumes as Mosaicked Image Data Record (MIDR) in a variety of different spatial resolutions in a mapped format. The Pioneer Venus mission and Magellan mission have together returned a significant amount of image data. Subsequently, Galileo Orbiter, on its way to Jupiter via a Venus-Earth-Earth Gravity Assist (VEEGA) trajectory to Jupiter also acquired a small number of images of Venus in reflected solar light through blue and near infrared filters. These data can also be imported into McIDAS-eXplorer and manipulated as described below.

3.2.1   Pioneer Venus OCPP Images

OCPP images are available in the roll-by-roll format on NSSDC archive tapes. Other files on the tape describe the tape format as well as the orbital elements for the Pioneer Venus orbiter and other information necessary for determining the navigation transform (PVORBELE, PVOATTSPN). GETCPP command imports data from the tape files into a McIDAS area and also attaches a preliminary navigation to the area.
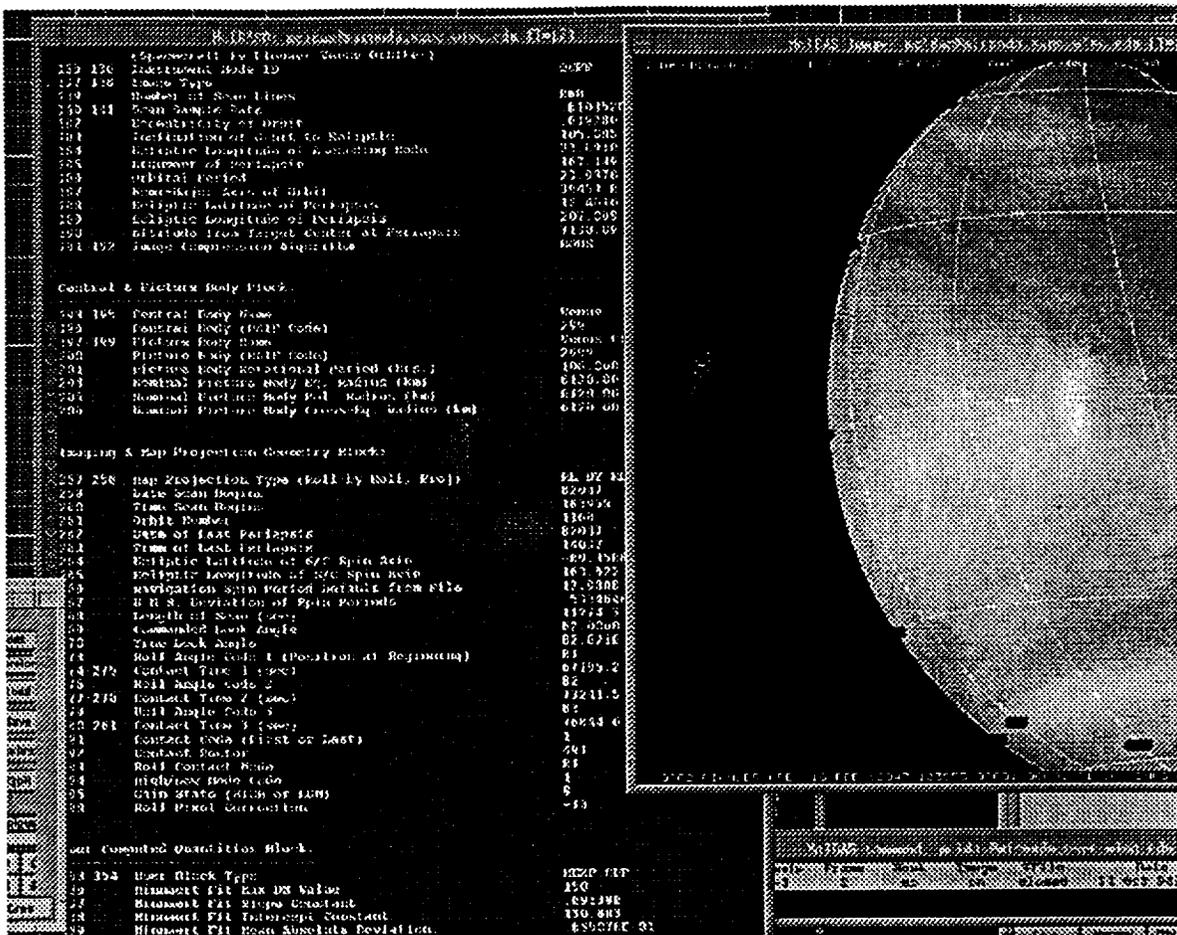
Figure 3.3 A navigated, roll-by-roll OCPP Venus image with the latitude longitude
grid is shown in the image window. The text window shows a portion of the output of
the LISTDDB command listing the DDB contents pertinent to that image.

Usually the nominal navigation performed using the spacecraft and instrument
geometry data can be refined by interactively determining the look angle and roll-angle by
matching the expected location of the Venus bright limb with the observed location. The
improved roll and look angles can be input to the DDB attached to that area using the
NAVCPP command.

Venus due to orbital motion in its eccentric orbit, the images can be mapped into a
more suitable projection using either MAKNAV or PLANAV projection navigations and either
REMAP or NRMIMG. NRMIMG requires that the Minnaert scattering coefficients be known
and can be determined using MINFIT.
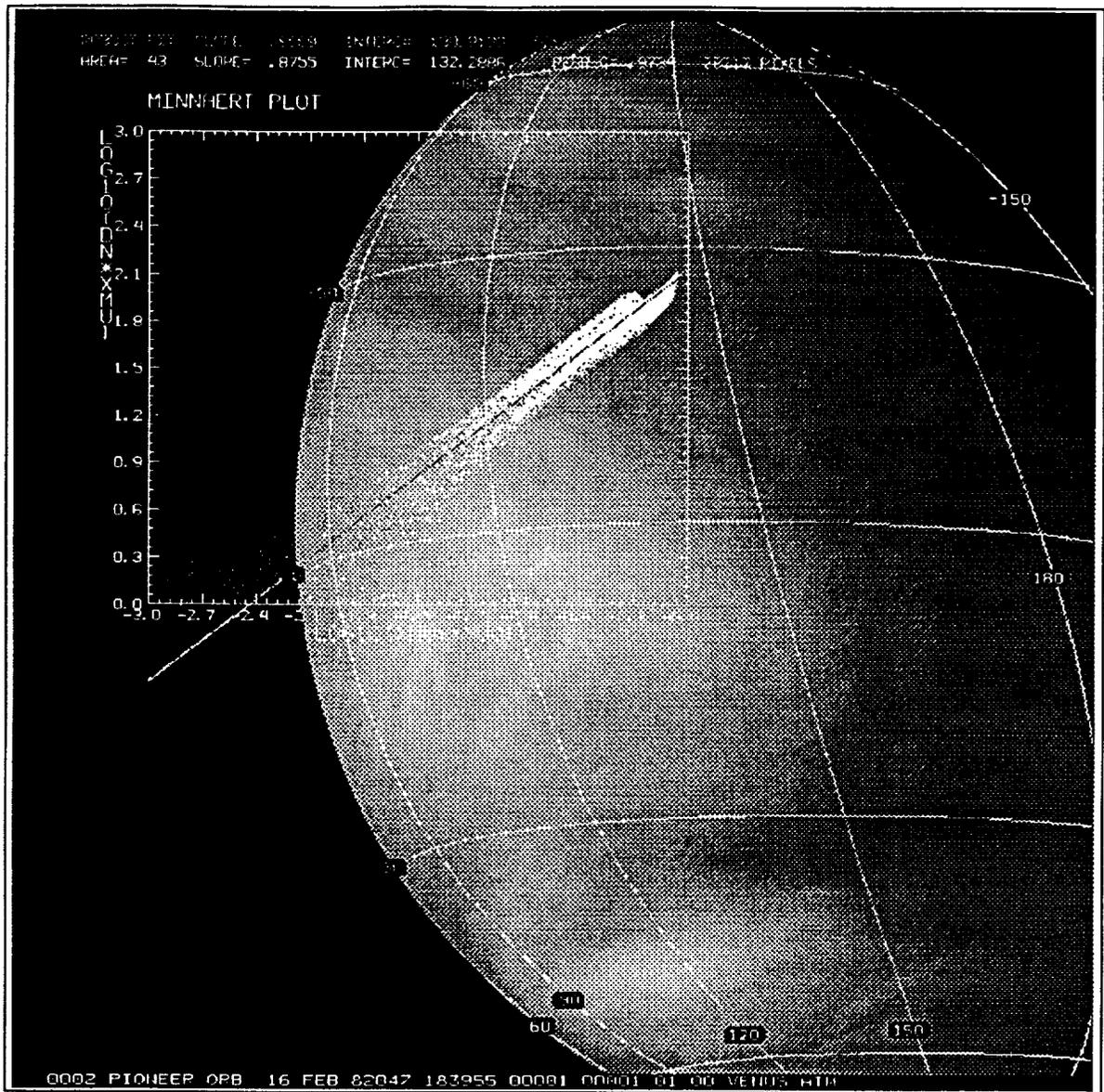
Figure 3.4 Plot generated by MINFIT command depicting the linear and robust fit to the brightness data. The Minnaert coefficients are stored in the DDB for the area which can be used by NRMIMG to remove the photometric shading.

Pioneer Venus OCPP images are normally available from NSSDC on 9-track tapes. The individual files containing the images can be imported into a McIDAS-eXplorer workstation via any available means (local tape drive or over a network). Unlike majority of the images acquired by NASA's solar system missions, the OCPP images were obtained using the spin scan technique pioneered by the geosynchronous earth weather satellites and also used on Pioneer 10 and 11 spacecraft to reconnoiter Jupiter and Saturn in the 1970's. In the case of the OCPP images the spin of the spacecraft provides a swath across the disk of Venus and the orbital motion of the spacecraft translates the successive scans across the disk of Venus. The CPP telescope optic axis is in a plane containing the spin axis of the Orbiter spacecraft and can be pointed between 45° and 135° with the spin axis. The spacecraft spin axis nominally points towards the celestial south pole. At the beginning of acquisition of a full disk image the Telescope is pointed towards the farther cusp of Venus and held there such that the orbital

motion will carry it to the other extreme of Venus disk. At this time to acquire another full disk image the telescope is repointed. A full disk image thus takes anywhere from 2.5 to 5 hours to acquire depending on the position of the Pioneer Venus orbiter in its highly inclined (105°) highly eccentric (0.8453) orbit. Consequently, NAIF SPICE kernels are not available for these images. Instead these images are navigated using the knowledge of the spacecraft orbit and imaging geometry. A single McIDAS-eXplorer command will import and navigate the raw roll-by-roll images into McIDAS areas as described below.

GETCPP

This command will import a Pioneer Venus OCPP image into a McIDAS-eXplorer area and attach the necessary navigation transform to it by retrieving the appropriate information from supplementary files stored within the /mcidas/data sub-directory. The image can then be manipulated , e.g. remapped, gridded or brightness normalized using the general McIDAS commands.

> CAUTION: If the time of observation is critical for analysis, e.g. in measuring cloud drift winds, then the nominal image start time with which McIDAS-eXplorer images are tagged with should not be used for Pioneer Venus images as each image takes several hours to acquire and time difference between the same regions on Venus in two successive full disk images is not constant. Use **CPPTIM** command to determine the observation time for a given location in a navigated OCPP image.

3.2.2 OCPP Polarimetry Data

These multispectral observations are available on tapes from NSSDC in a roll-by- roll format but with a significant difference. The pixels are already navigated. Because of the very low spatial resolution of these data, an image can be created by two-dimensional interpolation of the polarimetry mode data in a particular map projection.

3.3 MAGELLAN IMAGES OF VENUS SURFACE AND ALTIMETRY DATA

Magellan data is the largest component of the PDS CD-ROM data with nearly 130 volumes of radar imagery of Venus surface and 15 volumes of nadir altimetry and radar reflectivity data on the Venus surface. These two data can be linked in a displayed frame. There are also two CD-ROM volumes containing a global mosaic of the radar altimetry and radiometry data. There are separate McIDAS-eXplorer commands to import these data for analysis. The radar images require no further systematic processing as the required processing has already been performed. The only exception is if the radar reflectivity in calibrated units is required, in which case a special command converts the image from raw data units into calibrated units.

The radar images are stored in three different formats as components of a global maps. The individual components are mapped in a sinusoidal projection and are available at three different resolutions. Each CD-ROM volume also contains a 8-X reduced resolution 'browse' frame to provide a larger context for a specific geographic location. The steps in displaying a region of interest are briefly described below.

FINDFF, GETMGN and TILES

These three commands collectively enable the user to locate and import a radar image into McIDAS eXplorer. FINDFF searches the cumulative index (from the last MIDR volume, MG_0123) to determine the CD-ROM volume containing a region given by latitude and

longitude or by a feature name if known. The **NAMES** command can be used to list the named surface features on Venus.

Once the CD-ROM volume has been located and mounted in the CD-reader, GETMGN will import that frame into a McIDAS area from which it can be displayed using the DF command. If useful, the browse frame can be imported first, in which case the user is provided the option to import a full resolution image of one of the 56-component pieces (also called 'tile' or a 'framelet' or 'chip') of a browse frame by selecting a specific number from the displayed image. The tiles can be re-drawn using the **TILES** command.
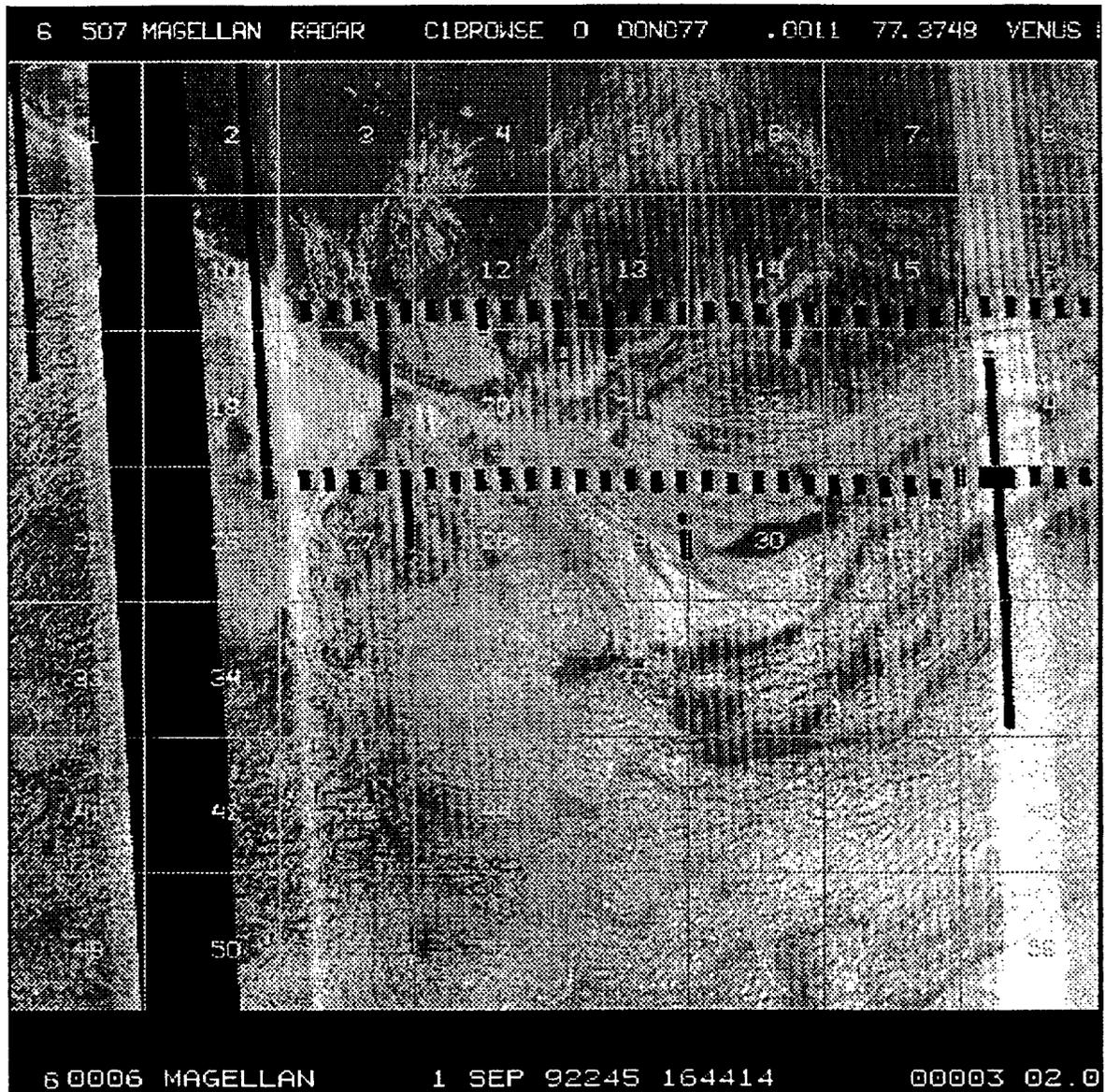
Figure 3.5 An example of a Magellan browse frame with the individual tiles shown. The tile numbers and locations are drawn by the TILES command on a C1-MIDR browse frame. With SCANM key-in any of these tiles can be retrieved from the CD-ROM in specified areas. SCANM is an interactive command and can be used to import more than one tile from the displayed browse frame from the mounted MIDR CD-ROM into consecutive areas.

FINDALT

FINDALT searches the ARCDR index to locate a particular CD-ROM volume on which the altimetry and radiometry data corresponding to a given orbit is stored. The Magellan orbit number corresponding to a specific location on Venus is most readily determined by scanning the audit trail of an area containing a Magellan radar image (F or any C-MIDR) by using the LA *area_#* FORM=AUDIT command.

GETALT

GETALT will retrieve the radiometry and altimetry data for that orbit and plot it on the screen over a displayed image of that region assuming the proper ARCDR volume has been mounted in the CD-ROM reader. ARCDR data are organized by orbit numbers. **MGNORB** can be used to guess the orbit number for either a nadir look (altimeter) or the side look (radar) for a given location on Venus indicated by the cursor location in a displayed MIDR image.
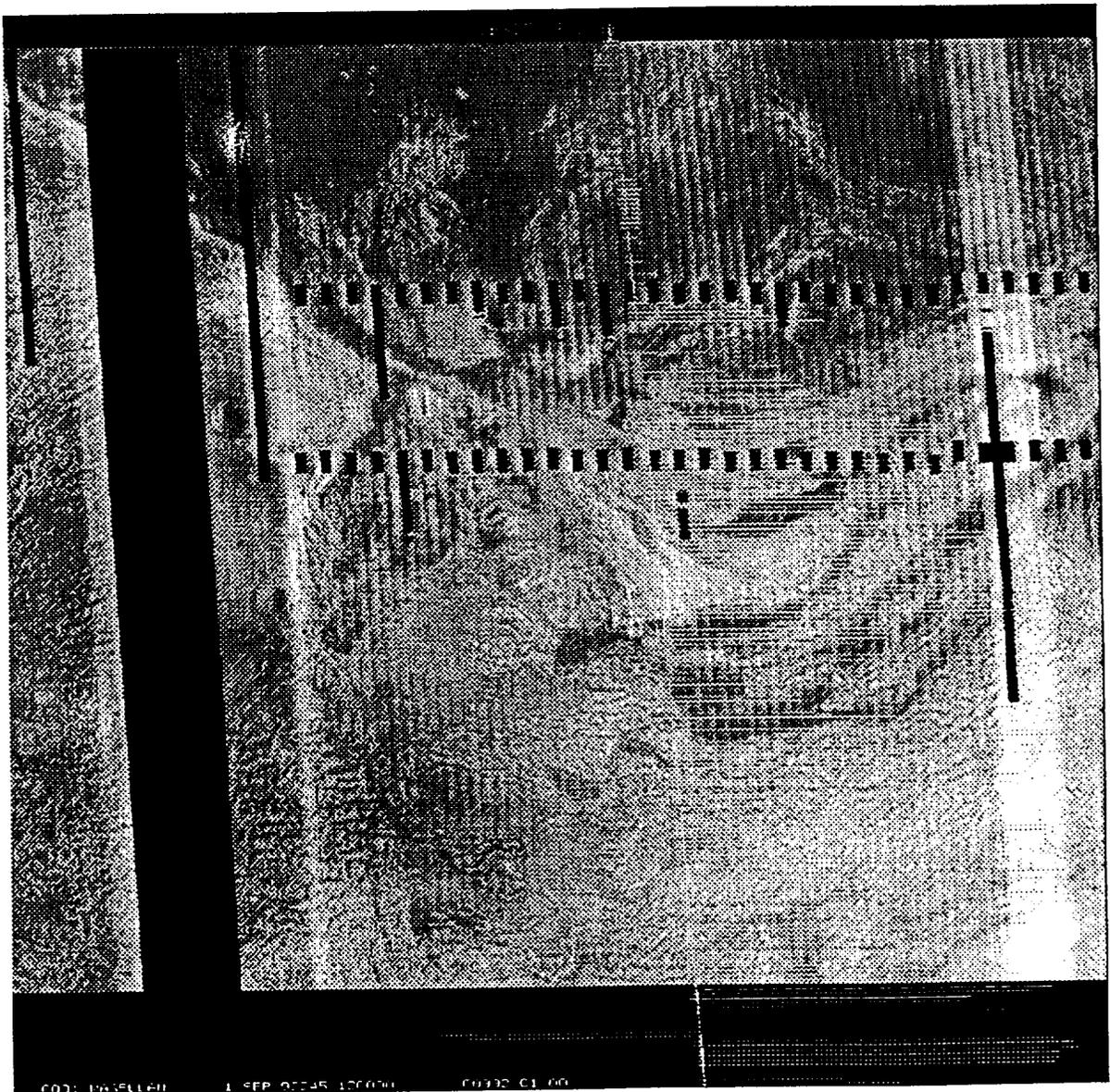
Figure 3.6   An example of Magellan altimetry data retrieved from ARCDR's and displayed on a composite of the Ovda region created by remapping several F-MIDR images. The spacecraft orbit track is shown by the + sign passing roughly north-south while the radius at each footprint is shown as a horizontal barb. MGNORB key-in will retrieve a very good guess for the orbit number and display the radar and altimeter footprint for a given Venus location.

3.4   GALILEO SSI IMAGES OF VENUS

Galileo SSI images of Venus resemble the Mariner 10 images of Venus taken during 1974 in terms of spatial and temporal coverage. Both acquired images from a fly-by trajectory and over a limited period. The temporal and phase angle coverage is thus limited and the spatial resolution varies with time. The main difference is that Galileo SSI has only one camera (two on Mariner 10) and that the detector is a CCD chip rather than a vidicon. Only about 81 images were acquired and these are contained on the PDS CD-ROM GO_0002. These images were obtained with the glass lens cover of the camera system still in its closed position. Therefore a number of blemishes (diffraction images if dust specks on the lens cover) appear on the Venus images which are mainly a cosmetic annoyance. The blemishes can be subdued using the **BLEMEDIT** command interactively if needed.

These images, like all other Galileo SSI images, can be imported into McIDAS-eXplorer environment with the **GETGO** command. SPICE kernels are generally available for these images in the PDS label, however, the experience has been that the north angle is frequently in need of adjustment. **NAVUTIL** can be used to make the desired changes.

3.5   IMAGES OF MARS: VIKING ORBITER IMAGES AND DIGITAL IMAGE MODELS (MDIMS)

The primary sources of Mars image data are the Viking Orbiters available on PDS CD-ROM volumes and the processed image products the Mars Digital Image Model data available on CD-ROM volumes produced by the USGS. The Viking EDR data are stored on the CD-ROM's in a loss-less compressed format without any other processing such as radiometric or geometric calibration. In order to use these images for any quantitative analysis such processing must first be performed on the images. At present the required programs or files for performing these steps do not exist within McIDAS-eXplorer. The Viking images can be imported into McIDAS-eXplorer using the **GETVO** command.

Processed Viking images are also available on a set of CD-ROM's through the USGS as Mars Digital Image Models. These disks contain cartographic projections of the Viking data which have been pieced together and stored as sub-sections of a global map. These individual images can be imported into the McIDAS-eXplorer environment using the **GETMDIM** command.
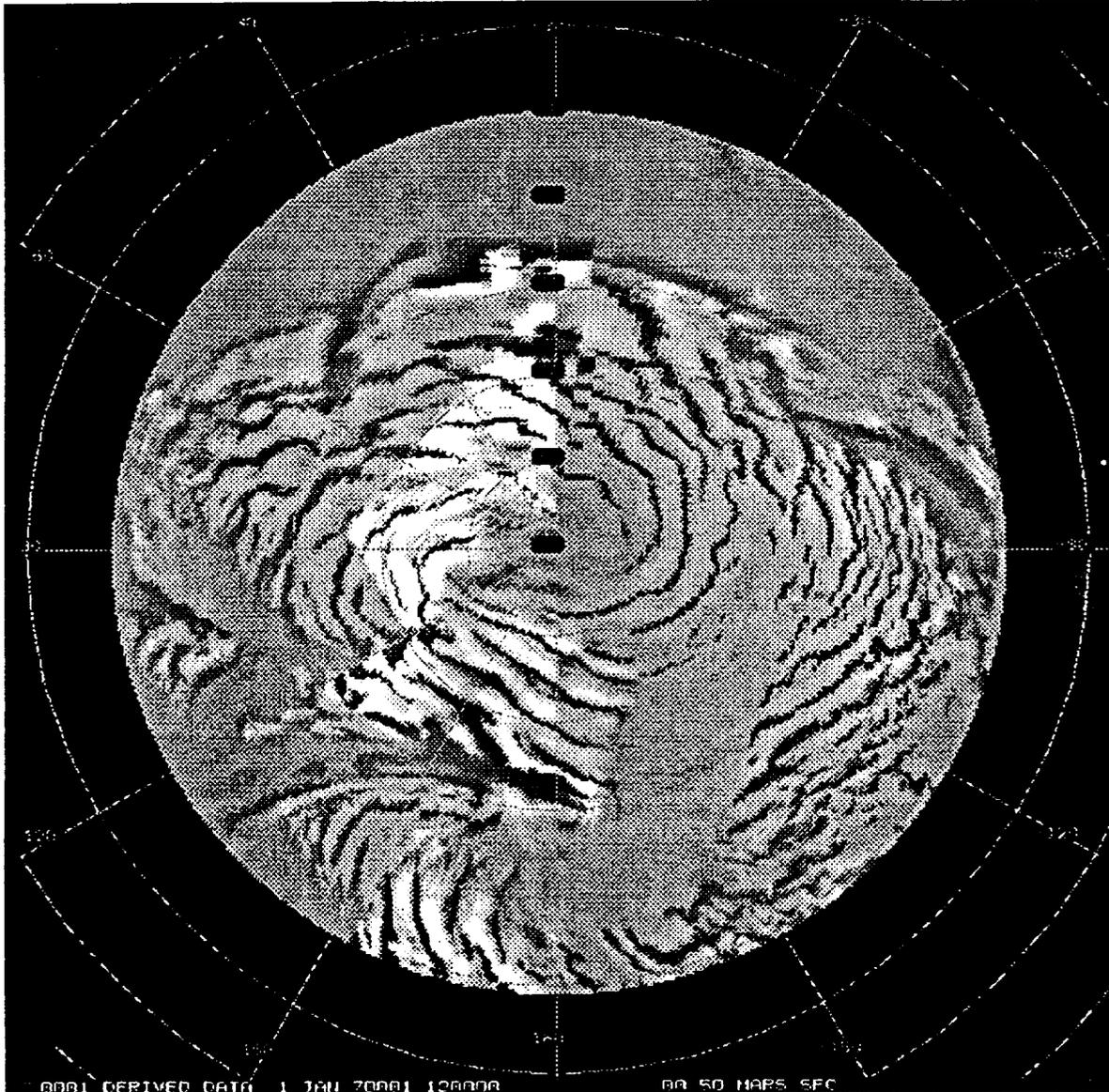
Figure 3.7. Example of a polar stereographic projection view of the Mars' North polar region retrieved from one of the MDIM's displayed with a latitude longitude grid.

HOW TO IMPORT DIGITAL IMAGES INTO MCIDAS-eXplorer

Before any image can be displayed or manipulated within McIDAS-eXplorer, it must first be imported into its database, which usually resides in the default ˜mcidas/data sub-directory on a workstation. The process of importing the image creates an area "directory" and a Data Description Block (DDB) that contain information about the image source, acquiring instrument, imaging geometry or navigation information, digital data calibration, i.e. the conversion of the raw data units into some known physical units, and brightness levels, as well as any text descriptors. As the source spacecraft and imaging instruments differ widely in their characteristics as well as in the exact format in which the images are stored, McIDAS-eXplorer has a selection of commands written specifically for certain known data types which are present in the PDS CD-ROM collection. There is also one general command which will read images with a FITS header (e.g. earth based telescope images or HST/WF-PC images). If the image is not in any of the recognizable formats, it may only be possible to display and manipulate it without the ability to perform native reference frame navigation and calibration of the data. The known data types and the commands that import those data are:

For most of the imaging data on PDS CD-ROM volumes, the McIDAS-eXplorer commands allow the user to create or import browse mode images as well as import the full resolution images into the eXplorer environment. When the full resolution data are imported, the accompanying navigation and calibration information as well as the full PDS label are imported and attached to the data. In general the task of importing or browsing the data is easily accomplished through the GUI provided, but can also be performed readily from the command window by issuing appropriate command(s).

Galileo SSI Images of Earth, Moon and Venus

Use **GETGO** to import images from PDS-CD-ROM volumes GO_0002 through GO_0006 (Volume GO_001 has not been published yet)..

GETGO will also allow the user to create a "browse" area that contains thumbnail versions of a range of images on the CD-ROM, a facility that is common to all the PDS mission specific CD-ROM key-ins. Since the SSI images of Venus reveal only the Venus cloud deck (as opposed to the surface in Magellan radar images), the target name is set to Venus_Cld to reflect the fact that the cloud deck is a considerable distance above the Venus surface, and hence a different radius is required for image navigation.

Magellan Radar Images of Venus surface

Use **GETMGN** to import radar images of Venus' surface from PDS CD-ROM volumes MG_0001 through MG_0123. These volumes contain the Mosaicked Image Data Record constructed from the radar returns at four different map resolutions- F-MIDR, C1-MIDR, C2-MIDR and C3-MIDR. The F-MIDR data has a nominal resolution of 225 meters. The compressed MIDRs are successively 8x sub-sampled at each step between C1 and C3. For each set a browse image containing 7 x 8 grid tiles is also contained on each volume.

The first problem that faces a novice Magellan data user is how to determine which CD-ROM volume to look at? If either the latitude and longitude of a region are known, or the name of a feature, then **FINDFF** can be used to determine which CD-ROM volume the data can be found on. FINDFF will list all CD-ROM volumes that

contain data over the specified region in either the LEFT or the RIGHT look modes and over all three cycles.

GETMGN can be used to accomplish three tasks--(i) create a 'super-browse' image from all the browse images contained on a given MIDR CD-ROM volume and write that image in an area, (ii) import a single browse image into an area, and (iii) import a single tile or a framelet from a selected directory or a browse image. The MIDR data are published at four different resolutions--F-MIDR at 225 m/pixel, C1-MIDR which is once compressed F-MIDR data, C2-MIDR which is twice compressed data, and C3-MIDR, thrice compressed data. Each of the compression steps results in a 8X reduction in spatial resolution and compasses larger and larger area. GETMGN will work with all four versions of the data. However, there are some differences as noted in the remarks below.

1. GETMGN tags the imported data (a browse frame or a a single component tile of the browse image) with a nominal time tag in the area directory that indicates the time (UT) of acquisition of the data. As these are images are mosaicked from many orbits, there is no single time that is appropriate for the image. The time tag corresponds to the *periapsis* time for the *first* orbit number noted in the PDS label for the data that are being imported. The purpose of this time tag is twofold- first, McIDAS expects a valid time for the data stored in an area, and one might as well tag the data with the most appropriate time possible, and second, the time helps distinguish between the three different cycles on which radar data were acquired and also in determining when the altimetry data were likely to have been acquired.

2. Navigation information is attached to the area according to the information contained in the PDS label. Thus the data when displayed, can be overlaid with a map grid, remapped into another projection, composited, etc.

3. The MIDR data have already been corrected for the radar scattering function through the Muhleman scattering law:

   The radar reflectivity can be computed from the digital data if the incidence angle is known at that location. GETMGN stores the incidence angle table associated with each tile in the area so that the radar reflectivity can be computed on demand.

   For C3-MIDR data however, the incidence angle tables are not available, and these data cannot be directly calibrated to radar reflectivity.

4. MGNORB can be used to plot the Magellan orbit tracks on a displayed MIDR image to depict the nadir track, or either the left or right look angle track that passes closest to a point indicated by the cursor position. By assuming nominal orbital elements MGNORB also returns the orbit number on which the data were acquired accurate to within 1 or two orbit periods. This is useful to determine the period when altimetry data could have been obtained on the nadir pass near the selected location.

5. FINDALT can be used to determine the ARCDR CD-ROM volume on which the altimetry data can be found for a displayed MIDR image.

6.   The complete PDS label attached to the browse image or a component tile can be listed for the data imported into an area with the LA *area_#* FORM=AUDIT command.

7.   **LISTDDB** ALL command will list the same information as interpreted and used by McIDAS-eXplorer.

8.   When a superbrowse area is created, the brightness data are dynamically stretched based on the histograms so that the output area will have a nearly uniform contrast over all the component browselets.

Magellan Radar Altimeter Data on Venus surface

Use **GETALT** to import data from PDS CD-ROM volumes ARCDR_2001 - ARCDR_2015. *Note that these are the only non-imaging data that are imported from the CD-ROM volumes by McIDAS-eXplorer.*

GETALT allows the user to examine any of the 22 quantities available for each altimeter footprint. For a single footprint all 22 can be listed on the screen or saved to a file. **GETALT** will also provide a listing of all of these quantities for a given range of footprints along the orbit track in two files containing the first 11 and the last 11 variables respectively. Typically, one of eight selected quantities can be plot as an overlay graph on a displayed MIDR or a GxDR image. The output file is an simple text file with a single header and is organized as a table, suitable for importing into a spreadsheet, or plotting using the **SHOW** utility plotting command.

Magellan Global Topography, Radiometry, and Terrain Data (GxDR's)

Use **GETGXDR** to import images from PDS CD-ROM volume MG_3001 and MG_3002.

GETMGXDR is functionally very similar to the GETMGN command although the organization of the CD-ROM volume is slightly different, and there are four different data types-- topography, slope, RMS slope and emissivity.

Mars Digital Image Model (MDIM's) Data

Use **GETMDIM** to import these images produced by the USGS from Viking Orbiter images of the surface of Mars (VO_0001 through VO_0014).

Viking images of Mars and its moons

Use the **GETVO** command to import images published on PDS CD-ROM volumes VO_1001 through VO_1014.

Voyager images of the giant planets and their satellites

Use the **GETVGR** command for data published on PDS CD-ROM volumes 1-25.

GETVGR accomplishes two tasks--(i) generate a browse area from a range of images (specified by FDS numbers) for a given target (maximum 56), and (ii) import one or more (full resolution) images into one or more areas for a given target object. When importing full resolution images, FILTER (0 through 7 or color) and CAMERA (WA or NA) can be specified to limit the choices.

The Voyager images as published on the PDS CD-ROM's do not have attached navigation and calibration data. Additional steps are necessary to geometrically and

photometrically calibrate the data and to navigate it. The calibration in general requires the following steps:

(i)   Interpolate the data for image compression gaps (primarily Voyager 2 Uranus and Neptune system data).

(ii)   Determination of the image geometric distortion by locating the reseau marks in the image.

(iii)   Photometric calibration of the image (output is a new area) using the shading file for the appropriate camera and filter and a dark current file appropriate for the exposure and data rate. Ideally the dark current file should be created from appropriate dark frames acquired as close in time to the image in question as possible. Typically four or more dark frames should be averaged and/or smoothed spatially.

(iv)   Geometric rectification of the photometrically corrected image (new output area).

These four steps can be accomplished by a single macro command provided appropriate dark noise area is available.

Unlike VICAR, eXplorer does not do internal geometry correction in the navigation of the data, and hence the geometric distortion must be removed by remapping the data into object space prior to making any position measurements.

Refer to **How to Navigate Planetary Images** to navigate the Voyager images.

Images with FITS headers
Use **GETFITS** to import images with FITS headers. If the headers contain enough information about the imaging geometry and calibration, then the images can be navigated and calibrated. If the exact keywords used in the label do not exactly match the FITS specifications, use **FITSKEY** to map the keywords in the label to the expected keywords.

All other images
Use **MKIMG** to import the images which have an unknown label format but whose header length and dimensions are known, e.g. images in uncompressed TIF format (8-bit per pixel data only).

HOW TO NAVIGATE AN IMAGE OF A SOLAR SYSTEM TARGET

McIDAS-eXplorer has tools to navigate images of solar system targets such as planets, their moons. The term "navigation" refers to the process of converting the image or instrument coordinates to a different coordinate frame, usually the native reference frame of the target object. It may also include a different frame located at the observer's location, such as the celestial frame (right ascension and declination) or ecliptic frame (ecliptic latitude and longitude), or any other reference frame whose orientation is known. If the images are of planetary ring systems and asteroids, the navigation tools will be added at a later date. The navigation of moons depends also on whether the moon is reasonably modelled as a triaxial

ellipsoid. In effect this means that the larger moons of the planets can be navigated, and the smaller "rocks" and most asteroids (including Ida and Gaspra) which are highly irregularly shaped and for which a triaxial shape model is not very representative, cannot be navigated as yet. These objects require a detailed shape model is required before navigation can be supported. A facility for handling navigation of irregular objects is feasible within eXplorer, but not yet implemented.

The general approach of navigation of images of planets and regular moons is described below. It is assumed that the images have been imported into McIDAS-eXplorer either from the PDS CD-ROM volumes or, in some standard format recognized by McIDAS-eXplorer, such as FITS or in the case of Pioneer Venus Orbiter images, the NSSDC format. If the images were obtained from the earth or other non-NASA spacecraft, then it is assumed that the imaging geometry information is available in some manner. If it is a full disk image, the minimum information required is the position of the observing instrument relative to the target. If the observing instrument is located on the earth or a planet, then the Universal Time (UT) of observation is sufficient to obtain the relative geometry information using the ephemeris tools incorporated within McIDAS-eXplorer (SUBPNT command), but the orientation of the image itself relative to the target must still be known (which way is the north direction in the image?) For targets such as Saturn and Jupiter, the north angle can be estimated either from the shape of the object and/or the zones and belt patterns, or, occasionally, from the locations of the parent planet's moons if they are in the same image frame. But it should preferably be obtained using reference stars.

For a variety of reasons, including backward compatibility, eXplorer offers a choice of different means to accomplish the desired navigation transform. These differ only in their approach to determining the precise instrument pointing by determining target object (typically its center) location in the data and then using the known imaging geometry to achieve the coordinate transform. Target location usually requires the knowledge of its center which is generally found from the bright limb for low resolution images or offset from known surface features for solid bodies. The location of the limb points allows the target center determination by unconstrained conic fits for most solar system objects. If the target in the observing wavelength is known then a constrained fit can also be used. Once the target center is known the instrument pointing is determined and then the coordinate conversion can be accomplished knowing the orientation of the different coordinate systems at the time the image was acquired. There are three different approaches available in eXplorer as described below. As they are completely independent, any one or all three can be attached to a given image with one of them being "active" as selected by the NAVUTIL command. Further, a fourth navigation type allows the equatorial coordinates to be determined if the camera optic axis pointing and orientation are known.

SPICE Kernel Navigation

For a subset of the solar system images acquired in the past and available on PDS CD-ROM volumes, the SPICE kernels are available (Voyager 2 images of Uranus and Neptune Systems and a limited number of Jupiter and Saturn System images). For newer missions such as Galileo and soon, Clementine, SPICE kernels should be generally available. In some cases the pointing implied by these kernels is not sufficiently accurate and may need to be refined before any quantitative analysis can be accomplished. This refinement requires that the C-Matrix or kernel by updated based on refined knowledge of target object location in the image either by limb fits or by location of known features. How to actually update the C-kernel is described later.

NAIF Navigation Type

For images without any SPICE kernels, the required C-matrix needs to be computed from available information about the imaging geometry. For a spacecraft mission such as

Viking or Voyager, these data are generally available as Supplementary Experiment Data Record (SEDR). The name NAIF here refers to the use of the NAIF FORTRAN subroutine package tool kit to determine the C-matrix directly from the SEDR data. For other data such as ground based images, the SEDR information is not generally available, typically only the time when the image was acquired, and hopefully, some knowledge of the orientation of the imaging system with respect to the target object's reference frame (North Angle). For the NAIF navigation type, eXplorer tools can compute the planet and target object ephemeris using NAIF supplied P kernels.

PLAN Navigation Type

This navigation type is provided for backward compatibility with McIDAS and is redundant. It is however used in the general perspective view navigation. Initially developed for Mariner 10 images of Venus, it was adapted for use with the Voyager images of the outer solar system, and as such used the SEDR data exclusively. For synthesizing views in a general perspective projection from known data the viewing distance, the relative location of the viewpoint (target frame latitude and longitude), the orientation of the image (North Angle) and the look angle (view angle with respect to the vector from the viewpoint to the target object center) can be specified to establish the transform.

RADC Navigation Type

RADC navigation type enables the sky coordinates to be determined if the camera pointing is known. This is useful in optical navigation of some images where the need to determine the right ascension and declination of a point in the image arises, e.g. in locating a new target such as a planetary moon, against a field of reference stars. For Voyager, Galileo and some ground based images the optic axis pointing information is picked up from the image headers and stored in the DDB attached to the area.

HOW TO NAVIGATE VOYAGER (ISS) IMAGES OF GIANT PLANETS AND SATELLITES WITHOUT SPICE KERNELS

Voyager images of the giant planets and their satellites were among the first planetary data to be published on CD-ROM volumes by the Planetary Data System, beginning with Voyager 2 Uranus System images (Volumes 1-3), continuing with selected Voyager 1 and 2 images of Saturn System (Volumes 4-6), selected Voyager 1 and 2 images of Jupiter (Volumes 7-8), and of the Neptune System (9-12). The entire collection of Voyager 1 and 2 images of the giant planets and their satellites and rings are now being systematically issued on Volumes 13-25. Since the Voyager project began before the SPICE navigation system was developed, the images on volumes 7-12 and subsequent volumes do not have SPICE kernels available. These images can be navigated using the Supplementary Experiment Data Record (SEDR) information directly until the SPICE kernels are available. The SEDR data for the Voyager missions can be obtained through the Planetary Data System. Further, for photometric calibration of the Voyager data, raw dark noise frames can be found on individual Voyager volumes, however, the shading correction files themselves have are not yet available on CD-ROM's.

Assuming that the SEDR data is available in the encounter specific formats, the respective images can be navigated as described below.

Pre-processing of Voyager Images

Voyager images were obtained using vidicon cameras. Consequently they suffer from both geometric and photometric distortions. The removal of these distortions is described elsewhere in this document. For the purpose of image navigation, it is only necessary that the geometric distortion be removed. Rather than work in virtual object

space where the distortion is accounted for "on-the-fly", McIDAS-eXplorer assumes that the image to be navigated has already been processed (GEOM command).

GEOM key-in creates a new dataset, or a new "area" in McIDAS parlance, leaving the original area alone. For GEOM to produce a reasonable looking output from images that either have excessive random noise or data compression gaps (Uranus and Neptune encounters), some preprocessing is generally desirable to correct for them. CLEAN and FILL0 are two commands that accomplish these tasks for the Voyager images. If the image is to be used for any photometric measurements, it should be processed with the SHADE9 key-in to remove vidicon shading **before** removing the geometric distortion. Finally, the **RF** command finds the reseau locations in the Voyager images that are needed by the GEOM command. **RESEAU** key-in can be used to list or plot the found (as well as nominal and object space) locations of the reseau marks in the Voyager images.

Note that the FILL0 command also performs another task— it strips off the 24 by-te line prefix in the area that is not used by eXplorer commands (and whose presence is sometimes problematic for some of the older McIDAS key-ins) in that the prefix presence can influence the data addressing.

How to Navigate Earth Based Telescopic Images of Planets

The procedure is similar to that of other framing camera images. First find the limb points using **LIMBPT** or **BRTCEN**.

If necessary, edit the limb points file interactively with **LIMBPT** first (assign the command, "LIMBPT DEL" to a function key, position the cursor over the points to be deleted, and press that function key to invoke the command).

Next, determine the image center using the **IMGCTR** command. Use **REDONAV** to update the navigation for ephemeris and the center, or **RENAVF** to update the image center image coordinates only.

Usually the epehemeris data (sub-earth or sub-observer point and the sub-solar point) on the target object in the target object's native reference frame and the range of the observer are computed using the NAIF toolkit corresponding to the date/time entries attached to the image/area. It is assumed that these quantities refer to the time of acquisition of the data and are UTC values and not refer to any local time zone.

For spacecraft data available on PDS CD-ROM volumes usually there is no ambiguity about the observation time. **However, the earth based data read from FITS files may contain the observation time in any time zone. Worse, often the local time zone may not be noted in the FITS label, and it if is, the difference between the local time and UT may be ambiguous. Also, the one way light time correction may have to be applied for some observations.**

If the observation date and or time are updated (as can be done using the CA command), then ephemeris information should be recomputed for consistency using the **REDONAV** command. If the ephemeris data are contained in the FITS label, these may be used in lieu of the NAIF computations. Please refer to the User Guide for more information on the use of **REDONAV** command.

Please see **Generic Navigation Recipe for Framing Camera Images**

The attached navigation can be examined by displaying the latitude-longitude grid as drawn by the **MAP** command and/or using the "E" key to list the coordinates for a point in the image at the cursor location.

Co-ordinate transformations and zenith angles for points in the target image can be performed for individual points using the LISZEN command. Cartographic projections can also be used to verify the navigation by remapping the source image into one of the many possible projections using either the **AAMAP** command or a combination of the **MAKOUT**, **MAKNAV** or **PLANAV** and **REMAP** commands described elsewhere in this document.

HOW TO NAVIGATE VIKING ORBITER IMAGES OF MARS

At present these images cannot be navigated or processed due to lack of calibration and SEDR data. The processing required for these images is similar to that required for the images from the Mariner 10 and Voyager imaging systems, namely the photometric and geometric distortion need to be removed. Both of these steps require the respective calibration files which are not yet available within McIDAS-eXplorer.

HOW TO NAVIGATE SPIN SCAN PIONEER ORBITER CLOUD PHOTOPOLARIMETER IMAGES OF VENUS

These images are available from NSSDC on computer compatible tapes. McIDAS-eXplorer uses a navigation model for these spin-scan images that is based on the assumption that the spin axis orientation and the average spin period of the spacecraft is constant over the duration of that image. Files containing orbital elements and other required information for the navigation of these images are also contained on these tapes. A preliminary navigation is attached to the area containing the image when the images are first imported (using the **GETCPP** command). These files should have been copied into the default ˜mcidas/data sub-directory previously. The default navigation which depends on the average spin period of the spacecraft, the spacecraft orbit around Venus and the CPP telescope look and roll angles can be verified by drawing a latitude-longitude grid and/or using the "E" key. The navigation can be updated using the **NAVCPP** command if necessary by re-determining the exact look and roll angles based on first/last contact with Venus and the location of the bright limb.

Please refer to the User Guide for information on how to use the **NAVCPP** command.

GENERIC NAVIGATION RECIPE FOR FRAMING CAMERA IMAGES

To attach navigation to a planetary frame, the following quantities need to be known: name (and NAIF ID) of the target object, the location of the sub-observer and sub-solar points on the target object (latitude and longitude), the distance of the observer from the target object, the field of view of the instrument, the number of lines and elements in the image (or, equivalently the pixel size in line and element directions), and the orientation of the target object in the image (where is the target object's North direction?). Much of this information is usually contained in the text labels attached to

the image data, and the importing programs try to decode it. If the labels are in non-standard format, or if the information is missing, the following key-ins will allow the user to create the required navigation.

Finding the Limb Points and Image Center

The limb points can be found by **BRTCEN, EDGES** or **LIMBPT** commands. The limb points can be edited using **LIMBPT** command. The image center and the quality of the limb point fit can be examined using **IMGCTR** command without attaching the navigation information and should be used for testing the limb fits.

Specifying the Image Center

Use **NAVUTIL** to specify the image center if known by other means.

Using the Target Image Center for Navigation

Use **IMGNAV** (To be combined from REDONAV and RENAVF) to recompute the navigation from the specified center. (Until IMGNAV is ready, use **RENAVF** to accomplish).

Re-computing the Sub-observer and Sub-solar point data

Usually the importing program will compute these data for the time of observation (UT). If that time is changed, then IMGNAV (REDONAV until IMGNAV is released) will compute the ephemeris data and update the DDB using the time that the image in an eXplorer area is tagged with. It will use the current center location to attach to the navigation.

Computing the North Angle for Planetary Images with Moons

For images of Jupiter and Saturn taken through small telescopes, particularly amateur telescopes, the north angle of the target object in the image is not easily obtainable, unless there is moon present in the image. The **IDMOON** key-in allows the user to identify one or more moons of Jupiter as well as use the observed image location of the moon to determine the angle the planetary axis of rotation makes with the image scan lines (North Angle).

Finding limb points

McIDAS-eXplorer provides a choice of four commands to determine the limb points in a planetary image. They use somewhat different algorithms and therefore the choice depends more on the image characteristics such as sharpness, contrasts and noise. If the noise is minimal, the edge points determined by these commands are in general consistent. The limb points are stored in a standard file named LIMBnnnn, where nnnn corresponds to the area number in which the image is stored and is padded on the left with zeroes if the nnnn is less than a 4-digit number. A complete copy of the DDB is stored within the limb points file so that the correspondence between an existing file and the digital area can be validated. The limb point finding choices are described below.

BRTCEN

BRTCEN accomplishes two tasks. First, it finds a "first guess" object center by determining the center of brightness (under the implicit assumption that the image is full disk and that the limb and terminator regions are contained in the area). Second, it

determines the locations of the limb points by determining 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.

EDGES
The **EDGES** command allows the edge points for an image to be interactively determined 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 that 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 (LIMBnnnn) is the same as that used by **BRTCEN** command and is recognized by the **IMGNAV** and **IMGCTR** commands.

LIMBPT
LIMBPT is very similar to **EDGES**, but uses a slightly more robust method of edge detection and therefore is less susceptible to noise than either **BRTCEN** or **EDGES**. Another difference is that **LIMBPT** allows you to enclose the right or the left limb with a box (using mouse-button clicks) to limit the search area for the edge detection.

The limb point file (LIMBnnnn) format is the same as that used by **BRTCEN** and **EDGES** commands and is recognized by the **IMGNAV** and **IMGCTR** commands.

PLAEDG
PLAEDG is a more primitive limb finding command that was initially used for Voyager and Mariner 10 images of Venus to find a limited number of limb points for use with constrained fits to find the planet image center location. It is restricted to finding no more than 25 limb points which are stored in a portion of the DDB rather than in a separate limb points file. It is normally intended for the PLAN navigation type for Voyager images. **CALCMA** is an associated keyin that actually facilitates the PLAN navigation from Limb points determined using **PLAEDG**. It is assumed that the SEDR data are available and attached to the image using either **SEDRIN** or **GETSEDR**. **PLAEDG** options allow the limb points to be listed, removed from the DDB or entered at the cursor location.

IMGCTR
In most planetary analysis, the planetary images first need to be navigated. The first step in image navigation is to locate the center of the target object in the image space. **IMGCTR** is a command 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 locate the limb by determining the location where the brightness gradient along a radial direction is maximum (relative to the first 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 are found in SEDR files also provided by the flight project. For the Voyager images (all Uranus and Neptune images and a limited number of images of Jupiter and Saturn and their moons) the pointing information is available as SPICE kernels. For these images the **IMGNAV** command is not needed because other commands read the SEDR or SPICE kernels and provide the required information to the navigation programs within McIDAS-eXplorer.

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 for display or for exporting to a new area in which the image is centered. This is an efficient means of creating an aligned sequence of images which all have the image center at a fixed area relative address (assuming the areas are all the same size).

NAVUTIL

Frequently, there is a need to modify some of the parameters used for navigation, particularly for earth based images. An example is when the planet image center (line and element coordinates) is known from some other means (such as offset from a known star) rather than from a fit to the limb points (default). NAVUTIL will allow the user to enter the center coordinates into the DDB so that navigation programs can access that information.

NAVUTIL also lets the user specify the NORTH angle for the planetary image (measured clockwise from decreasing line direction, i.e. the 'up' direction as seen on the display).

Finally, NAVUTIL will allow the navigation reference frame to be selected when multiple reference frames are possible. For example, a planetary image can have observer based celestial navigation attached to it, or, the navigation referring to the native body reference frame. For ringed planets, a third choice (RING navigation) is possible, (not yet implemented).

SUBPNT

SUBPNT computes observing geometry (the sub-earth and sub-solar coordinates and ranges) for a given image. It assumes that the date and time attached to the image refer to UT when the image was originally acquired at the telescope. 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.

NAVIGATION OF IMAGES OF PLANETARY RINGS

Navigation of planetary rings for Saturn, Uranus, Neptune has not been implemented.

NAVIGATION OF IMAGES OF ASTEROIDS & IRREGULAR MOONS

The smaller moons of the outer planets, e.g. Phobos and Deimos, Amalthea, 1989N12 and asteroids such as Gaspra and Ida are irregularly shaped. Triaxial ellipsoid models are available for many of these irregular objects. eXplorer however does not currently have the ability to implement the shape-model based navigation of these objects.

HOW TO UPDATE SPICE KERNEL NAVIGATION OF PLANETARY IMAGES

The SPICE kernel navigation provides the "C" matrix that transforms image co-ordinates to the native coordinate system of the target. Occasionally there may be a need to update these kernels if the navigation is deemed to require a change either in the planet center, orientation, or size. Prior to updating the existing SPICE kernel, the revised planet center in the image and the orientation of the planet in the image and any change in the size and shape used for the target object must be obtained. The image center can be obtained using the bright

limb if available or using features with known coordinates either from simultaneous wide-angle images or preceding or succeeding navigated images.

A common problem with planetary image navigation is noticeable error in the north angle which results in a slight tilt of the navigation grid with respect to the true reference frame. Such a mis-orientation of the planet in an image (as specified by the SPICE kernels) is usually obvious when it is viewed in a time sequence with a **constant** orientation (as can be arrived at by remapping the images to force a constant north angle in the output images). It can also be occasionally verified by the presence of stars or satellites in the particular image which allow the true orientation of the imaging instrument to be determined independently.

SPICENAV command can be used to update the SPICE kernel based navigation.

IDMOON key-in offers a means to determine the image orientation and also the image scale information for images of Jupiter provided at least one moon is visible in the image. As soon as the P-kernels for satellites of Saturn and other planets are available, the key-in-in can be extended to include those planets/satellites. If multiple moons are visible in the image, maximum accuracy is achieved in both the north angle determination and the image scale size if the furthest satellite is used.

HOW TO MEASURE DISTANCES and AREAS WITHIN AN IMAGE OF A PLANET OR A MOON

DSTNCE
This application allows the user to measure distances on any displayed and navigated image between pairs of points in the image or along a multi-segment path in physical units (meters, km, nm or miles). The command obtains the proper scale factors based on the same physical constants as are listed for the target object by the command **PHYSCON**. The target identification is based on the Data Description Block (DDB) attached to the image area (word # 263 contains the NAIF id value). The physical parameters for the object are obtained from a call to the eXplorer subroutine BODCON and allows for differentiating between radii for solid surface and different atmospheric levels for objects bearing extended atmospheres.

ASTAT
The **ASTAT** command allows the user to obtain statistics on the digital data distribution in a portion of the area or the whole image (one band at a time). The area portion can either be an arbitrary closed outline, or a box defined by the cursor location. For more information, please see the command reference.

IMGTS
When a time series of digital data variation over a limited area at a fixed location in the image needs to be compiled from digital areas, **IMGTS** is useful. After it is compiled, the time series data can also be shown as a plot. For more information on how use this command, please see the command reference.

HOW TO DIGITALLY FILTER AN IMAGE

FILTER
FILTER is 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.

MA

This command also has both low pass and high pass filter options that are one-dimensional (along the line direction) and can be useful in some cases. This command can also remove "noise" in the image that usually occurs due to telemetry errors in the transmission of the data. Please refer to the command description for more information on how to use it.

HOW TO DETERMINE THE PLANETARY PHOTOMETRIC FUNCTION

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:

$$I\mu = Io\ \mu o \mu \beta \text{ or:}$$
$$\ln(I\mu) = \ln(Io) + \beta * \ln(\mu\mu o), \text{ where:}$$

$$I: \text{ Observed intensity}$$
$$Io: \text{ A constant, called normal albedo,}$$
$$\mu: \text{ cosine of observer zenith angle,}$$
$$\mu o: \text{ cosine of solar zenith angle, and}$$
$$\beta: \text{ a constant.}$$

If the actual target behaves as a Minnaert surface, then the plot of $I\mu$ vs. $\mu\mu o$ on a log-log scale should be a straight line, with Io determined from the intercept and β being the slope of the linear fit. The applicability of the law is thus self evident over the $\mu\mu o$ 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 by the mean absolute deviation 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 is "perfect", devoid of any noise, then the regression and the robust fits will generally be very close. Most imaging instruments however contain some systematic and/or random "noise" (an example is the presence of the reseau marks or

their residue in Voyager images). To the degree that such noise is present in the image data, the regression and robust fits will differ somewhat, with the robust fit being generally superior.

MINFIT stores the Minnaert coefficients and those for other photometric functions in the DDB for that image. **NRMIMG** looks in those locations for removal of the brightness variation if the Minnaert Law is being used for removing the photometric function from the data as described below.

Hapke Photometric Function
The determination of Hapke Photometric function parameters from a planetary image is under development.

Buratti Photometric Function
The determination of the Buratti photometric function parameters is under development.

HOW TO REMOVE THE PHOTOMETRIC FUNCTION FROM AN IMAGE OF A PLANET OR A MOON

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:

NRMIMG source_area dest_area spline_size FUNCTION=MINN intcpt slope

Minnaert Photometric Function
The Minnaert photometric function (default) can be specified in the **NRMIMG** command with the FUNCTION keyword. The Minnaert fit parameters (slope and intercept) can be picked up from the source area's DDB if they previously have been computed and stored. Otherwise they can be specified as second and third parameters of the FUNCTION keyword respectively. For large images (actual target size), the image data can be sampled to speed up the computation. The data can also be restricted to include only a certain range of latitudes and/or longitudes.

Extended Minnaert Photometric Function for Thick Atmospheres
For objects with thick atmospheres such as Venus and Titan, the extension of the photometric terminator beyond the geometric terminator can be approximated within the Minnaert function by the introduction of a bias in the solar zenith angle (Sromovsky, 1989):

$$I\mu \ = \ \text{Io} \ (\mu\mu^*)\beta \ \text{where,}$$
$$\mu^* \ = \ (\mu o + \mu 1)/(1 + \mu 1) \ \text{for} \ \mu o > 0, \ \text{and,}$$
$$\mu^* \ = \ (\mu 1^* \exp(\mu o / \mu 1)) \ / \ \mu 1 \ \text{for} \ \mu o < 0$$

The function parameters are specified as the second, third and fourth arguments of the FUNCTION keyword:

    NRMIMG source_area dest_area spline_size
              FUNCTION   =   MINNEX *intcpt slope muoffset*

Hapke Photometric Function

    NRMIMG source_area dest_area spline_size
              FUNCTION   =   HAPKE a b c

HOW TO EXAMINE IMAGE DIGITAL DATA IN A DISPLAYED IMAGE

COTV
COTV is a McIDAS core command that produces either a contour map (2-D) or a three dimensional surface plot of the brightness values within the cursor location

POPVAL
POPVAL is an experimental command that runs constantly in the background once started and displays the digital data value at the cursor center location in the displayed image. The data display is constantly updated as the cursor is moved or when a new frame (stepping through the allocated frames) or an image is brought into view (by displaying a new image on a particular frame). The cursor coordinates and the calibrated data value are also displayed so that this process accomplishes simultaneously the same purpose as the "E" and the "D" key commands together.

> **Exception:** The Magellan SAR imagery data conversion of raw digital numbers to radar reflectivity requires significant computations; therefore, the calibrated data are not listed for these data in **POPVAL**.

D
The "D" key will list the raw, calibrated, and brightness values corresponding to the image location identified by the cursor position in a displayed image. The digital area must be present. The listing includes the image, frame, and target object's native reference frame coordinates of the cursor.

OD
When the digital data for more than a single pixel need to be examined, the OD command can be used to list the data within the cursor positioned on a displayed image in specified units ("BRIT", "RAW" or calibrated). As with the "D" key, the digital data (source area from which the frame was loaded) must be present and unchanged.

LINPLT

LINPLT allows the data along a path between any two arbitrary points in the displayed image to be extracted and plotted on the displayed frame as a line plot of distance vs. data value. The data is plot in the respective physical units except if the image displayed is a Magellan MIDR product image. For Magellan MIDR data 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 as it requires a table interpolation at each point along the path to add back the angular dependence of the returned radar signal which was removed when the data were rendered as images.

If the image displayed is navigated, then the physical distance along the path is expressed in km or meters as appropriate; otherwise the distance is given in image pixels.

The default line plot is along the line at which the cursor is located. The position parameters SEG and CUR allow the data to be examined along a path between two arbitrary points within the displayed image, or, along within the cursor limits along the line passing through the line where the cursor is located.

HOW TO ENHANCE AN IMAGE

The appearance of an image as displayed can be controlled based on the digital data values that get translated into screen brightness. This translation takes place internally in a look-up table that assigns an output brightness level in each of the three colors (red, green and blue output of the display) for the input image data. Manipulating this table is the process of "enhancement" of an image and affects only the appearance on the display and not the actual data stored in the area. Note that the appearance of the image can be changed in other ways, such as by digitally modifying the data in some manner, as well as spatial filtering. In McIDAS-eXplorer, however the term "enhancement" is restricted to changing the look-up table. There is one look-up table per frame, and hence each frame in a McIDAS work session can have a separate enhancement. Further, because there is only one table per frame, the enhancement applies to the entire frame and cannot be restricted to portions of a frame.

Black and White Enhancement

When all three colors are assigned the same output values, the result is a black and white enhancement. One of the simplest black and white enhancements is linear contrast-stretch enhancement, which linearly maps the input data range into an output brightness range. This can be accomplished by using the EB command in one of two different ways. The first way is to invoke EB without any argument; the user is then prompted to move the cursor with mouse movements within the displayed frame upon which the look-up table is updated in real-time. The line position of the cursor controls the input range of the image data, while the element position controls the output brightness range. A mouse click terminates the process, leaving the last value of the enhancement table.

> **Caution:** The enhancement is changed only for the frame being displayed when **EB** is initiated. If the display is stepped to another frame while EB is active and the cursor is moved, the enhancement table for the original frame will continue to be changed until EB is terminated either deliberately or automatically if the cursor is not moved for a certain duration of time.

A desired enhancement can be saved in a file:

EU SAVE *table_name*

and can be removed by:

EU

and restored back on that frame by:

EU REST *table_name*

A saved enhancement table can be restored, either for a looped sequence of frames, or any other range of frame numbers with the **EU** command, if desired. The enhancement table may or may not be suitable for the data displayed on those frames. The enhancement tables for each frame can be different even when the frames are being animated in a loop.

EU LIST will list all the names of the enhancements saved on a given workstation and can be recognized by the ".ET" extension to the individual file names.

False Color Enhancement

False color enhancements are handled in a manner similar to the black and white enhancement, except that instead of EB, the command EU is used with the MAKE option to specify the output brightness range in red, green and blue for a specified input brightness number. This is the same as input image data number for one-byte data or the output of the calibration table for two-byte data. The calibration or conversion from two byte data to a display brightness level (always a 1 byte value) can be changed with the SU command.

The syntax of the command for false color enhancement is as follows:

EU MAKE *low_input high_input low_red hi_red low_green hi_green low_blue hi_blue*

Note that this format allows the user to arbitrarily assign an output color combination to any of the input 256 brightness levels. If a saw-tooth or other multiple combinations of ramp black and white enhancement are desired, using identical red, green, and blue ranges for output brightness will achieve the desired enhancement.

As with the black and white enhancement tables, the false color enhancements can also be saved, removed, and restored using the **EU** command in exactly the same manner.

True or Three Color Display or Enhancement

If the display hardware allows it, McIDAS-eXplorer can be operated in the 24-bit mode which allows display of three different images through the red, green and blue guns of the display device. If these three images are components of a 24-bit images such as from a color scanner,then the result is a true color image. Spacecraft images generally are not obtained as true color images but are acquired either through different filters either singly or simultaneously such as with an imaging spectrometer. If the images are acquired one at a time through different filters over a short time, such as the Voyager images of giant planets and their satellites, they need to be registered to

account for any camera pointing differences and/or time differences which may reveal small but significant rotation of the target object in the three different filtered images.

Depending on the target, the wavelength at which the images are obtained, and which wavelength image is displayed in which of the three colors available through the display device, the color composite rendered will appear different. Frequently, the colors may be muted and may require at the very least significant contrast stretches in one or more colors for a pleasing output, or other selective enhancements.

Please see "How to make a Color Composite" for the tools available within McIDAS-eXplorer to accomplish this.

Digital Filtering
The appearance of Monochrome or multicolor images can also be altered by selectively enhancing or removing certain spatial frequencies in the image by digitally filtering the image using either the **FILTER, FILTVGR** or the **MA** command. Different filters produce different effects as may be expected. **FILTVGR** is a spatially adaptive filter that produces least objectionable output when the image contains sharp boundaries (e.g. the bright planetary limb). **MA** filter options are one dimensional (along each image line) and are useful in only certain applications. A Low Pass filter may remove high frequency noise and make the resulting image look smoother and perhaps more pleasing, while a High Pass filter applied to a full disk planetary image acquired in reflected sunlight can remove the shading due to the varying scattering geometry, an effect similar to "flattening" or "brightness normalizing".

Digital Data Modification
Besides digital filtering, the image data can be altered in other ways, such as by adding a constant value to all or selected data points, applying an analytic function that changes the appearance of the image, e.g. a known photometric function; combining multiple areas in some fashion etc. **IMGPRO** and **MC** commands allow multiple areas to be arithmetically manipulated to create a new output area.

HOW TO OBTAIN INFORMATION ABOUT AN IMAGE/AREA

Each image stored in area files in McIDAS-eXplorer contain a header record that describes the data. Unlike the FITS format, this header is in binary format and meant for system use. A utility command allows the header information to be printed on demand as text. The image data are followed by text records that document the processing history of that image. Generally, all the supplementary information present in the original data imported into McIDAS-eXplorer (e.g. from PDS CD-ROM volumes) is copied into the 64-word directory, the Data Description Block (DDB) and/or the processing history records. The directory and the processing history can be listed using the **LA** command. The contents of the DDB can be listed with the **LISTDDB,** command and the audit trail that informs which commands have altered the area in some manner can be listed with **LISTAUD**:

LISTDDB *area_#*
(default area number is the area corresponding to the image displayed on the current frame)

LISTAUD *area_#*

(default area number is the area corresponding to the image displayed on the current frame)

LA *area_#*
(default area number is the area corresponding to the image displayed on the current frame)

A quick one-line text summary of the contents of one or more areas or frames (source spacecraft, target object, unique image identifiers) can be obtained using the **WHERE** command as follows:

WHERE AREA begin_area_# end_area_#, or

WHERE FRAME begin_frame_# last_frame_#, will annotate the displayed frames

WHERE LIMB begin_frame_# last_frame_#, will list the areas/images for which a limb points file is present.

HOW TO MAP PROJECT IMAGES

Assuming that an area containing a navigated image exists, a new area containing a view of that image in a different cartographic projection or a map can be generated. If the source image is to be "flattened" or "brightness normalized" by removing the gradual shading due to the illumination and viewing geometry via a known photometric function at the same time, please refer to the section for **NRMIMG**, "How to remove the photometric function" for additional information. The first task is to set up a destination area in which to write the output projection. There are three steps necessary--create an output area, attach proper navigation, and create the required projected image. In many cases a macro command, **AAMAP** may be used to generate a few simple projections. For other projections or assembly of composite or global mosaics, the three steps can be used successively as described later. Projections such as rectilinear, polar stereographic or Mercator can be created using **AAMAP** when the image scale as well as latitude and longitude of the center of the output image are known before hand:

AAMAP *source_area dest_area frame_# PROJ lat lon km/pixel #lines #ele, where:*
   PROJ = MERC or PS
   #lin = number of lines in the output area (created by the command), and
   #ele = number if elements in the output area
   lat = latitude of the area center (lin#/2, ele#/2), and
   lon = longitude of the area center

A listing of the **AAMAP** macro will provide clues as to how the navigation is created using the **MAKNAV** command.

The **AAMAP** macro generates an output area of the specified size (default is 480 x 640) with one byte per pixel data, attaches to that area the directory information of the source area, creates the required navigation information for the specified projection, creates the output image using the navigation transformations, and finally displays the output on the specified frame if different from zero (in which case no call to DF is made to display the result). The processing history is copied, and an entry is made in the output area detailing the **AAMAP**.

If the source image is two bytes per pixel, **AAMAP** uses the default BRIT calibration to convert the two-byte pixel data into one byte pixel values, resulting in a loss of dynamic range of the data. Note that the default scaling of the two byte data to one byte brightness data is linear but can be changed using the **SU** command.

If the two byte range of the original image is to be preserved, then the more elaborate recipe below should be followed.

> Caution: The **AAMAP** macro DOES NOT copy the Data Description Block used in the eXplorer version.

Map Projecting Images: Step by Step

1. Creating an output area to store the result

So that the output can be readily identified, it is best to attach the same directory information for the output as is available for the source image. There are two ways to accomplish this-- one is to use the AA command to "copy" the directory and create an output area of appropriate size, the DDB and the processing history records.

AA *source_area output_area frame_# coord_type x_coor y_coor* 1 *#_lines #_elements*

The second method eliminates the need to copy the entire data by using the **MAKOUT** command to create the output area directory based on the source area:

MAKOUT *source_area output_area* SIZE= *#_lines #_elements #_bytes/pixel*

2. Attaching the required navigation for the output area

The second task is to attach the proper navigation information for the output image corresponding to the projection desired. This is accomplished using the **MAKNAV** command for the rectilinear (constant scale factors for latitude and longitude) map and most standard cartographic projections (polar stereographic, sinusoidal equal area, transverse Mercator, Lambert Conformal, and Mollweide equal area projection. For perspective views of a planet or a moon, the navigation for the output area is created with the PLANAV command.

MAKNAV	output_area_#	RECT *= line lat ele lon degplin degpele*	PLANET =
MAKNAV	output_area_#	SIN *= lin lat ele lon degplin degpele*	PLANET =
MAKNAV	output_area_#	PS *= lin ele lat lon pixsiz hemisphere*	PLANET =
MAKNAV	output_area_#	LAMB =	PLANET =
MAKNAV	output_area_#	MERC *=* lin ele lat lon pixsiz	PLANET =
MAKNAV	output_area_#	MOLL	PLANET =

where PLANET is the name of the solar system object.

If a perspective view is required then instead of **MAKNAV**, use **PLANAV** to simulate a view from an arbitrary distance (specified in terms of planetary radius) with arbitrary view direction (aim point relative to nadir direction and rotation about the aim point relative to object's north direction):,

PLANAV *area Planet angle* KEYWORDS, where,

Keywords:
    AREA = Output area number to define navigation for (required)

   LINES = line dimension if a new square area is to be created. (Default is LINES=1000, a 1000 x 1000 pixel area)

 PLANET = Name/ID# of a solar system object (either the NAIF ID number or name is required). RADIUS & ECC will default correctly if the value of PLANET is specified. They can be forced to other values by the user. For Venus, use VENUS_SFC (297) or VENUS_CLD (298).)
     diam | Planet diameter in pixels (default is LINES-50)
   radius | Planet equatorial radius (km)
      ecc | Planet eccentricity (oblateness parameter 1-a**2/b**2)

  ANGLE = north nadir na_azim
   north | Spin axis tilt (deg.) clockwise from vert (def=0.0)
   nadir | off_axis tilt of optic axis from planet-to-spacecraft translation vector (nadir angle)
 na_azim | Rotation angle of nadir angle about optic-axis

VIEWPOINT = lat lon dist
    lat | Planetocentric latitude at s/c subpoint (default=0.0)
    lon | Planetocentric longitude at s/c subpoint (default=0.0)
   dist | Distance s/c to planet center in RADIUS (def=10.0). DIST=1.000 is at planet or cloud top surface! Infinite distance yields orthographic projection.

    LINE = Line in area to put subpoint (default=area LINES/2-20)
     ELE = Pixel in area to put subpoint (default=area ELES/2)

     SUN = sub_sun_lat sub_sun_longitude

DIRECTORY = ss yyddd hhmmss
      ss | McIDAS Spacecraft ID (Default=50)
   yyddd | Image day & year (default is current day & year)
 hhmmss | Image time (default is current time)
        (If the area exists prior to PLANAV call, the existing SS, YYDDD, HHMMSS will be used as defaults).

  REPLACE = NAV/NO/AREA
        REPLACE=NO merely generates CRT output of the navigation parameters. [default is REPLACE=NO, which with default value of 128 for the keyword NAV lists the 128 word navigation block]

     NAV | (REPLACE=NAV replaces only current nav block for area)

   AREA | (destructive: REPLACE=AREA (re)generates area & nav)

     NAV = Display NAV words of current PLAN navigation only. (Maximum useful number and default is NAV=128)

    MORE = 0-3 (Adds additional output for detailed nav diagnosis)

Examples:

PLANAV	*(Lists current navigation for last accessed area)*
PLANAV	23 VENUS_CLD 180.0 REPLACE=AREA
	(Venus upside down in area 23)
PLANAV	23 SATURN REPLACE=AREA VIEWPOINT=90.0 180.0 15
	(north polar perspective view at a distance of 15 planetary radii)
PLANAV	AREA=23 500 500 PLANET=JUPITER REPLACE=AREA
	(default projection of Jupiter is generated in a 500x500 size area)
PLANAV	23 EARTH VIEWPOINT=-23.5 10 1.025 ANGLE=0 50 20
	REPLACE=AREA
	(-23.5 lat, 160 km above earth surface, looking leftward toward limb)

NOTES

If the remap runs too fast and gives a black image, you do not have a destination location which ought to contain any source data -- typically you are on the back side of the planet or are using incompatible parameters which the program resolves in a way you don't expect. The trouble could be in either the source area or the destination area navigation. Destinations with all data within a single spline domain may also truncate to black. Try DF's and grid both images with MAP LALO for analysis.

MAP LALO will show a lat-lon grid even on a completely black image, unless the planet surface lies completely outside the image boundaries.

One must remap images using the right-handed transformations generated by PLANAV (we don't spatially invert clouds in the real world), but the lat-lon grid (being left-handed) must be inverted. This is accomplished post-REMAP by using the keyin PLAREV to interchange east and west longitudes.

PLANAV area EARTH ANGLE=0.0 REPLACE=AREA
REMAP source_area area
PLAREV area
DF area frame; MAP LALO
(Always DF and MAP after navigation mods to check results)

Once the navigation has been attached to the destination area, its validity can be verified before actually creating the output image by moving the data by displaying the area on a given frame and displaying the latitude-longitude grid on it. If that area was created using MAKOUT, the screen will most likely be black, i.e. no visible should be visible as all the data values are still null. If the output area was created using AA, then the source image will be displayed, but with the new navigation attached.

3.   **Actually writing the remapped image into the output area**
      The third and final step is to remap the source area into the output area using the
      REMAP command:

                    REMAP *source_area output_area spline_size*, where:

spline_size | size of the bilinear spline block (square) in pixels. Default is 50, which is a good
              number for an input image size of about 1000 lines x 1000 elements.
              The minimum spline size allowed is dependent on the size of the source
              image and should be generally about 1% of the larger dimension.
              Larger spline size results in a faster generation of the output at the risk
              of perhaps losing some accuracy in the projection.

KEYWORDS:

      MERGE = YES or NO |
      SMOOTH = flag flag | where flag is YES or NO

Depending on whether or not the output images is being assembled as a composite, the
MERGE option should be set to YES (in which case the output of the remapping process is
digitally merged with the data already in the area if non-zero or above a certain digital number
value), or NO (in which case any existing image data in the destination area is overwritten so
that upon completion, the output area contains only the result of projecting the input image).

      The SMOOTH option has two distinct targets. The first response flag controls
smoothing of the data in the output area by (2/3, 1/3) weighting of the nearest two pixels, a
quick and dirty approximation to bilinear interpolation of the data. The second flag controls
whether the limb of the image in the output is to be generated without bilinear splines to
remove the "stair-stepping" effect caused by the fact that the spline domains span the visible
edge of the output image such that some points within the spline domain are actually off the
target such as in a full or partial disk of a telescopic image of a planet.

      Regardless of whether a perspective view or a cartographic map projection is being
generated, the user needs to know and choose a few critical quantities for the projection such
as scale of the output image in degrees per pixel or km per pixel, the central longitude,
hemisphere, etc. The scale and extent of the source image are also important because wrong or
incompatible values will result in an unsuitable output.

      If a known photometric function is to be removed from the image at the same time, that
can be accomplished using the **NRMIMG** command instead of the **REMAP** command,
provided the coefficients for the photometric function are known. At present, only the
Minnaert and the modified Minnaert functions are supported.

HOW TO GENERATE A THREE-COLOR COMPOSITE IMAGE

      If McIDAS-eXplorer is being run on a workstation with a 24-bit video capability, then
it is possible to display multispectral data as three-color composites as opposed to using false

colors. In order to be able to display three-color composites, the mcidas session needs to be started with the bit plane option set to 24:

mcidas -bp 24 {-ig [y|n]} {-fr [1|n]} {-imsiz [lin ele]},

where the braces indicate optional specifications for initial and maximum number of frames allowed, frame size for the initial frames allocated and whether graphics are to be embedded in the image or shown as an overlay.

Since each frame in the 3-color mode requires three times the memory, the number of frames to be allocated should be limited so as not to exceed a reasonable fraction of the physical memory installed in the workstation. Typically, in a workstation with 32 mb of real memory installed, four 1000 x 1000 frames will required about 12 Mb of memory and twice that if the double buffered display mode is being used.

If all three bands to be superposed coexist in a multibanded area, then entering a single command (a variation of the DF command) will enable a three color composite to be displayed on the chosen frame number:

DFC *area_# frame_#* Red= *band_#* Green=*band_#* Blue=*band_#*
or, if the three bands are in three different areas, then:

DF3 *red_area frame_#* COLOR=R
DF3 *grn_area frame_#* COLOR=G
DF3 *blu_area frame_#* COLOR=B

where, red_area, grn_area, and blu_area refer to the area numbers in which the data to be displayed in red, green, and blue color exist respectively.

In both the cases, the syntax is identical to that of the DF command with the addition of the COLOR keyword.

Since most scientific data are not acquired through the red, green and blue filters, the appearance of the image data will not be in natural colors, and the combination of different spectral bands (among those available for the data) and color in which they are displayed will usually require some experimentation. For data from the AVHRR instrument on NOAA polar satellites, the combination of bands 1 (0.5 micron), 2 (0.9 micron), and 4 (10.7 micron) displayed through red, green, and blue channels usually gives a pleasant looking image, assuming the infrared data are shown inverted such that cold clouds (low radiance values) appear white and the warmer land/ocean areas are dark.

In most cases the appearance of the image may require enhancement by using either histogram equalization in all bands or other methods. The histogram equalization can be performed using the **MA** command on each of the bands separately. Unfortunately, **MA** can process only one band at a time, thus three different output areas are produced if three bands are processed one at a time. These three output areas can then be combined into a single area using the **COMBIN** command. If this is to be done repetitively, the commands can be collapsed into a single macro command.

In the three-color mode the frame directory will eventually contain information about all three bands (or areas) being displayed. The "D" key and the "OD" command will also list the digital data values for all three displayed bands.

HOW TO CLASSIFY A MULTISPECTRAL IMAGE

Multispectral classification is a means of determining cross-spectral spatial relationships in the image data. It is an extension of the object of pattern recognition in a given image to the spectral domain. Generally used in earth remote sensing applications such as crop analysis or mineral survey, spectral classification is equally applicable to the solar system data if concurrent multi-color imaging data are available, e.g. Voyager multi-color images of Jupiter, which are near concurrent, or Viking orbiter images of Mars' surface. For the purpose of classification it is not necessary that the data be obtained by an imaging instrument--they could be processed data from a combination of sources or numerical models, e.g. gravity and topography data composited from Magellan data. The assumption is that there are only a discrete number of groups in which the features in a given area will fall into based on their spectral characteristics.

Classification can be accomplished in a number of ways. Two common methods are unsupervised classification and supervised classification. The latter requires some ground truth data and training sets. For planetary applications this is not readily possible so far, and only the unsupervised classifier is presently available within McIDAS-eXplorer (USCLAS).

Classification of a Multispectral image is relatively easy, however requires several iterations to understand the results. It generally is fairly CPU intensive. The first step is to identify a region of an image that is to be classified. Since the classification is a purely brightness signature driven process, the shading due to varying illumination geometry, if any, should be removed in each spectral band. If it is a planetary image, this can be accomplished using NRMIMG if an analytic photometric function is known. High Pass filtering may be sufficient in many cases as well. Note that the classifier uses only the brightness values (8-bits). Therefore, if the original data are 2-byte per pixel, the appropriate range of the data should be scaled into the 8-bit/pixel domain using a suitable linear or a non-linear transfer function using MAKESU. The command COMBIN will enable multiple areas to be combined into a single area of desired spectral bands of 1-byte/pixel data. Once the input area is ready, USCLAS will classify the image and write a new area containing the classified image with an appropriate color table. The spectral classes themselves can be examined using the ELLIPS command.

For further reference, look up 'A comprehensive Unsupervised clustering technique for the classification of remotely sensed data', G. Peltzer, M.S. Thesis, Civil and Environmental Engineering, U. of Wisconsin-Madison, 1992.

HOW TO MEASURE CLOUD MOTIONS

Measuring cloud motions on a sequence of navigated or aligned images involves recording coordinates of selected features in a two or more images, as well as recording the time of observation of those features. For framing cameras, the time of observation is provided by the time tag that is attached to the individual images. The convention used is this time tag notes the beginning of image data acquisition. Typically, the exposures are rarely longer than a few seconds and the intervening time interval and the spatial resolution of planetary images is such that the precise time (more accurate than say a second) at which the target is viewed in that image is not very critical. This is usually not the case with images acquired using a scanning instrument which usually acquire an image of the target object over an extended period. An extreme case is the NOAA AVHRR images for a whole orbit which are acquired over a roughly 90-minute period, or Pioneer Venus CPP images which typically require 3-5 hours per full disk image. In these cases, the exact time when a feature is viewed by the satellite is calculable from the image navigation, and these times are then used for the velocity computations.

There are two commands that accomplish this. **PCMW** allows a feature to be tracked across a sequence of frames using visual location with the mouse driven cursor, in each frame of a sequence . Digital correlation of the image data is feasible but not currently supported within McIDAS-eXplorer to determine the motions. The **TRACK** command records the native reference frame coordinates of selected target locations in a text file for later analysis.

PCMW
The cursor can be "trained" to move at a certain rate in a certain direction based on the image interval. The velocity vectors computed from a pair of position measurements in two images separated by the corresponding time interval are printed out when the measurement process for each target is complete over the image sequence. Please refer to the command help in the User Guide for information on how to use this command.

TRACK
The **TRACK** command is intended for more elaborate analysis of the feature motions in a subsequent process. It records the coordinates and time of observation in a text file and graphically notes their locations in a graphics frame using the image navigation. A linear fit is performed to compute the average drift speed and direction. Please refer to the User Guide for information on how to use this command.

HOW TO EXPORT DIGITAL IMAGES FROM MCIDAS-eXPLORER

The format of files in which McIDAS stores its images is compact but unique. Although these files can be exported as such, many programs may not be able to make use of all the information stored in the accompanying header information. When the destination workstation is not known, it is better to export images from McIDAS-eXplorer in a format very similar to the FITS format. Any single-banded area can be exported into another file using the **XPORT** command, which writes the directory data, the DDB, and the processing history as ASCII 80-character labels followed by the digital data. For simplicity, multibanded data can be exported as separate files by extracting individual bands using the same command.

XPORT source_area_# *file_name* BANDS= *band1 band2 band3 .... bandn*

Alternately, as described previously the data can be exported as GIF files.

HOW TO CREATE A FUNCTION KEY MENU

The Function Key based menu system is described more fully in the McIDAS-X Users Guide. Multiple menus are possible to be created and used. A menu is a text file containing specific instructions for the text to be displayed and to relate a specific function key to a McIDAS command. User input (one item at a time) can be solicited using the ASK1 command. The menu script uses the first character on a line to define the instruction. A portion of a sample menu 'exp' is shown below. For futher information, please refer to the McIDAS-X User's Guide.

```
M 0..........................................................................Menu number
F  1 @01....................................................................Function Key 1
T  1 10 14      "WELCOME to McIDAS-eXplorer......................Text for Function Key 1 at (10,14)
T  4 10 12 "              Query Database
T  4 40 11 " - F1
T  6 10 12 "Import New Images from PDS CD-ROMs
T  6 40 11 " - F2
T  8 10 12 "    Display an Image from an Area
T  8 40 11 " - F3
T 10 10 12 "          Enhance Frame (B/W)
T 10 40 11 " - F4
T 12 10 12 "     Restore an Enhancement Table
T 12 40 11 " - F5
T 14 10 12 "       Save an Enhancement Table
T 14 40 11 " - F 6
T 20 10 14 "       Press ESC key to Exit Menu
F 0 "*QUIT..................................................................Function Key 10
F 1 @01
F 2 @02
F 3 "ASK1 area {Which Area?}; ASK1 frame {Which Frame?}; .......Solicit Input
+    ASK1 mag {Magnification?};DF #area #frame X X X #mag
F 4 "EB
F 5 "EU LIST;ASK1 table {Which Enhancement Table to Retore?}
+    EU REST #table
F 6 "ASK1 table {Name for the Table};EU SAVE #table
```

5. DATA STRUCTURES FOR MCIDAS-EXPLORER

INTRODUCTION

In McIDAS (Man-computer Interactive Data Access System), image data is stored in a data file called an "area". McIDAS areas contain: (1) header blocks containing bookkeeping information which is needed for linking to all the McIDAS commands or keyins which manipulate the image data, (2) the image data, and (3) an audit trail showing the successive keyins which have been applied to massage and manipulate the image data. This document describes the "area" file structure for planetary imagery analysis within the McIDAS-X (Unix X-Windows) environment. The planetary image analysis system, built on top of McIDAS-X, is called "McIDAS-eXplorer", or "McIDAS-eXp". The current version of this documentation is stored in a plain ASCII text file called /mcidas/exp/PLANAREA, and can be read online by the McIDAS-eXp keyin EXPDOC (i.e. "EXPDOC PLANAREA"). McIDAS is maintained by the University of Wisconsin Space Science and Engineering Center (SSEC) with support from the "McIDAS Users Group" (MUG).

One of the aspects of McIDAS-eXp philosophy is that if processing documentation travels with a data source on CD-ROM or on tape files (such as a VICAR label, for instance), that information will be stored in the McIDAS area header blocks or audit trail and can be scanned and used by McIDAS-eXp keyins, so the user does not have to be consciously aware of commonly used information. Key parameters will also be extracted and placed in a separate Data Description Block (DDB), which can be easily listed by the command LISTDDB.

We need to carefully distinguish between the McIDAS words: "area", "image", and "frame". An "area" is simply a numbered data file. Like most low-level data structures, its coordinates are zero-based and, for the most part do not have to be known by the user. An "image" is that subset of an area file which contains digital data values or digital numbers (DN values). An image is always assumed to be rectangular, and to be composed of lines and elements, or pixels. Most images have the upper left pixel identified as line=1 and element=1. Some images are subsets of other images, however, so the upper left corner coordinates are somewhat arbitrary, and they must always be defined in the directory block of an area.

A "frame" is what is displayed in a window on the video screen. A frame is a subset of an image, which can be displayed at varying degrees of positive and negative magnification. Thus, frame coordinates always start with the upper left pictel (not pixel) as line=1 and element=1, but to get back to image coordinates, one must perform a linear transformation which includes a magnification factor. A frame never exists without an image, but many different frames can be generated on the video screen from a single image.

An image must always reside in an area. Thus, every frame gets its coordinates and image from a source area. The core McIDAS keyin C relates a displayed frame to its source area. All that is known by McIDAS about a displayed image comes from information or file pointers stored in the source area for each frame. All of the coordinate conversions are handled internally by McIDAS so that when a user places the cursor over a pictel on the screen, McIDAS knows the exact value and location of the corresponding pixel in the image in the data file, as well as all the available navigation and calibration data related to that specific byte.

We have defined a new McIDAS-eXp area structure, compatible with all versions of McIDAS. A new McIDAS-eXp keyin, DDBUTIL, accepts standard or "core" McIDAS area formats and converts them to the new planetary McIDAS-eXp area format, which contains a new entity called a Data Description Block (DDB). DDBUTIL will also generate a new McIDAS-eXp format area, for any chosen image size, which the user can then read and write with other McIDAS-X or McIDAS-eXp keyins.

There are additional options within McIDAS-eXp for reformatting imagery from other sources. There exists a set of CD-ROM reader commands, named GETxyz, where xyz is a three letter acronym for a planetary spacecraft:

VGR	=	Voyager 1 and 2 Missions to the outer planets
MGN	=	Magellan Radar Mission to Venus
GXDR	=	Magellan Global Data Products
GO	=	Galileo Orbiter SSI Images of the Earth, Moon and Venus
GONIMS	=	Galileo NIMS Observations (future)
FITS	=	Hubble Space Telescope and other ground based images in FITS format
VO	=	Viking 1 and 2 Orbiter Missions to Mars
MDIM	=	Mars Digital Image Model Data derived from Viking Observations
CLEM	=	Clementine Image products (future)

These CD-ROM readers allow the user to import the corresponding data directly to the new McIDAS-eXp area format with a DDB so that the eXplorer tools can be utilized.

Images can also be imported or input directly to McIDAS-X from tapes, such as Mariner 10 or Voyager EDRs and VICAR tapes. Such images would have to be reformatted using Unix or OS/2 versions (which as of yet do not exist) of the mainframe McIDAS-MVS background programs PBNEWEDR and PBVICAR2. Those programs may be rewritten for McIDAS-eXp if a need arises to read tapes at the workstation level, but the current trend is toward acquiring data either remotely via TCP/IP and FTP in standard PDS formats, or locally from CD-ROM.

The new planetary area format is documented below. The format is fully backward compatible with all existing McIDAS workstation software, so the areas may be freely moved from one McIDAS workstation environment to another via FTP (from Silicon Graphics, to Sun, to PC, to RS6000) and can be used wherever a copy of McIDAS-eXplorer is running.

5.1   eXplorer AREA STRUCTURE

The mainframe version of the planetary McIDAS software kept navigation data in files called "codicils", separate from the image areas. On McIDAS-X and McIDAS OS/2, each eXplorer area is stored as a single binary disk file containing all the information necessary to display and navigate the image. Image calibration (conversion of DN values to physical values) is directly available for images with a single calibration table (of 10 bits or less per pixel) for the entire image. For composite images such as Magellan Venus mosaic data, where many small tiles have different incidence angles, it is necessary to have a separate keyin (MAGCAL) to recover such things as surface reflectivity. Each eXplorer area has the same format, although file lengths are variable with image size, calibration data, and the amount of audit trail. The first 256 bytes of every file contains the area directory block for the image. Each value in the block is a

4-byte word (64 words total). This directory contains information about both the area and the original image it was created from. The area directory is described in detail later.

The next entry contains the 'NAV ' or navigation block for the image. Again, each value in this block is a 4-byte, 8-byte, or 12-byte quantity holding the navigation parameters necessary to locate the projection of the image pixels on a target body surface. If no navigation is available for the image the block will be zero filled, or contain the McIDAS standard hex byte string "80808080", meaning "no data". This block also contains the Data Description Block (DDB) subblocks, described later. Word 35 of the area directory contains the byte offset of the NAV block within the file. For eXplorer, the new navigation block length is always 5*128=640 words or 2560 bytes. This is the maximum block length which core McIDAS is currently able to accomodate.

The next block of bytes contains a 'CAL ' entry. This entry will be filled with data if the image is radiometrically calibrated or if (in the case of Mariner or Voyager imagery) reseaus need to be located in the image to geometrically calibrate it. This 'CAL ' entry may be zero length if no calibration information is needed. Like the area directory and NAV blocks, each value in a CAL block is a 4-byte, 8-byte, or 12-byte quantity. Word 33 of the area directory is a byte offset to the CAL block's position within the file. For Voyager image data the calibration block entry consists of three parts, totalling 512+4096+1616=6224 bytes. This is the maximum size the calibration block can be.

1.   Part one is a 128 word entry (512 bytes) used to parameterize a function to display the image. Two byte image data on the mainframe, for example, uses a three parameter linear transfer function (min, max, scale factor) to convert a range of 16-bit DN values to 63 levels on the display screen. The keyins MAKESU and DF with SU option set up and use a transfer function file for displaying two-byte images in McIDAS on a 8-bit display. Then the core McIDAS keyin EB can be used to further adjust contrast and dynamic range linearly, in the display. Color composite images in McIDAS-eXp require 24-bits per pixel, as well as a 24-bit display (such as the Silicon Graphics Indigo).

2.   Part two consists of 1024 4-byte words (4096 bytes), suitable for up to 10 bits/pixel resolution in a lookup table of 4-byte floating point or scaled integer radiance values. This transfer function is appropriate for doing calculations with physical quantities instead of DN values. The McIDAS core D keyin is modified in McIDAS-eXp, so the table lookup or analytic conversion from DN to physical values is always done in the appropriate way for the data being displayed. Thus, when an 8-bit Magellan tile is displayed, for example, it is possible to obtain the latitude, longitude, alti-tude, orbit number, incidence angle, and radar reflectivity (plus others) for any pixel in the displayed image, using the D keyin.

3.   Part three contains space for a set of 202 REAL*4 line-element reseau locations (1616 bytes). Mariner and Voyager class spacecraft used vidicon sensors with electron beam readout subject to variable distortions from electromagnetic fields the spacecraft passed through. The image geometry was preserved by etching reseau marks on the glass vidicon faceplate so one could reconstruct the exact geometry the telescope optics projected into the focal plane at which the vidicon resided. These reseau locations are found by keyin RF (Voyager reseau finder).

The next entry contains the actual digital data values for the image arranged line by line, with no record separators. The length of the 'DATA' block is computed using values within the area directory entry. Word 34 of the area directory is the byte offset to the start of the DATA block within the file. Image data stored in a McIDAS digital area is organized in a two-dimensional array of lines and elements. Each pixel in an area has a line number, starting with zero at the top, and an element number starting with zero on the left side of the line. This line-element number pair defines a coordinate system, called the "area coordinates", for the elements in the area. Note that the pixel count for areas (but not for images or frames) starts at zero, not at one. The line and element counting for images and frames is arbitrary and must be specified in words 6 and 7 of the area directory. All McIDAS applications software must use this convention.

Finally, after the image data, we have a trailing entry which contains ASCII data that more fully identifies the data source and stores time stamped comments and notes from all applications programs, or from the user (using eXplorer audit trail utility keyin LISTAUD). This provides an audit trail of variable length, giving a full history of the processing. Because it is at the end of the area file, this entry may grow without limit as the image continues to get processed.

The first six lines of the audit trail are called the "image identification block", and those six lines have the same format for every planetary image, independent of the source. Some Voyager images acquired from EDR's or VICAR tapes may have erroneous data in this block, but the information acquired from CD-ROM sourced images (via keyins GETXXX) is generally correct. All McIDAS-eXplorer keyins use the Image Identification Block data (acquired by subroutine IIDBLK) and the Data Description Block (acquired by subroutine DDBBLK) to identify default keyin values for any image. The user is permitted a wide latitude to change McIDAS-eXplorer keyin parameters, but we try to prevent misidentification of data or its stage of processing by keeping many parameters internal to the system, and requiring that the system complain if patently wrong input or output is specified by the user. If information is available internally to the system, the user should not be required to specify it.

The global structure of a McIDAS-eXp area for Voyager images is illustrated below.

```
         BYTES                                WORDS

      0...------------------...0
           |  DIRECTORY        |
    256...------------------...64
           |  NAVIGATION       |
   2816...------------------...704
           |  CALIBRATION      |
   9040...------------------...2260
           |  IMAGE            |
 ENDIMG.------------------
           |  AUDIT TRAIL      |
    EOF....------------------
```

Again, please note that all coordinates relative to an area are zero-based, but within a block, or within an array, an image, or a frame, coordinates start with the index 1. The calibration block may arbitrarily be of length 0-6224, but all other blocks must always be present:

The global structure of a McIDAS-eXp area for Magellan MIDR is illustrated below:

```
        BYTES                                    WORDS


             0...---------------------...0
                 |   DIRECTORY       |
           256...---------------------...64
                 |   NAVIGATION      |
          2816...---------------------...704
                 |   CALIBRATION     |
          2816...---------------------...704
                 |   IMAGE           |
        ENDIMG.------------------
                 |   AUDIT TRAIL     |
          EOF....------------------
```

The byte offsets for any McIDAS area may be seen by executing the core McIDAS command "LA
FORM=ALL".

5.2   AREA DIRECTORY

Each area that is extracted from a spacecraft image has associated with it a record called the 'area
directory'. The data in the directory are stored as 32-bit (4-byte) two's complement binary integers or as
ASCII character data. The length of the directory is 256 bytes (64 words). A list of the directory contents
follows:

```
WORD    NAME AND DESCRIPTION
----    ---------------------
   1.   Contains zeros if record is valid.
   2.   Area Format: Always 4 (current core as of June 1985).
   3.   SSS:       Spacecraft Identification Number.
   4.   YYDDD:     Nominal Year and Julian day of area.
 · 5.   HHMMSS:    Nominal Time of image.
   6.   UPPERLEFTLINE: Image line coordinate of area line 0, elem. 0.
   7.   UPPERLEFTELE: Image element coordinate of area line 0, elem.0.
   8.   Not used. (Reserved for true three-dimensional data sets)
   9.   NLINES:    Number of lines in this digital area.
  10.    NELES:    Number of elements in each line.
  11.   ELESIZ:    Number of bytes/element (1, 2 or 4).
         area file
  12.   LINERES:   Line Resolution; spacing in image-lines between
                   consecutive area lines.
  13.   ELERES:    Element Resolution; spacing in image-elements
                   between consecutive area elements.
  14.   NCHANS:    Maximum number of bands/line of area.
  15.   PRESIZ:    Length of line prefix in bytes. Indicated by the
                   sum of words 49, 50, 51 (+4 if validity code is
                   present, see 36).
  16.   PROJ:      McIDAS user project number under which the area
                   was created.
  17.   CREATION DATE:   Area creation day in YYDDD format.
  18.   CREATION TIME:   Area creation time in HHMMSS format.
  19.   FILTER MAP: (for Multi-Channel Images) a 32 bit vector.
                       If a bit=1 there are data for that band in the
```

area. The rightmost bit is for band 1.

20. FDS COUNT: Spacecraft clock ticks since last computer reset
21-24. Internal use only.
25-32. Memo: (32 ASCII characters available for comments).
33. Number of area containing this directory.
34. Byte offset to the start of the image data within the area file.
35. Byte offset to the start of the navigation block within the
36. Validity Code: If these bytes are non-zero they represent a
                      code which must match the first 4 bytes of
                      the line prefix. If the code and prefix bytes
                      are not equal the line does not contain valid
                      data and must be ignored
37-44. PDL: Exists if the image was made in GOES mode AA
                      or AAA packed byte format.
45. If image is a Mode AA DS ('STEP','DWEL') these bytes indicate
      the origin of Band 8. Not used for GOES mode AAA.
46. Actual image start YYDDD. (Nominals above are set by convention
47. Actual image start HHMMSS.
48. Actual starting scan line.
49. Line prefix documentation section length in bytes.
50. Line prefix calibration section length in bytes.
51. Line prefix level map section length in bytes.
52. Image type: 'VISR', 'VICR', 'VAS ', 'ERBE', 'AVHR', 'FITS',...
      (McIDAS-eXp images default to line-ele imagery of type VISR,
      unless they are two-byte photometrically corrected 'VICR')
53. Calibration Type: Physical units in which the digital data
      are stored. The calibration type determines how the image is
      displayed on the screen or processed by various applications.

           e.g. 'BRIT'   8-bit DN values,
                'CAL '   16-bit DN values (specific units)
                'RAW '   16-bit DN values (undefined linear units)
                'TEMP'   Degrees Kelvin,
                'RAD '   Watts/cm**2/ster (scaled integer),
                '2BYT'   2 byte signed integers

           (If not VISR: BRIT or CAL, or VICR: RAW, the core DF command
           may not work for the data in an area. Also, VICR: RAW
           images have to be converted to albedo using solar distances
           and other con-stants located in the audit trail, for
           instance. A separatee keyin must be used to convert
           physical units in multi-byte data into an acceptable range
           of usable, visible contrast in the displayed McIDAS-X
           frames. This restriction extends to the use of the D and OD
           commands on multi-byte data as well.)
54-62. Internal use only.
63. Byte offset to the start of the calibration block within
      the area file
64. Number of lines in the audit trail.

        McIDAS assigns a unique three digit code field to spacecraft for use in the area directory. This "SSS" spacecraft code is converted to a CHARACTER*12 name when the image is loaded to a frame by the keyin DF. The name appears in a title bar at the bottom of the frame. The file mcidas/data/SATANNOT contains the table converting SSS to a name. Negative codes are used by NAIF and the SPICE routines for spacecraft. The NAIF ID number which controls definition of all spacecraft identification is the one in word 133 of the Data Description Block for an area. The code assigned to a

particular spacecraft is the negative of the code assigned to the same spacecraft by JPL's Deep Space Network (DSN). Integer codes have been assigned for the following spacecraft:

-12	Pioneer 12 (Venus Orbiter)
-18	Magellan Venus Orbiter
-27	Viking 1 Mars Orbiter
-30	Viking 2 Mars Orbiter
-31	Voyager 1
-32	Voyager 2
-77	Galileo Jupiter Orbiter
-94	Mars Observer (Vehicle has failed)

The current spacecraft SSS numbers used in McIDAS-eXp are shown in the table below:

```
Contents of /mcidas/exp/SATANNOT
=================================
```

Sensor Source	SSS Code	Spacecraft/Target Name
Pioneer Venus Orbiter	-12	PIONEER ORB
Magellan Venus Orbiter	-18	MAGELLAN
Viking Mars Orbiter 1	-27	VIKING 1 ORB
Viking Mars Orbiter 2	-30	VIKING 2 ORB
Voyager 1 (Jupiter, Saturn)	-31	VOYAGER 1
Voyager 2 (Jup, Sat, Uranus, Neptune)	-32	VOYAGER 2
Galileo Jupiter Orbiter	-77	GALILEO ORB
Mars Observer	-94	MARS OBSERVR
Non-Image Derived Data	0	DERIVED DATA
Miscellaneous	1	TEST IMAGE
Graphics	2	GRAPHICS
MDR Radar	3	MISC
Meteosat Visible	4	METEOSAT VIS
Meteosat Infrared	5	METEOSAT IR
Meteosat Water Vapor	6	METEOSAT WV
RADAR	7	RADAR
Miscellaneous Aircraft Data (MAMS)	8	ACFT
	9	RMET
	10	COMPOSITE
	11	
GMS Visible	12	GMS
GMS Infrared	13	GMS IR
ATS 6 Visible	14	ATS6 VIS
ATS 6 Infrared	15	ATS6 IR
SMS-1 Visible	16	SMS-I
SMS-1 Infrared	17	SMS-I IR
SMS-2 Visible	18	SMS-II
SMS-2 Infrared	19	SMS-II IR
GOES-1 Visible	20	GOES-1
GOES-1 Infrared	21	GOES-1 IR
GOES-2 Visible	22	GOES-2
GOES-2 Infrared	23	GOES-2 IR
GOES-3 Visible	24	GOES-3
GOES-3 Infrared	25	GOES-3 IR

GOES-4 Visible (VAS)	26	GOES-4
GOES-4 Infrared & Water Vapor (VAS)	27	GOES-4 IR
GOES-5 Visible	28	GOES-5
GOES-5 Infrared & Water Vapor (VAS)	29	GOES-5 IR
GOES-6 Visible	30	GOES-6
GOES-6 Infrared	31	GOES-6 IR
GOES-7 Visible	32	GOES-7
GOES-7 Infrared	33	GOES-7 IR
	34	
	35	
	36	
	37	
	38	
	39	
	40	
TIROS-N	41	TIROS-N
NOAA-6	42	NOAA-6
NOAA-7	43	NOAA-7
NOAA-8	44	NOAA-8
NIMBUS Satellites	45	NOAA-9
Mariner 10	46	MARINER 10
Voyager 1	47	VOYAGER1
Voyager 2	48	VOYAGER2
Galileo	49	GALILEO ORB
Hubble Space Telescope	50	HUBBLE ST
	51	
	52	
	53	
Meteosat 3	54	METEOSAT3
Meteosat 4	55	METEOSAT4
Meteosat 5	56	METEOSAT5
	57	
	58	
	59	
NOAA-10	60	NOAA-10
NOAA-11	61	NOAA-11
NOAA-12	62	NOAA-12
NOAA-13	63	NOAA-13
NOAA-14	64	NOAA-14
	65	
	66	
	67	
	68	
	69	
GVAR	70	GVAR
GVAR Sounder	71	GVAR SNDR
Future GOES	72	GOES-J
Future GOES	73	GOES-J
Future GOES	74	GOES-K
Future GOES	75	GOES-K
Future GOES	76	GOES-L
Future GOES	77	GOES-L
Future GOES	78	GOES-M
Future GOES	79	GOES-M
ERBE	80	ERBE
	81	
	82	
	83	
	84	
	85	

	86	
Defense Dept. Weather	87	DMSP-F8
	88	DMSP-F9
	89	DMSP-F10
	90	DMSP-F11
	91	DMSP-F12
	92	
	93	
	94	
	95	FY-1B
	96	FY-1C
	97	FY-1D
	98	

Codes have also been assigned for the following barycenters:

0	Solar system barycenter	
1	Mercury	"
2	Venus	"
3	Earth	"
4	Mars	"
5	Jupiter	"
6	Saturn	"
7	Uranus	"
8	Neptune	"
9	Pluto	"
10	Sun	"

The code for a satellite is normally computed by adding its IAU designation to 100 times the code for its barycenter. A planet is always considered to be the 99th satellite of its own barycenter. For a visible target body surface, one would simply use the NAIF ID number 99-999. For planets with atmospheres, we have adopted a McIDAS-eXplorer protocol which requires the target body to be identified by its NAIF ID number times 10 (a four digit number NNN0), which is fed to a target body constants subroutine BODCON and produces three nominal atmospheric radii defined at the 1 bar level (along with other IAU constants). For rotating planets, two or more of those radii will, of course, be equal. One can add the digits 1-9 to this number (NNN1 - NNN9) to obtain spectral or filter dependent radii, or radii defined at different optical depths, etc.

The user must add these experimenter dependent atmospheric radii to /mcidas/exp/BODCON.FOR and recompile McIDAS-eXp with shell script "makeplan" to make new body constants accessible to the McIDAS navigation routines. Users can update or insert IAU data into BODCON at their convenience, prior to recompiling McIDAS-eXp. The NAIF ID number which controls definition of all target body constants is the one in word 200 of the Data Description Block for an area. This datum is mandatory for all image navigation in McIDAS-eXplorer, and is first set to a default value by GETXXX when reading a CD-ROM, or by DDBUTIL when the TARGET= keyword is used. In addition, /mcidas/exp/TGTANNOT must be updated to reflect the correct image annotation for the experimenter's new radii.

The current target ID numbers used in McIDAS-eXp are shown in the table below:

Contents of /mcidas/exp/TGTANNOT
===================================

Target Object		SSS Code	Target Name
Sun		99	SUN
Mercury		199	MERCURY
Venus (Surface)		299	VENUS_SFC
Venus		2991	VENUS_CLD
Moon		301	MOON
Earth Surface		399	EARTH_SFC
Earth		3991	EARTH_ATM
Phobos		401	PHOBOS
Deimos		402	DIEMOS
Mars		499	MARS_SFC
Mars		4991	MARS_ATM
Io		501	IO
Europa		502	EUROPA
Ganymede		503	GANYMEDE
Callisto		504	CALLISTO
Amalthea		505	AMALTHEA
Himalia		506	HIMALIA
Elara		507	ELARA
Pasiphae		508	PASIPHAE
Sinope		509	SINOPE
Lysithea		510	LYSITHEA
Carme		511	CARME
Ananke		512	ANANKE
Leda		513	LEDA
Thebe	(1979J2)	514	THEBE
Adrastea	(1979J1)	515	ADRASTA
Metis	(1979J3)	516	METIS
Jupiter		599	JUPITER
Mimas		601	MIMAS
Enceladus		602	ENCELADUS
Tethys		603	TETHYS
Dione		604	DIONE
Rhea		605	RHEA
Titan		606	TITAN_SFC
Titan		6060	TITAN_ATM
Hyperion		607	HYPERION
Iapetus		608	IAPETUS
Phoebe		609	PHOEBE
Janus	(1980S1)	610	JANUS
Epimetheus	(1980S3)	611	EPIMETHEUS
Helene	(1980S6)	612	HELENE
Telesto	(1980S13)	613	TELESTO
Calypso	(1980S25)	614	CALYPSO
Atlas	(1980S28)	615	ATLAS
Prometheus	(1980S27)	616	PROMETHEUS
Pandora	(1980S26)	617	PANDORA
Saturn		699	SATURN

```
Ariel                        701        ARIEL
Umbriel                      702        UMBRIEL
Titania                      703        TITANIA
Oberon                       704        OBERON
Miranda                      705        MIRANDA
Puck         (1985U1)        706        PUCK
Portia       (1986U1)        707        PORTIA
Rosalind     (1986U2)        708        ROSALIND
Juliet       (1986U3)        709        JULIET
Cressida     (1986U4)        710        CRESSIDA
Belinda      (1986U5)        711        BELINDA
Desdemona    (1986U6)        712        DESDEMONA
Cordelia     (1986U7)        713        CORDELIA
Ophelia      (1986U8)        714        OPHELIA
Bianca       (1986U9)        715        BIANCA
Uranus                       799        URANUS

Triton                       801        TRITON
Nereid                       802        NERIED
1989N1                       803        1989N1
1989N2                       804        1989N2
1989N3                       805        1989N3
1989N4                       806        1989N4
1989N5                       807        1989N5
1989N6                       808        1989N6
Neptune                      899        NEPTUNE

Charon       (1978P1)        901        CHARON
Pluto                        999        PLUTO
```

5.3   COORDINATE SYSTEMS FOR THE IMAGE BLOCK

The image block usually starts at byte 9040 in an area, although it could appear as early as byte 2816. Spacecraft images occur in several different orms, depending on the original data source. They can be from framing cameras, such as vidicons, or solid state detector arrays, or from spin scan cameras such as Pioneer. They can be map projections or mosaics. They can be multiple subsets of all of these as well. We describe an image as a sequence of "lines" arranged each below the previous one and numbered from top to bottom, the top line being number 1. Each line consists of a sequence of "elements" arranged across the line and numbered left to right, the left-most element being number 1. An element may be an 8-, 16-, or 32-bit quantity, depending on the image source and format. Most raw images are 8 bits, while photometrically corrected images are 16 bits. Color composites are normally 24-bits, embedded in a 32-bit pixel. Raw 10 or 12 bit imagery must be stored in McIDAS areas as two bytes per pixel. Radiometrically corrected images or composite multispectral images may have other formats, but are generally limited in McIDAS to 4 bytes per pixel. More than 4 bytes requires using the spectral band structure alluded to in the description of the area directory. McIDAS data is not fully three-dimensional, because word 8 of the area directory is not currently used, but the existing band structure and 32-bit pixels allow for building up "layers" of two-dimensional images.

This line/element numbering scheme determines a pair of coordinates for each element, called the "image coordinates" of the element. This coordinate system is defined only by the spacecraft/camera combiand is independent of how the data are stored. If all of the elements of a raw image were contained in

nation an area, there would be no point in distinguishing between "image" and "area" coordinates. What is stored in an area, however, is a rectangular subset or superset of an image, obtained by sampling, averaging, repeating, or editing of lines and elements, or some other pixel mapping process.

In order to map an area to the original image the following formulas are used:

```
Image_Line    =  UpperLeftLine + ( Area_Line    * LineRes )
Image_Element =  UpperLeftEle  + ( Area_Element * EleRes  )
```

UpperLeftLine is the image line coordinate of the first area line. UpperLeftEle is the image element coordinate of the first area element. When LineRes = EleRes = 1, the area is said to be at "Resolution 1", or "Full Resolution". When, for example, LineRes = EleRes = 4, only every fourth line and element of an image originally at resolution 1 are included in the area. This area is said to be at "Resolution 4". Each line in an area has the same total length. This length, in bytes, is always multiple of four.

The image data in an area may be viewed as a continous stream of bytes numbered from 0. Within this stream of bytes, the area data are contained line-by-line, with the lines in order, first to last. Each line is further divided into two parts, the 'Line Prefix' and the actual line data (image elements).

```
line prefix 1    line data 1    line prefix 2    line data 2 etc.
|_____|_____|_____|_____|____  ...
        0     byte numbers increase -->
```
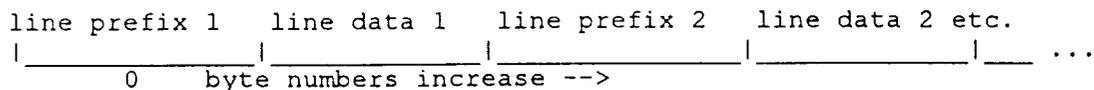
The line prefix contains documentation about the image and the particular line:

```
         val code      documentation    calibration       level
 |_____|_____|_____|_____|
        0     byte numbers increase -->
```
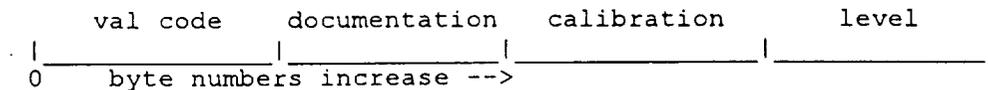
The size and content of the line prefix depends heavily upon the area type, which in turn is determined by the data source. The area type is given in word 52 of the area directory. McIDAS-eXp areas usually contain the area type "VISR". Regardless of the area type, each line in the area has the same length prefix. This length, in bytes, is given in word 15 of the area directory. It may be zero, and if so, there is no line prefix defined for the area. Images will normally (default) be displayed by the DF keyin from the first byte of each line in the area, unless specified otherwise.

NAVIGATION BLOCK

To navigate an image is to associate planet-based coordinates, usually planetocentric latitude and longitude, with the pixels of the image. This is done using highly complex mathematical models of the spacecraft and camera embedded in parameterized McIDAS navigation software modules. Navigation parameters for a digital area, when present in the McIDAS system, will be supplied in the 'NAV' block of the area file. Navigation information is used with the McIDAS navigation software to convert image coordinates (line,element) to planet-centered coordinates (latitude, longitude).

The first 128 words in the planetary McIDAS area navigation block are designated as the "current" navigation for the area, for use with any McIDAS compatible navigation software modules, such as:

```
NVXGOES.DLM          Geostationary GOES Spin Scanners
NVXLAMB.DLM          Lambert Conformal Projection
NVXMERC.DLM          Mercator Projection
NVXMSAT.DLM          Meteosat Spin Scanner
NVXPLAN.DLM          Planetary Navigation Framing Cameras
NVXPS.DLM            Polar Stereographic Projection
NVXRADR.DLM          Weather Radar Projection
NVXRECT.DLM          Rectilinear Projection
NVXSIN.DLM           Sinusoidal Equal Area Projection
NVXTIRO.DLM          Polar Orbiter Nadir Scanners
```

In McIDAS, the "current" navigation or map projection type is specified in word 1 of the Navigation Block (word 64 of the area) as a 4-byte ASCII string:

```
'GOES'  for Geostationary GOES Spin Scanners
'LAMB'  for Lambert Conformal projections
'MERC'  for Mercator projections
'MSAT'  for Meteosat Spin Scanners
'PLAN'  for Planetary Framing Cameras & Perspective Views
'CPP '  for Pioneer-12 Venus OCPP spin scan images
'NAIF'  for Planetary Framing Cameras using SPICE position kernels
'SPCE'  for Planetary Framing Cemeras using SPICE C-Matrix kernels
'RADC'  for Right Ascension and Declination navigation
'PS'    for Polar Stereographic Projections
'RADR'  for Earth Weather Radar Projections
'RECT'  for Rectilinear Projections
'SIN'   for Sinusoidal Equal Area Projections
'TIRO'  for Polar Orbiter Nadir Scanners
'    '  (or binary 0), '□□□□' (or binary 80808080) for
        no navigation
```

If the type is 'PLAN', the succeeding words are the same as the 128 word McIDAS-MVS planetary navigation codicil format. This navigation format provides geometry parameter and a matrix for conversion from a framing camera image to planet lat-lon coordinates, and contains some redundant information from the Supplementary Experimenter Data Records (SEDR) for Mariner 10 and Voyagers 1 & 2. Other map projections are usually just sets of a few map parameters and scale factors and fill just a few of the first 128 words.

The first 128 word block must be loaded by a call to subroutine NVPREP prior to doing anything with a McIDAS navigation module. This is normally handled by each applications keyin.

5.4   DATA DESCRIPTION BLOCK

The last 512 words in the navigation block are part of the Data Description Block (DDB). The words fall into five groups:

1)   Spacecraft, Image, & Instrument Specific (129-192), [Describes orbit parameters, instrument and image types.]

2)   Central & Picture Body Specific (193-352), [Describes target body physical constants and positional parameters WRT the central body]

3)   User Computed Quantities (353-460), [Ancillary information used in data analysis by the scientist. Fixed block size & format.]

4)   Supplementary Information (461-512). [User definable block.]

5)   User Defined Navigation (513-640), [Describes the spacecraft attitude, instrument
     orientation, and geometrical quantities needed to find points on the planet in the data.]

Each group is detailed below. Two asterisks after a word location indicate the datum location is
mandatory if a DDB is present. Mandatory entries are in the same place for every DDB, regardless of
spacecraft or instrument, but they do not all need to be filled. The DDB entries for a McIDAS-eXplorer
area are listed by the keyin LISTDDB.

Note that there may be several entries for a similar value such as for Voyager with the navigation
north angle (words 528-529), the SEDR (data) north angle (word 516) and the north angle computed
from a limb fit (words 358-359). The navigation entry is the value used when the area is navigated.

An important note: The navigation routines which rely on accessing the Data Description Block
for navigation information (NAIF, RADC, SPCE) require that DDB word 124 contain the area number of
the area. Explorer keyins which copy or move data will update this number, but a core Mcidas or Unix
copy routine may not. If an area contains a value in word 124 other than the area number the user MUST
correct this using the "NAVUTIL AREA=area_number ID=area_number" command.

```
                --------------------------------------------------------
                  Data Description Blocks for McIDAS-eXplorer Areas:
                --------------------------------------------------------


     WORD      ITEM     (S/C, Image, & Instrument)          TYPE   COMMENTS
     -------   ------------------------------------------   ----   ------------------
      124**Area Number of Image                            I*4    Needed for DDB
                                                                  access, passed in
                                                                  NAV block (1-128)
      129**DDB Identifier                                   C*4    Always = 'DDB0'
      130**DDB Block Type & Version (BBBV)                  C*4
                'VGR '  =  Voyager
                'VO  '  =  Viking Orbiter
                'CPP '  =  Pioneer Venus
                'MGN '  =  Magellan
                'MO  '  =  Mars Observer
                'HST '  =  Hubble Space Telescope
                'GO  '  =  Galileo Orbiter
                'CLEM'  =  Clemintine Lunar Survey
                  (words 133-134 identify spacecraft and camera)

    131-512  MISSION SPECIFIC DATA INFORMATION, SEE BELOW

    513-640  Navigation information defining the position
             of observer, pointing of the instrument and
             parameters describing the image geometry.
             This block contains most of the data needed for
             the NAIF and SPCE navigation routines to function.

     WORD      ITEM (Position, Attitude, Image Geometry)   TYPE   COMMENTS
     -------   ------------------------------------------   ----   ------------------
        513   Spare                                         I*4
        514   Smear Direction (deg relative to scan dir)    R*4    If present
        515   Smear Velocity (km/s relative to tgt sfc)     R*4       "
        516   Data North Angle (as read from SEDR etc.)     R*4
        517   Optic Axis RA                                 R*4    Nav. S/C
        518   Optic Axis Decl                               R*4    Nav. S/C
       .519   Sun Phase Angle at SC/Planet/Sun Center       R*4
    520-522   L-Vector ( Az, El, Twist)                     R*4
    523-525   Pitch, Yaw, and Roll Limit Cycle Angles       R*4    IOS VECTOR
    526-527   Direction to sun in image coord system        R*8    "LSUN"
    528-529   Nav North Angle (deg relative to scan dir)    R*8    Nav. "NORANG"
    530-531   Nav Ecliptic North Angle (as above)           R*8    Nav. "ECLANG"
    532-535   Spare
    536-553   3x3 Transform Matrix Inst-->Planet            R*8    From data source,
    554-571   3x3 C-Matrix       Inertial->Instrument       R*8    tape, CDROM,
    572-589   3x3 Rot. Matrix  Inertial->PicBody Cent.      R*8    SPICE Kernels,
etc.
    591-592   Tilt Angle of Optic Axis                      R*8
    593-594   Azimuth Angle of Optic Axis                   R*8
    595-600   S/C Position Vector (Picture Body Fixed)      R*8    RSC X,Y,Z
    601-602   Sub S/C Planetocentric Latitude               R*8    RSC - LAT
    603-604   Sub S/C Planetocentric Longitude              R*8    RSC - LON
    605-606   Sin of half angle subtended by equat. axis    R*8    "SINALP"
    607-608   Width to Height Pixel Ratio                   R*8    Ratio >= 0
    609-614   Sun Position Vector (Picture Body Fixed)      R*8    RSOL X,Y,Z
    615-616   Sub Sol Planetocentric Latitude               R*8    RSOL - LAT
    617-618   Sub Sol Planetocentric Longitude              R*8    RSOL - LON
    619-624   Earth Position Unit Vector (S/C to Earth)     R*8
    625-640   Spare
```

```
                -----------------------------------------
                Voyager DDB:    Identifier='DDB0VGR '
                -----------------------------------------


WORD      ITEM    (S/C, Image, & Instrument)        TYPE   COMMENTS
-------   ----------------------------------------   ----   ------------------
131-132**Data Type (S/C Image, Data, Mapped)        C*8
           'RAW S/C ' = Raw Spacecraft Image (800x800)
           'PROC S/C' = Processed Spacecraft Image
           'MAP PROJ' = Map Projection
           'MOSAIC  ' = Mosaic
     133**Spacecraft ID (NAIF Code)                 I*4    VG1= -31,VG2= -32
     134**Instrument ID (NAIF Code)                 I*4    -31001,-31002, etc
135-136**Instrument ID                              C*8    ISSNA, ISSWA
137-138  Picture ID-1 (FDS)                         C*8    S/C Data ID
139-141  Picture ID-2 (PICNO)                       C*12
     142  Picture Time (Year)                       I*4
     143  Picture Time (Day)                        I*4
     144  Month                                     I*4
145-146  Picture Time (hh:mm:ss)                    C*8
     147  Frame Size (Pixels in scan direction)     I*4
     148  Frame Size (Pixels in cross-scan direction)I*4
     149  Focal Length (mm)                         R*4
150-151  FOV (Degrees in scan direction)            R*8
152-153  FOV (Degrees in cross-scan direction)      R*8
     154  Exposure Time (sec)                       R*4
155-156  Filter ID (name)                           C*8
     157  Filter ID (ordinal)                       I*4
     158  Filter ID (central wavelength)            R*4
     159  Filter Half Width at Half Maximum         R*4
160-161  Units of Above (nm, microns)               C*8    normally nm
162-163  Imaging Sequence Mnemonic                  C*8    VPHOT etc.
164-165  Imaging Mode Mnemonic                      C*8    BOTSIM etc.
     166  Imaging System Camera Gain                C*4    HIGH/LOW
     167  Imaging System Camera Scan Rate           C*4    1:1,3:1,5:1, etc.
     168  Imaging System Edit Mode                  C*4    1/1,1/3, etc.
     169  GEOMed or not                             C*4    'GEOM' or '    '
     170  PHOTometrically Corrected or not          C*4    'PHOT' or '    '
     171  A1 photometric constant (ft-L to I)       R*4
     172  A2 photometric constant (DN to ft-L)      R*4
     173  A3 photometric constant (ft-L to I/F)     R*4
174-182  Spare
     182**Eccentricity of Orbit                     R*4
     183**Inclination of Orbit to Ecliptic          R*4
     184**Ecliptic Longitude of Ascending Node      R*4
     185**Argument of Periapsis                     R*4
     186**Orbital Period                            R*4
     187**Semi-Major Axis of Orbit                  R*4
     188**Ecliptic Latitude of Periapsis            R*4
     189**Ecliptic Longitude of Periapsis           R*4
     190**Altitude from Target Center at Periapsis  R*4
191-192**Image Compression Algorithm                C*8    'NONE','HUFFMAN',
                                                           'LZW', etc.



WORD      ITEM    (Central & Picture Body)          TYPE   COMMENTS
-------   ----------------------------------------   ----   ------------------
193-195**Central Body Name                          C*12
     196**Central Body (NAIF Code)                  I*4
197-199**Picture Body Name                          C*12
```

```
          200**Picture Body (NAIF Code)                      I*4
          201**Picture Body Rotational Period (hrs.)         R*4
          202  Picture Body Pole Right Ascension             R*4     S/C EME
          203  Picture Body Pole Declination                 R*4     S/C EME
          204**Nominal Picture Body Eq. Radius (km)          R*4
          205**Nominal Picture Body Pol. Radius (km)         R*4
          206  Nominal Picture Body Cross-Eq. Radius (km)    R*4
          207  Color Dep. Picture Body Eq. Radius (km)       R*4
          208  Color Dep. Picture Body Pol. Radius (km)      R*4
          209  Color Dep. Picture Body Cross-Eq. Rad.(km)    R*4
          210  Picture Body Eccentricity:  SQRT(e2-p2)/p     R*4
      211-217  Spare
      218-219  Reference System                             C*8
      220-339  Spare
      340-345  S/C Position Vector WRT Central Body          R*8     S/C EME
      346-351  S/C Velocity Vector WRT Central Body          R*8     S/C EME, KM/S
      352      West Convention for longitude                I*4     1 or -1


WORD       ITEM   (User Computed Quantities)                TYPE  COMMENTS
-------    ---------------------------------------------    ----  -----------------
353-354**User Block Type                                    C*8   'MEXP-VGR'
            'MEXP-VGR' = McIDAS-eXp Voyager
            'MEXP-MGN' = McIDAS-eXp Magellan
            'MEXP-CPP' = McIDAS-eXp Pioneer Venus
            'MEXP-FIT' = McIDAS-eXp Flexible Image Transport System
            'MEXP-VO ' = McIDAS-eXp Viking Orbiter
          (specifies user dependent block format)
355-357  Spare
358-359  Computed North Angle from Limb fit                 R*8   Not used for Nav
360-377  Computed Transform Matrix Inst-->PicBod            R*8      "
378-395  Computed Transform Matrix Inst-->Planet            R*8      "
396-413  Computed  C-Matrix     Inertial->Instrument        R*8      "
414-431  Computed Rot. Matrix   Inertial->PicBody           R*8      "
432-433  Computed Optic Axis RA                             R*8      "
434-435  Computed Optic Axis Decl                           R*8      "
    436**Minnaert Fit Constant (Max DN Used)                I*4
    437**Minnaert Fit Constant (Calc Slope)                 R*4
    438**Minnaert Fit Constant (Calc Intercept)             R*4
    439**Minnaert Fit Constant (Mean Abs. Dev)              R*4
440-441  Picture Body Center Line                           R*8   If avaiable, and
442-443  Picture Body Center Element                        R*8   necessary
444-445  Pixel Diameter of Picture Body                     R*8
446-447  Navigation Status                                  C*8
448-449  Navigation System Type                             C*8
450-451  Image/Navigation Processing Status                 C*8
452-460  Spare


WORD       ITEM   (Supplementary Information)               TYPE  COMMENTS
-------    ---------------------------------------------    ----  -----------------
461-462  Supplementary Block Type                           C*8   'SUPL-VGR'
463-465**Data Source (CD-ROM Volume, tape name)             C*12
465-512  Satellite & Shadow Positions
         Star Locations
         Rings
```

```
                    ------------------------------------
                    Magellan  DDB:   Identifier='DDB0MGN '
                    ------------------------------------


WORD       ITEM    (S/C, Image, & Instrument)          TYPE  COMMENTS
-------    ------------------------------------------   ----  -----------------
131-132**Data Type (S/C Image, Data, Mapped)           C*8
         'C1', 'C2', 'C3', 'F-MIDR'
    133**Spacecraft ID (DSN/NAIF Code)                  I*4
    134**Instrument ID (NAIF Code)                      I*4
135-136**Instrument ID (Name)                           C*8
137-138  Image Type                                     C*4   'C2-MIDR'
139-140  Picture Location                               C*8   'LLNLLL'
    141  Tile or Framelet Number                        I*4
    142  Number of First Orbit                          I*4
    143  Number of Last Orbit                           I*4
    144  First Orbit Ascending Node Time (Year)         I*4
    145  First Orbit Ascending Node Time (Day)          I*4
    146  First Orbit Ascending Node (Month)             I*4
147-148  First Orbit Ascending Node Time (hh:mm:ss)     C*8
    149  Frame Size (in scan direction)                 I*4
    150  Frame Size (in cross-scan direction)           I*4
151-152  Side Looking Direction (LEFT,RIGHT,OTHER)      C*8
153-182  Spare
    182**Eccentricity of Orbit                          R*4
    183**Inclination of Orbit to Ecliptic              R*4
    184**Ecliptic Longitude of Ascending Node          R*4
    185**Argument of Periapsis                          R*4
    186**Orbital Period                                 R*4
    187**Semi-Major Axis of Orbit                       R*4
    188**Ecliptic Latitude of Periapsis                R*4
    189**Ecliptic Longitude of Periapsis               R*4
    190**Altitude from Target Center at Periapsis       R*4
191-192**Image Compression Algorithm                    C*8   'NONE','HUFFMAN',
                                                              'LZW', etc.


WORD       ITEM    (Central & Picture Body)             TYPE  COMMENTS
-------    ------------------------------------------   ----  -----------------
193-195**Central Body Name                              C*12
    196**Central Body (NAIF Code)                       I*4
197-199**Picture Body Name                              C*12
    200**Picture Body (NAIF Code)                       I*4
    201**Picture Body Rotational Period (hrs.)          R*4
    202  Picture Body Pole Right Ascension              R*4
    203  Picture Body Pole Declination                  R*4
    204**Nominal Picture Body Eq. Radius (km)           R*4
    205**Nominal Picture Body Pol. Radius (km)          R*4
    206  Nominal Picture Body Cross-Eq. Radius (km)     R*4
207-209  Spare
    210  Picture Body Eccentricity:  SQRT(e2-p2)/p      R*4
211-256  Spare


WORD       ITEM   (Imaging or Map Projection Geometry)  TYPE  COMMENTS
-------    ------------------------------------------   ----  -----------------
    257  Map Projection Type                            C*4   generally 'SIN '
    258  Original Map Scale                             R*4
    259  Sampling Factor                                I*4
```

```
      260   Image Scale Factor (km/pixel)                 R*4
      261   PROJSAMP                                       I*4
  262-263   Projection Longitude                          R*8
  264-265   Image Center Latitude                         R*8
  266-267   Image Center Longitude                        R*8
  268-269   Image LAT_UL                                  R*8
  270-271   Image LAT_UL                                  R*8
  272-273   Image LAT_UL                                  R*8
  274-275   Image LAT_UL                                  R*8
  276-277   Image LAT_UL                                  R*8
  278-279   Image LAT_UL                                  R*8
  280-281   Image LAT_UL                                  R*8
  282-352   Spare


WORD      ITEM   (User Computed Quantities)          TYPE  COMMENTS
-------   ------------------------------------------  ----  -----------------
353-354**User Block Type                             C*8   'MEXP-MGN'
          'MEXP-VGR' = McIDAS-eXp Voyager
          'MEXP-MGN' = McIDAS-eXp Magellan
          'MEXP-CPP' = McIDAS-eXp Pioneer Venus
          'MEXP-FIT' = McIDAS-eXp Flexible Image Transport System
          'MEXP-VO ' = McIDAS-eXp Viking Orbiter
        (specifies user dependent block format)
355-435  Spare
    436**Minnaert Fit Constant (Max DN Used)         I*4
    437**Minnaert Fit Constant (Calc Slope)          R*4
    438**Minnaert Fit Constant (Calc Intercept)      R*4
    439**Minnaert Fit Constant (Mean Abs. Dev)       R*4
440-460  Spare


WORD      ITEM   (Supplementary Information)         TYPE  COMMENTS
-------   ------------------------------------------  ----  -----------------
461-462   Supplementary Block Type                   C*8   SUPL-MGN
463-465**Data Source (CD-ROM Volume, tape name)      C*12
465-512   Spare
```

```
                -----------------------------------------------
                Pioneer Venus  DDB:   Identifier='DDB0CPP '
                -----------------------------------------------


WORD        ITEM     (S/C, Image, & Instrument)      TYPE   COMMENTS
-------     ----------------------------------------  ----   ------------------
131-132**Data Type (Raw S/C, Image, Data, Remapped)  C*8
    133**Spacecraft ID (DSN/NAIF Code)                I*4
    134**Instrument ID (NAIF Code)                    I*4
135-136**Instrument Mode ID (IMAGE,LIMBSCAN,POLARIM)  C*8
137-138  Image Type                                   C*8
    139  Number of Scan Lines                         I*4
140-141  Scan Sample Rate                             R*8
    142  Image number                                 I*4
143-181  Spare
    182**Eccentricity of Orbit                        R*4
    183**Inclination of Orbit to Ecliptic             R*4
    184**Ecliptic Longitude of Ascending Node         R*4
    185**Argument of Periapsis                        R*4
    186**Orbital Period                               R*4
    187**Semi-Major Axis of Orbit                     R*4
    188**Ecliptic Latitude of Periapsis               R*4
    189**Ecliptic Longitude of Periapsis              R*4
    190**Altitude from Target Center at Periapsis     R*4
191-192**Image Compression Algorithm                  C*8    'NONE','HUFFMAN',
                                                             'LZW', etc.


WORD        ITEM     (Central & Picture Body)         TYPE   COMMENTS
-------     ----------------------------------------  ----   ------------------
193-195**Central Body Name                            C*12
    196**Central Body (NAIF Code)                     I*4
197-199**Picture Body Name                            C*12
    200**Picture Body (NAIF Code)                     I*4
    201**Picture Body Rotational Period (hrs.)        R*4
    202  Picture Body Pole Right Ascension            R*4
    203  Picture Body Pole Declination                R*4
    204**Nominal Picture Body Eq. Radius (km)         R*4
    205**Nominal Picture Body Pol. Radius (km)        R*4
    206  Nominal Picture Body Cross-Eq. Radius (km)   R*4
207-209  Spare
    210  Picture Body Eccentricity:  SQRT(e2-p2)/p    R*4
211-256  Spare


WORD        ITEM    (Imaging or Map Projection Geometry)  TYPE   COMMENTS
-------     ----------------------------------------  ----   ------------------
257-258  Map Projection Type (Roll-by-Roll, Proj)    C*8
    259  Date Scan Begins                             I*4    YYDDD
    260  Time Scan Begins                             I*4    HHMMSS
    261  Orbit Number                                 I*4
    262  Date of Last Periapsis                       I*4    YYDDD
    263  Time of Last Periapsis                       I*4    HHMMSS
    264  Ecliptic Latitude of S/C Spin Axis           R*4    Degrees
    265  Ecliptic Longitude of S/C Spin Axis          R*4    Degrees
    266  Navigation Spin Period                       R*4    Default from file
    267  R.M.S. Deviation Spin Periods                R*4
    268  Length of Scan (sec)                         R*4
```

```
     269   Commanded Look Angle                          R*4
     270   True Look Angle                               R*4
 271-272   Roll Index Pulse Time                         R*8
     273   Roll Angle Code 1 (Position at Beginning)     I*4
 274-275   Contact Time 1 (sec)                          R*8
     276   Roll Angle Code 2                             I*4
 277-278   Roll Shift Time 2 at (sec)                    R*8
     279   Roll Angle Code 3                             I*4
 280-281   Roll Shift Time 3 at (sec)                    R*8
     282   Roll Angle Code 4                             I*4
 283-284   Roll Shift Time 4 at (sec)                    R*8
     285   Roll Angle Code 5                             I*4
 286-287   Roll Shift Time 5 at (sec)                    R*8
     288   Roll Angle Code 6                             I*4
 289-290   Roll Shift Time 6 at (sec)                    R*8
     291   Contact Code (First or Last)                  I*4
     292   Contact Sector                                I*4
     293   Roll Contact Code                             I*4
     294   High/Low Mode Code                            I*4
     295   Gain State (HIGH or LOW)                      I*4
 296-297   One Way Light Time, Venus to PVO              R*8
     298   Roll Pixel Correction                         I*4
     299   Old Spin Period                               R*4
     300   Old Orbital Period                            R*4
     301   Average Spin Period (Scan_Length/ #Lines)     R*4
     302   Mean of the Line by Line Spin Periods         R*4
     303   Phase Angle                                   R*4
     304   Time since Periapsis from Scan Start          R*4    Hours
     305   Alternate Roll Code Flag is Present           I*4    1 if Present
 306-352   Spare


WORD      ITEM   (User Computed Quantities)              TYPE   COMMENTS
-------   ---------------------------------------------   ----   ------------------
353-354**User Block Type                                 C*8    'MEXP-CPP'
             'MEXP-VGR' = McIDAS-eXp Voyager
             'MEXP-MGN' = McIDAS-eXp Magellan
             'MEXP-CPP' = McIDAS-eXp Pioneer Venus
             'MEXP-FIT' = McIDAS-eXp Flexible Image Transport System
             'MEXP-VO ' = McIDAS-eXp Viking Orbiter
          (specifies user dependent block format)
355-435   Spare
     436**Minnaert Fit Constant (Max DN Used)            I*4
     437**Minnaert Fit Constant (Calc Slope)             R*4
     438**Minnaert Fit Constant (Calc Intercept)         R*4
     439**Minnaert Fit Constant (Mean Abs. Dev)          R*4
440-460   Spare


WORD      ITEM   (Supplementary Information)             TYPE   COMMENTS
-------   ---------------------------------------------   ----   ------------------
461-462   Supplementary Block Type                       C*8    SUPL-CPP
463-465**Data Source (CD-ROM Volume, tape name)          C*12
465-512   Spare
```

```
                   -----------------------------------
                   FITS  DDB:   Identifier='DDB0FIT '
                   -----------------------------------


WORD      ITEM    (S/C, Image, & Instrument)         TYPE   COMMENTS
-------   ------------------------------------------  ----   ------------------
131-132**Data Type (Telescope Image, Other Data)     C*8
   133**Spacecraft ID (DSN/NAIF Code)                I*4    0 for Earth-Based
   134**Instrument ID (NAIF Code)                     I*4    0 for Earth-Based
135-136**Instrument ID (Name)                         C*8    First 8 bytes
137-141  TELESCOP (Name of telescope)                 C*20
142-146  INSTRUME (Name of Instrument)                C*20
147-149  FILTER   (Name of Filter)                    C*12
150-151  FOV (Degrees in scan direction)              R*8
152-153  FOV (Degrees in cross-scan direction)        R*8
154-158  OBSERVER (Name of observer)                  C*20
159-181  Spare
   182**Eccentricity of Orbit                         R*4    N/A, Unused
   183**Inclination of Orbit to Ecliptic              R*4         "
   184**Ecliptic Longitude of Ascending Node          R*4         "
   185**Argument of Periapsis                         R*4         "
   186**Orbital Period                                R*4         "
   187**Semi-Major Axis of Orbit                      R*4         "
   188**Ecliptic Latitude of Periapsis                R*4         "
   189**Ecliptic Longitude of Periapsis               R*4         "
   190**Altitude from Target Center at Periapsis      R*4         "
191-192**Image Compression Algorithm                  C*8    'NONE','HUFFMAN',
                                                             'LZW', etc.


WORD      ITEM    (Central & Picture Body)            TYPE   COMMENTS
-------   ------------------------------------------  ----   ------------------
193-195**Central Body Name                            C*12
   196**Central Body (NAIF Code)                      I*4
197-199**Picture Body Name                            C*12
   200**Picture Body (NAIF Code)                      I*4
   201**Picture Body Rotational Period (hrs.)         R*4
   202  Picture Body Pole Right Ascension             R*4
   203  Picture Body Pole Declination                 R*4
   204**Nominal Picture Body Eq. Radius               R*4    KM
   205**Nominal Picture Body Pol. Radius              R*4    KM
   206  Nominal Picture Body Cross-Eq. Radius         R*4    KM
   207  Color Dep. Pict. Body Eq. Radius              R*4    KM
   208  Color Dep. Pict. Body Pol. Radius             R*4    KM
   209  Color Dep. Pict. Body Cross-Eq. Radius        R*4    KM
   210  Picture Body Eccentricity:  SQRT(e2-p2)/p     R*4
211-215  OBJECT (Name of object observed)             C*20
216-217  EQUINOX (Equinox in years for coordinates)   C*8
218-219  Reference System                             C*8
220-351  Spare
352      West Convention for Longitude                I*4    1 or -1


WORD      ITEM    (User Computed Quantities)          TYPE   COMMENTS
-------   ------------------------------------------  ----   ------------------
353-354**User Block Type                              C*8    'MEXP-FIT'
            'MEXP-VGR' = McIDAS-eXp Voyager
            'MEXP-MGN' = McIDAS-eXp Magellan
            'MEXP-CPP' = McIDAS-eXp Pioneer Venus
```

```
            'MEXP-FIT' = McIDAS-eXp Flexible Image Transport System
            'MEXP-VO ' = McIDAS-eXp Viking Orbiter
            (specifies user dependent block format)
355-357   Spare
358-359   Computed North Angle from Limb fit          R*8   Not used for Nav
360-377   Computed Transform Matrix Inst-->PicBod      R*8        "
378-395   Computed Transform Matrix Inst-->Planet      R*8        "
396-413   Computed  C-Matrix    Inertial->Instrument   R*8        "
414-431   Computed Rot. Matrix  Inertial->PicBody      R*8        "
432-433   Computed Optic Axis RA                       R*8        "
434-435   Computed Optic Axis Decl                     R*8        "
    436**Minnaert Fit Constant (Max DN Used)           I*4
    437**Minnaert Fit Constant (Calc Slope)            R*4
    438**Minnaert Fit Constant (Calc Intercept)        R*4
    439**Minnaert Fit Constant (Mean Abs. Dev)         R*4
440-441   Picture Body Center Line                     R*8   If avaiable, and
442-443   Picture Body Center Element                  R*8   necessary (needed
444-445   Pixel Diameter of Picture Body               R*8   for F.I.T.S )
446-447   Navigation Status                            C*8
448-449   Navigation System Type                       C*8
450-451   Image/Navigation Processing Status           C*8
452-460   Spare
```

WORD	ITEM (Supplementary Information)	TYPE	COMMENTS
461-462	Supplementary Block Type	C*8	SUPL-FIT
463-465**Data Source (Laboratory, Scientist)		C*12	
465-512	Spare		

```
--------------------------------------
Voyager DDB:   Identifier='DDB0VO '
--------------------------------------


WORD     ITEM     (S/C, Image, & Instrument)          TYPE   COMMENTS
-------  ---------------------------------------------  ----   ------------------
131-132**Data Type (S/C Image, Data, Mapped)           C*8
         'RAW S/C ' = Raw Spacecraft Image (1056x1204)
         'PROC S/C' = Processed Spacecraft Image
         'MAP PROJ' = Map Projection
         'MOSAIC  ' = Mosaic
    133**Spacecraft ID (NAIF Code)                      I*4    -27,-30
    134**Instrument ID (NAIF Code)                      I*4
135-136**Instrument ID                                  C*8
137-138  Picture ID-1 (FDS)                             C*8    S/C Data ID
139-141  Picture ID-2 (IMAGE ID)                        C*12
    142  Picture Time (Year)                            I*4
    143  Picture Time (Day)                             I*4
    144  Month                                          I*4
145-146  Picture Time (hh:mm:ss)                        C*8
    147  Frame Size (Pixels in scan direction)          I*4
    148  Frame Size (Pixels in cross-scan direction)    I*4
149-150  FOV (Degrees in scan direction)                R*8
151-152  FOV (Degrees in cross-scan direction)          R*8
    153  Focal Length (mm)                              R*4
    154  Exposure Time (sec)                            R*4
155-156  Filter ID (name)                               C*8
    157  Filter ID (ordinal)                            I*4
    158  Filter ID (central wavelength)                 R*4
    159  Filter Half Width at Half Maximum              R*4
160-161  Units of Above (nm, microns)                   C*8    Normally nm
162-163  Imaging Sequence Mnemonic                      C*8
164-165  Imaging Mode Mnemonic                          C*8    GAIN,OFFSET,FLOOD
    166  Imaging System Camera Gain                     C*4    HIGH/LOW
167-168  Spare
    169  GEOMed or not                                  C*4    'GEOM' or '    '
    170  PHOTometrically Corrected or not               C*4    'PHOT' or '    '
    171  A1 photometric constant (ft-L to I)            R*4
    172  A2 photometric constant (DN to ft-L)           R*4
    173  A3 photometric constant (ft-L to I/F)          R*4
174-180  Spare
    181  Orbit Number                                   I*4
    182**Eccentricity of Orbit                          R*4
    183**Inclination of Orbit to Ecliptic              R*4
    184**Ecliptic Longitude of Ascending Node          R*4
    185**Argument of Periapsis                          R*4
    186**Orbital Period                                 R*4
    187**Semi-Major Axis of Orbit                       R*4
    188**Ecliptic Latitude of Periapsis                 R*4
    189**Ecliptic Longitude of Periapsis                R*4
    190**Altitude from Target Center at Periapsis       R*4
191-192**Image Compression Algorithm                    C*8    'NONE','HUFFMAN',
                                                               'LZW', etc.


WORD     ITEM     (Central & Picture Body)            TYPE   COMMENTS
-------  ---------------------------------------------  ----   ------------------
193-195**Central Body Name                              C*12   Mars
    196**Central Body (NAIF Code)                       I*4    499
197-199**Picture Body Name                              C*12
```

```
      200**Picture Body (NAIF Code)                    I*4
      201**Picture Body Rotational Period (hrs.)        R*4
      202  Picture Body Pole Right Ascension            R*4
      203  Picture Body Pole Declination                R*4
      204**Nominal Picture Body Eq. Radius (km)          R*4
      205**Nominal Picture Body Pol. Radius (km)         R*4
      206  Nominal Picture Body Cross-Eq. Radius (km)    R*4
      207  Color Dep. Picture Body Eq. Radius (km)       R*4
      208  Color Dep. Picture Body Pol. Radius (km)      R*4
      209  Color Dep. Picture Body Cross-Eq. Rad.(km)    R*4
      210  Picture Body Eccentricity:  SQRT(e2-p2)/p     R*4
  211-217  Spare
  218-219  Reference System                             C*8   EME50 etc.
  220-225  S/C Frame x,y,z of Picture Body              R*8   S/C EME
  226-231  Central Body EME x,y,z of S/C Position        R*8   Central Body EME
  232-237  Central Body EME relative S/C Velocity        R*8   Central Body EME
      238  Scan Platform Clock Angle                     R*4
      239  Scan Platform Cone Angle                      R*4
  240-245  Earth Direction Unit x,y,z Vector             R*8   S/C EME
  246-251  Sun Direction Unit x,y,z Vector               R*8   S/C EME
  252-256  Spare
```

```
WORD      ITEM   (Imaging or Map Projection Geometry)  TYPE  COMMENTS
-------   -------------------------------------------  ----  -----------------
    257   PG Intersect Latitude of S/C x,y,z at Sfc    R*4   Central Body EME
    258   PC Intersect Latitude of S/C x,y,z at Sfc    R*4   Central Body EME
    259   Orbital Longitude of Picture Body            R*4   EME50
    260   PG Sub-Sun Intersect Latitude at Sfc         R*4   Central Body EME
    261   PC Sub-Sun Intersect Latitude at Sfc         R*4   Central Body EME
    262   Sun Longitude                                R*4   Central Body EME
263-264   S/C Range from Picture Body Center           R*8
265-266   S/C Range to Earth                           R*8
267-268   S/C Range to Sun                             R*8
269-274   S/C x,y,z Velocity in Target Frame           R*8
    275   Smear Direction (deg relative to scan dir)   R*4
    276   Smear Velocity (km/s relative to tgt sfc)    R*4
    277   North Angle (deg relative to scan dir)       R*4
278-295   3x3 Transform Matrix Inst-->Planet           R*8
296-313   3x3 C-Matrix      Inertial->Instrument       R*8
314-331   3x3 Rot. Matrix   Inertial->PicBody Cent.    R*8
    332   Optic Axis RA                                R*4
    333   Optic Axis Dec                               R*4
334-336   L-Vector (Az,El,Twist)                       R*4
337-339   Pitch, Yaw, and Roll Limit Cycle Angles      R*4
    340   Nadir Angle of Optic Axis                    R*4
    341   Azimuth Angle of Optic Axis                  R*4
342-352   Spare
```

```
WORD      ITEM   (User Computed Quantities)            TYPE  COMMENTS
-------   -------------------------------------------  ----  -----------------
353-354**User Block Type                               C*8   'MEXP-VO'
          'MEXP-VGR' = McIDAS-eXp Voyager
          'MEXP-MGN' = McIDAS-eXp Magellan
          'MEXP-CPP' = McIDAS-eXp Pioneer Venus
          'MEXP-FIT' = McIDAS-eXp Flexible Image Transport System
          'MEXP-VO ' = McIDAS-eXp Viking Orbiter
          (specifies user dependent block format)
355-356   Navigation Status                            C*8
357-358   Navigation System Type                       C*8
```

```
    359  Computed North Angle                          R*8
360-377  Computed Transform Matrix Inst-->PicBod       R*8
378-395  Computed Transform Matrix Inst-->Planet       R*8
396-413  Computed Transform Matrix Inst-->EME          R*8
414-431  Computed Transform Matrix PicBod EED-->EME    R*8
432-433  Computed Optic Axis RA                        R*8
434-435  Computed Optic Axis Decl                      R*8
    436**Minnaert Fit Constant (Max DN Used)           I*4
    437**Minnaert Fit Constant (Calc Slope)            R*4
    438**Minnaert Fit Constant (Calc Intercept)        R*4
    439**Minnaert Fit Constant (Mean Abs. Dev)         R*4
    440  PicBod Center Line                            R*4
    441  PicBod Center Element                         R*4
    442  Pixel Size on PicBod Surface                  R*4
    443  RMS PicBod Radius Error for Navigation        R*4
    444  Sun Phase Angle at OptAxis/Sfc Intersect      R*4
    445  Best Fit Equatorial Radius of PicBod          R*4
    446  Best Fit Polar Radius of PicBod               R*4
447-448  Image/Navigation Processing Status            C*8
449-460  Spare
```

WORD	ITEM (Supplementary Information)	TYPE	COMMENTS
461-462	Supplementary Block Type	C*8	'SUPL-VO '
463-465**	Data Source (CD-ROM Volume, tape name)	C*12	

```
465-512  Satellite & Shadow Positions
         Star Locations
         Rings
```

5.5 CALIBRATION

Calibration is the process of converting the raw data stored in the eXplorer area into meaningful physical units. Calibration data are specific to the spacecraft, the instrument, and thus the calibration procedures and software also may differ. Although the area format allows some room for the calibration information to be stored, frequently other means are necessary to accomplish this task. Often, particularly for scanning type of devices, the calibration is included as part of line documentation on every line and treated as a line "prefix" in McIDAS. Sometimes, the calibration data require a significant amount of data, in which case these are stored separately, and more than one calibration may be necessary. Voyager images require both a radiometric and a geometric calibration. Radiometric calibration of Voyager vidicon images are an illustration of the situation where the data files that are necessary for converting raw data numbers into radiometric units occupy about 240 Mbytes of disk space for each camera. The calibration is actually a separate processing step. SHADE9 keyin raw DN values to watts/cm**2/ster, with a separate specific dark noise file corresponding to the Voyager camera and exposure time and a 9-point transfer function for each of the filter positions. The calibration produces a two-byte per pixel output from single byte raw Voyager images. Simple "field flattening" using a linear two-point transfer function is often adequate for many tasks, and requires far less disk space to operate. It runs fast, removing "hot corners" and improving contrast, and produces a compact one byte per pixel image. The Voyager calibration of shade corrected images then is reduced to converting the 2-byte data numbers into physical units which is a simple linear process with proper constants.

The amount of data required for geometric calibration is much smaller and the calibration block in the DDB for Voyager images in the eXplorer format is used to store these data. These data are the position of some fiducial marks, "reseaus" which are etched on the faceplate of the Voyager, Mariner and Vikling cameras. Keyin RF finds reseaus in Mariner and Voyager images, and places a set of nominal or found reseaus at the end of the calibration block. These reseaus are used by the GEOM keyin to produce a remapped image which has geometry very close to that of the focal plane image in the camera.

For the PDS solar system imaging data, the eXplorer software generally reads the attached PDS labels and extracts the required calibration information and stores it in the DDB. The same is also true for the attached navigation information.

Some data, such as the map projected Magellan radar imagery of Venus must be calibrated using incidence angles related to the orbit data. A single calibration block, designed for a framing camera with a small number of pixels, is not adequate for a large radar image mosaic. We will provide special McIDAS-eXp keyins to generate reflectivity and altitude maps from CD-ROM data in the same scale and projection as the radar imagery. Then it will be possible to make false color composites as 24- or 32-bit images and display on a Silicon Graphics McIDAS-X workstation.

5.6 AUDIT TRAIL

To keep a history of the processing to which an image is subjected to, most eXplorer key-ins attach a one line record that includes the date, time, keyin name, and keyin parameters used to modify the area in any way. Those modifications include any changes to the navigation or calibration information. The audit trail can be querid by using the LA FORM=AUDIT command.

The first lines of the audit trail may contain an "image identification block", or IID block. This identifies the spacecraft, camera, planet, scan mode, processing, map projection constants, VICAR header,

etc. for the image contained in the area. It is of different length for different images. McIDAS-eXp keyin DDBTUIL will create a new planetary area with DDB (Data Description Block), suitable for the SPICE-oriented navigation and two-byte pixels from radiometric conversion from any standard McIDAS-X, McIDAS-OS2, or McIDAS-MVS format area. The new areas remain completely backward compatible with the old as far as core McIDAS utilities and applications software is concerned.

APPENDIX I

APPENDIX I

McIDAS-eXplorer Command Guide

This section describes the **McIDAS-eXplorer** commands that can be used with the planetary data in detail. These are in addition to the McIDAS-X commands which are described in the McIDAS-X Users Guide.

The syntax of the commands, keyword explanations and examples are given along with some explanatory remarks. A separate document containing etailed output from typical sessions is planned.

This manual can also be viewed on-line from within McIDAS-eXplorer using the **EXPDOC** command.

PLEASE READ.........

McIDAS commands accept both positional; parameters as well as keyword values as inputs. In this document, the required positional parameters are indicated in italics. Any KEYWORDS if needed or specified, should be specified in upper case only, unless explicitly stated. In general, the keywords should follow the positional parameters. Any global keywords, e.g. DEV=N or DEV=P should be the last parameters on the command line.

A common positional parameter is the area_number for the image to be manipulates, and is generally indicated by *area_#*. If the result of the operation is another area, then the intial area may be indicated by *source_area_#* or *input_area_#* and similarly, the result is indicated by *destination_area_#* or *output_area_#*. In some cases, the operation is performed on the image being viewed. If the command is designed for such use (most are), then the area number is not generally necessary.

ANGLE - Determine the north angle for a Jupiter image by measuring the tilt angle of the zones and belts for earth based images for which the north angle is not independently known.

ANGLE

Parameters: None

Use the cursor to select several points along a linear feature. A robust fit will be applied to the points to determine the slope of line indicated by the points with the element direction.

REMARKS

This command should return a decent approximation to the orientation of the planetary image (Jupiter and Saturn). Because the command has no way of knowing which is north and south, the required north angle for image navigation (NAVUTIL command) could be a 360-degree complement of the returned value.

ASTAT - Measure image statistics on a displayed image

ASTAT   *optcoord* KEYWORDS

Parameters:

     opt - option type from one of the following:
     BOX | rectangular outline (default)
     CIR | circular or ellipitical outline
     IRR | irregular shaped outline
     LIN | outline based on line between 2 points

     coord - coordinate type-- one of the following:
     IC | image coordinates (default)
          All options are designed to run interactivly on the current image frame.
     EC | earth coordinates
     EC   station dist - sfc station loc and radius (km) for CIR
     EC   lat lon dist - lat lon circle and radius (km) for CIR
     EC LAT=lat1 lat2 LON=lon1 lon2 - lat/lon pairs for BOX
     EC   stn1 stn2 dist - point to point corridor (km) for LIN

Keywords:

     AREA = area number
     BAND = spectral band (default= current frame or, 1st band in area)
    COLOR = graphics color (default=2)
      CUT = lo hi | data range (default=0 10000)
     TAIL = % | tail percentage 0-100 (default=5%)
     HIST = frame# | plot a histogram on graphics frame   (default=no plot)
     LAT = lo hi | latitude range (LON= keyword must also be specified)
     LON = lo hi | longitude range (LAT= keyword must also be specified)
     ARC = lo hi | angular segment of an circle (CIR option only), where, deg1=
                    degrees from 0 to begining of arc segment, and deg2 =
                    degrees from 0 to end of arc segment
     FORM =   output | format of output statistics
    output =   1 | standard statistics (default)
    output =   2 | standard stats + BRIT bins
    output =   3 | standard stats + BRIT bins + BRIT
               histogram

   LEVELS =   nbin min max [for UNIT=BRIT only]
           nbin | number of bins (defaults: VGA=13, WWW=16, TOWR=16)
           min | minimum brightness level (default=0)
           max | maximum brightness level (default=255)

REMARKS

     This command allows the user to obtain statistics about the contents of an image or a section of it as determined by one of the many selection. The IRR option lets the user draw an outline to enclose an area on a displayed image using the mouse. The data units are user selectable as well.

BILIN - Scale an image in line and element direction by any arbitrary factor by bilinear interpolation

---

BILIN *source_area_#* *output_area_#* ASPECT= INPUT=

Parameters:

souce_area_# | area number containing the image to be scaled in x and y dimensions

output_area_# | output area number that will contain the scaled image

KEYWORDS

ASPECT = line_factor element_factor magnify
Defaults values are 1 , 1, 1, respectively

INPUT = start_line start_ele #line #element
Default values are 1, 1, #source_lines, #_source_ele, respectively

REMARKS

Bilin does area subsection blowup/blowdown using bilinear interpolation, on pixel value vs pixel location, currently max box size is 800 x 800.

The routine may also be used to correct images with non-square pixels (e.g. many of the amateur telscopic images are acquired with Lynx or other cameras which have rectangular pixels). Rendering the pixels square simplifies the navigation by not having to propagate the pixel aspect ratio throughout the navigation.

Examples:

1. Project an image (area=1111) with 165 lines by 192 pixels into a square field (area=9999):

    BILIN 1111 9999 ASPECT=165 192

2. Magnify the same area 1.75 times:

    BILIN 1111 9999 ASPECT=X X 1.75

BLEMEDIT - An interactive program for editing blemishes in a displayed image. The image data within the cursor are replaced by a bi-linear average of the data in a larger box surrounding the cursor.

BLEMEDIT	*line ele*

or,

BLEMEDIT	FILE =

REMARKS:

The cursor size can be changed using the CUR key-in to contain the blemish but the margin around it that defines the larger box cannot be changed except by exiting the command. The cursor is placed over the blemish and a mouseclick then performs the data replacement.

Clicking the middle and the right mouse keys terminates the program.

If the blemish locations are previously known, the command can be executed in the batch mode by specifiying the blemish locations (image line and element numbers) and the size of the box that specifies their size (also in lines and elements) from a text file.

BOTSIM - Transfer navigation from the navigated frame to the unnavigable frame for a pair of Simultaneously shuttered Wide-Angle Narrow-Angle Voyager Images. To be used only for images with the PLAN navigation type.

BOTSIM *navigated_area# unnavigated_area#* SIMUL = YES/NO

(Uses transform matrix for simultaneous WA/NA Voyager (1 or 2) image pair to link the unnav_area# to a navigated navigated_area# using the WA/NA co-ordinate transform matrix.
Both images must have identical shutter times and be "BOTSIM" shutter mode.

(must have previously run SEDRIN to define the camera geometry for the unnavigated frame)

SIMUL = YES/NO | (YES is default, NO turns off date/time check for simultaneous shutter times. If times are not the same, no correction for rotation of the target planet between images is made.)

CENTER = LIN ELE | (Planet center line-element in unnavigated image, default is planet center translated from the navigated image)

NOTE: The north angle of the navigated_area is used for the unnavigated_area. This permits navigated_area roll angle and spin axis corrections to be propagated to the unnavigated

REMARKS

This command is useful for close encounter images from Voyager cameras of obbjects when the higher resolution narrow anlge frame does not contain an adequate or any bright limb to be able to determine the object center with any accuracy. If a simultaneously shuttered wide angle frame is available, then this command transfers the navigation from the wide angle frame to the narrow angle frame, accounting for the misalignment (determined from ground based measurements) between the two cameras on both spacecraft. Note that because the resolution of the WA cameras is 7.5 times worse than that of the NA cameras, the navigation of the the NA frames navigated frames this way is no better than that of the wide-angle frames.

BROWSE - Display a Magellan MIDR 8 x Browse image on a frame and overlay the 7 x 8 tiling grid with framelet or tile numbers to show the component frames. Normally called by GETMGN when retrieving Browse images from MIDR CD-ROM volumes

---

BROWSE *area_#* *frame_#*

PARAMETERS:
area_# | Area containing browse image
frame_# | Frame to load and grid

REMARKS:

This program is a combination of the DF keyin and a specialgridding routine specifically used for Magellan browse images.

Normally, this keyin is called by GETMGN, but you may call it separately to restore the browse image to the McIDAS screen if the browse frame was overwritten.

BRTCEN - Determine the center of brightness of a full disk at a given sampling, then conduct a radial scan at a set angular interval to determine the limb of the body as the first step in center finding for the purpose of image navigation of mages of objects without permanent, fixed surface features. Primarily intended for earth based images.

BRTCEN area_# *linskip*   *eleskip* KEYWORDS

KEYWORDS:

COL	=	color_level (1 - 7) (default = 3)
INC	=	angular_increment (azimuth increment, degrees) (default = 5)
RADIUS	=	hi low (radial range for limb point test, 1.0 = estimated radius) (default = 1.1 0.8)
SCAN	=	start stop (azimuth interval for limb point test, degrees) (default = 0.0 360.0)
NUMBYTE	=	number_bytes_data_per_pixel (default = 1), usually picked up from area directory
DN	=	low hi (dn range for limb scan) (default = 10 255 [1 byte/pixel data], 100 32000 [for 2-byte data])
PLOT	=	QUE (plots the inner and outer radii for the limb test) (default is no plot)

Note that the use of a median filter on "dark" noisy images can improve BRTCEN's performance.

REMARKS:

Once a 'guess' image center is determined by using the center of brightness, this key-in initiates a radial search for the planet's bright limb in specified azimuth range in increments of *deginc* from an inner radius to an outer radius and then plots the detected limb points over the image. The array of limb points are written to LIMBxxxx, where xxxx is the area number of the displayed frame.

CALCMA - Calculates Transform Matrix for Planetary Navigation for framing camera image navigation. Currently is set up for Voyager images only.

CALCMA	*area No_Center_Find_Flag* ROLLOFF=

Parameters:

area | area containing navigation block to be updated
NCFF | no center find flag (0 or any other number)
(This parameter, if non-zero, forces program to use planet center coordinates already in the navigation block rather than perform a best fit to the bright limb points stored in the navigation block. (i.e. it forces the planet center position)

KEYWORDS:

ROLLOFF = roll offset correction (subtracted from north angle) as determined from optical navigation by determination of the actual roll (north) angle by referencing a star or a satellite and noting the difference from the SEDR value of the north angle.

EXAMPLES:

CALCMA   *(updates matrix for area last accessed)*
CALCMA 1022 1   *(forces planet center for area 1022)*
          (will default to area last accessed)

CHANGECD - Unmount/mount a CD-ROm volume in the UNIX workstation's CD-ROM reader.

CHANGECD

Remarks

Most UNIX systems require that CD-ROM volumes be "mounted" before they can be used to read data. CHANGECD command makes this process simpler by allowing the user to unmount and mount a CD in the reader.

CLEAN - Remove Shot Noise and Line Dropouts from Images

CLEAN *input_area output_area frame_# option threshold_DN DN_gradient*

Parameters:

input_area#	source area that contains the image of interest
output_area#	new area to be written
threshold_DN	brightness above the neighbouring pixels beyond which pixel classified as noise
DN_gradient	brightness DN between pixel at same element addrees on preceeding and subsequent lines that tags the current pixel as a noise pixel
opt	Noise filter option. Picjk one from:
	'NOI' OPTION IS LINE DROPOUT AND SHOT NOISE FILTER COMBINED.
	'BAD' REALLY BAD NOISE... SPIKES > 1 PIXEL FILTERS OVER 5 PIXELS HORIZONTALLY, WITH SOME RESOLUTION LOSS LIKELY)

DEFAULTS: CLEAN <area-in> <area-out> 0 NOI 15 20

KEYWORDS FOR FRAME LOAD:

LOCATE (DEFAULT=AU)
YCOOR (DEFAULT=0)
XCOOR (DEFAULT=0)
MAG   (DEFAULT=1)

REMARKS:

Program first checks to see if there is a smoother than gradient transition from the preceeding to the subsequent line. If so, and the middle line pixel exceeds the average of above and below pixels, by threshold, the middle pixel is replaced by the average. This vertical interpolation removes correlated noise bursts along a line. Then a shot noise filter is applied horizontally on the line to any pixel deviating by more than the threshold from its preceeding or following neighbor.

Thus, gradient=0 gives an ordinary shot noise filter, while setting it non-zero turns on the vertical filter to remove correlated noise along a line.)

COMBIN - Make a multiband area from several single band area. MAY ALSO BE USED TO REDUCE 2-BYTE DATA TO 1-BYTE DATA.

COMBIN *outarea* BANDS=area1 area2...areaN

PARAMETERS:

    outarea | area with N bands (maximum 6 at present).

KEYWORDS: (MANDATORY)

    BANDS = BANDS= area1 area2 ... areaN
              Single Banded rea #s to regroup. Area1 will be BAND1 of outarea, area2, will be BAND2 outarea, etc.

    CUTOFF = Percent of data to CUTOFF in 2-BYTE to 1-Byte compression.
              DEFAULT = 1.0% of data at upper and lower ends

    BANDWIDTH = output range for 2-BYTE raw data, from 2 to 255. DEFAULT = 255
         UNIT = BRIT or RAW input data type DATA: BRIT, RAW.
              DEFAULT = RAW

REMARKS

    Combine several singel banded areas into a single multibanded area.

COMP - General data compression utility for eXplorer area data which allows a choice between several lossless and lossy compression methods. The metadata, i.e. the data directory and the DDB are NOT compressed at all, only the image data. The output is a compressed file with a different name than the area name.

DECOMP command will reverse the process exactly (and in place), if the compression method used was lossless, else the best rendition if the method applied was lossy.

COMP	*area_to_compress* KEYWORDS

KEYWORDS

```
    CMP  =  compression_algorithm  ( LZW, DCT, HUF, ARI )  (default = LZW )
   QUAL  =  quality_factor (for the DCT compressor 1 - 50 )    (default = 3)
  ORDER  =  order_of_compressor (for Arithmetic compessor 1, 2 or 3) (default = 2)
    OPT  =  option to output information on the various files used during compression
            ( OPT = STAT displays the information )
```

Compression routines presently coded:

```
DISCRETE COSINE TRNSFORM (DCT)   -        Lossy
ADAPTIVE HUFFMAN (HUF)      -       Lossless
      ARITHMETIC  (ARI)     -       Lossless
   Lempel Ziv Welch (LZW )  -       Lossless
```

REMARKS

This is one way of increasing the disk space used in the data directory.

DBL - Query an eXplorer database file (.MDB extension) created using DBI to list specified fieldnames or KEYS

```
DBL  database_filename    KEYS= "sort
```

Parameters:

database_filename |	database file (.MDB) to list data from
KEYS |	list of database KEYS to list values for
	To print a list of the KEYS or fieldnames, use:
	DBU LIST KEYS 'data_base_file_name
"sort |	list of sort conditions

REMARKS

To facilitate a quick search of the contents of a CD-ROM or mission specific data, the respective CD-ROM index for each volume or each data type can be imported into a database file within McIDAS-eXplorer using the fieldnames provided in the index. This is a poor man's version of a more sophistacated database, but servers the desired purpose quickly.

DBU - Database utility program to query the fieldnames or keys constituting a database in the .MDB file format.

DBU *option database_filename*

PARAMETERS

option | LIST to list the database file configuration information
| KEYS to list the list of valid fieldnames for the specified database file

REMARKS

See also DBL.

Examples

DBU LIST voyager1.mdb *to list information about the Voyager 1 index file*

DECOMP - To decompress a file compressed using COMP. The routine will apply the appropriate expander based on the compressor ID stored in the compressed file.

DECOMP	*area_to_decompress new_area* KEYWORD

KEYWORDS

OPT = STAT will display some information on the various files used during decompression

REMARKS

Decompression routines presently coded:

DISCRETE COSINE TRNSFORM
ARITHMETIC
ADAPTIVE HUFFMAN
LZW

DDBUTIL - Utility for manipulating, inserting and copying DDB entries. The utility may be used to build an area with a DDB from an existing area withou a DDB, or to copy a DDB from one area into another.

DDBUTIL	*source_area dest_area* **KEYWORDS**

KEYWORDS

			DEFAULT
DDBSIZE	=	word size of the DDB block	640
OPT	=	option describing operation (INSERT, COPY)	INSERT
DDBTYPE	=	3 letter DDB identifier (FIT, VGR, CPP, VO, GO, CLEM)	FIT
TARGET	=	NAIF ID of target body	0
OBS	=	ID of observer	50 (Hubble)

EXAMPLES

Take an area, 122, and build a new area with a DDB, 222, for a Hubble derived image of Jupiter:

DDBUTIL   122 222 TARGET=599

Copy the DDB from 122 and place the data in area 222:

DBUTIL   122 222 OPT=COPY

REMARKS

This command can be used to attach a DDB block so that the eXplorer specific commands can be used on that area.

DF3 - Display a component of a three-color composite in a specified color (Red, Green or Blue). Basically a version of the core command DF for the 24-bit version of McIDAS

DF3 *area_# frame_# opt loc_x loc_y mag* BAND= COLOR=

Parameters

area_#	Area to be displayed
frame_#	Frame_# to display the Area on
opt	Coordinate option, I, E or A
loc_x	x-coordinate to load at
loc_y	y-coordinate to load at
mag	magnification factor (=ve for blowups, negative for blowdowns)

KEYWORDS

COLOR = Red, Green or Blue
BAND = Area band_# if it is a multibanded area

REMARKS

A macro command DFC is available to load all three bands at once. The format is identical to DF3 except that all three bands are specified with the RGB keyword instead of COLOR keyword.

DSTNCE - Measure linear distances on a navigated and displayed planetary image, optionally plot range circles for a given distance (in km, nm or miles) on the displayed image.

```
DSTNCE    opt
DSTNCE    CIR angle inc distance
DSTNCE    ROT angle inc distance
DSTNCE    STE angle din distance
DSTNCE    E lat lon
DSTNCE    I line ele
DSTNCE    T raster pictel
```

where, *opt* is one of:

(none)	|	measure distance between a pair of points or continuous segments indicated by mouse clicks
CIR	|	draw a circle around the initial cursor location beginning at a specified distance and angle
ROT	|	draw all or part of a circle around the initial cursor location beginning at a specified distance and angle
STE	|	step the cursor away from the initial cursor location at a specified distance and angle
E	|	step the cursor away from the initial cursor location by the specified latitude and longitude increments
I	|	step the cursor away from the initial cursor location by the specified line and element increments
T	|	step the cursor away from the initial cursor location by the specified raster and pictel increments

PARAMETERS

angle	|	moves the cursor away from the original location by this meteorological angle (def=0)
din	|	increment to step the cursor along its straight-line path
distance	|	distance to move the cursor from its original location
inc	|	angular increment, in degrees
lat	|	degrees of latitude to move the cursor; northward is positive
lon	|	degrees of longitude to move the cursor; westward is positive
line	|	number of image lines to move the cursor; downward is positive
ele	|	number of image elements to move the cursor; rightward is positive
raster	|	number of lines (rasters) to move the cursor; downward is positive
pictel	|	number of TV elements (pictels) to move the cursor; rightward is positive

KEYWORDS:

COLOR	=	graphics color level of the characters (typically between 1 and 7, but as permitted for the workstation). Default = 2
SIZE	=	height of the plotted characters, in pixels (def=5)
SYM	=	character to mark points with (def=.). Allowable symbols are '.', '+', '*', 'o'.
UNIT	=	distance units, one of:

KM	|	kilometers (default)
MI	|	statute miles
NMI	|	nautical miles

EDGES - Program to determine the limb points from an area containing a planetary image for finding the center for the purpose of image navigation. Particularly useful for ground based telescopic images of the planets as no navigation data are required either for EDGES or for IMGCTR.

EDGES *option*

Parameters:

      option | is one of the following:

         FIN | Find limb points from a displayed image and create a new limb points file to store the points and display them on the graphics frame
        ADD | Append more limb points to an existing file
        DEL | Delete limb points for locations within the cursor from the limb points file and erase them from the graphics display (not in McIDAS-X)
        PLT | Plot the limb points for the diaplayed image from the corresponding file
        LIS | List the limb points file corrresponding to the displayed image

KEYWORDS:
        DER = TOT for total derivative (actually max of gradient in the line or element direction
        DER = ELE to compute derivative in the element direction dB/dE
        DER = LIN to compute derivative in the line direction, dB/dL

Remarks:

      Limb points are found along the longer dimension of the cursor. This is crucial when finding limb points near the top or the botom of the image when the planet's visible (bright) limb is almost tangent to one of the sides of the rectangular cursor (box). This command is useful when there is excessive noise in the background or when there are rings present such that automatic limb determination is problematic. Use IMGCTR to determine the shape, size and center of the object by a general conic fit to the image frame limb co-ordinates.

      See also LIMBPT for another similar command with a different edge detection algorithm

ELLIPS - Draw signature ellipses from a USCLAS spectral classification of a multibanded image.

ELLIPS *inarea LCLAS HCLASS MEAN STD*

Parameters:

LCLASS	|	lowest class # to display
HCLASS	|	highest class # to display
MEAN	|	1 to display class means only
STD	|	2 is default.

Defaults are 0 to the number of the largest class present, ellipses displayed. The graphs are displayed in a new window which closes itself when all the graphs have been viewed.

EXPDOC - On-line help utility for McIDAS-eXplorer commands. This command will bring up different user manuals in a new text window which can be viewed using the vi editor commands

---

EXPDOC *guide_name*

---

where,

guide_name | USERGUIDE - introductory user guide
| COMMAND - command help (this section)
| DATA   - data file structures

REMARKS

The vi editor commands can be used to search for specific items. Help Command_Name will list the help for that command.

FILL0 - Fill zeroes in scan lines due to data compression in Voyager Uranus/Neptune images using the alternate side compression by averaging across lines that contain data

---

FILL0	*area_in area_out* OPT=LINE/BOX

KEYWORDS:

$$\begin{aligned}
\text{NUMAVG} &= 3 \text{ (default BOX size)} \\
\text{MINDN} &= 0 \text{ (minimum DN used to compute average DN in BOX)} \\
\text{OPT} &= \text{LINE (Default) or BOX}
\end{aligned}$$

(If OPT=BOX, then zeroes in image are filled by average of up to NUMAVG x NUMAVG non-zero or DN > MINDN pixels centered on a pixel)

REMARKS

After the Saturn encounter, the image readout for Uranus and Neptune encounters of Voyager 2 was changed to account for the lower data rate due to the increased range. So that more images could be returned, image data were compressed by editing out data on alternate lines altenating between the right and the left edges of the frame. These gaps need to be removed before reseau's can be found near the edges, and certainly before rectifying the images. The gaps are filled by interpolating across the gap element by element from the immediate neighbors above and below the compressed line.

FILTVGR - A command to apply a spatial filter to an image with planetary limb. This is an adaptive, edge sensitive filter that shrinks its domain as it approaches the limb and therefore produces a cosmetically better looking image near the limb. Will also remove noise pixels.

FILTVGR *souce_area_# dest_area_# opt*

NOTE: The filters are so heavily parameterized, it is often impossible to predict in advance what effect will be produced. We suggest trying the default values first, and then selectively varying the parameters one at a time until desired results are obtained. This filter keyin will work on most McIDAS-X or McIDAS-OS/2 images.

KEYWORDS:

INAREA = area#

OUTAREA = area# (default is input area number)

FRAME = frame# magnification (displays OUTAREA to frame#)
(default is no frame load)

OPTION = NOI   threshold gradient

BAD   threshold gradient

DIV   *idrange threshold bleedbloom addback length height increment decrement*

DIF   *idrange threshold bleedbloom addback length height increment decrement*

DFA   *midrange threshold bleedbloom addback length height increment decrement*

LOW   *midrange threshold bleedbloom addback length height increment decrement*

'NOI' OPTION IS A LINE DROPOUT AND SHOT NOISE FILTER COMBINED.

'BAD' OPTION REMOVES REALLY BAD NOISE CORRELATED ALONG A LINE

THRESHOLD = DN DELTA ABOVE NEIGHBORING PIXELS ON A LINE BEFORE A NOISE SPIKE IS SQUASHED
GRADIENT = DN DELTA TOLERATED BETWEEN PRECEEDING LINE & SUBSEQUENT LINE BEFORE SQUASHING SPIKE

NOISE REMOVAL ALGORITHM FIRST CHECKS TO SEE IF THERE IS A SMOOTHER THAN GRADIENT TRANSITION FROM THE PRECEEDING TO THE SUBSEQUENT LINE. IF SO, AND THE MIDDLE LINE PIXEL EXCEEDS THE AVERAGE OF ITS ABOVE AND BELOW PIXELS, BY THRESHOLD, THE MIDDLE PIXEL IS REPLACED BY THE AVERAGE OF ITS TWO VERTICAL NEIGHBORS. THEN A SHOT NOISE FILTER IS APPLIED HORIZONTALLY TO ANY PIXEL DEVIATING BY MORE THAN THE THRESHOLD FROM ITS PRECEEDING OR SUBSEQUENT NEIGHBOR. THUS, GRADIENT=0 GIVES AN ORDINARY SHOT NOISE FILTER, WHILE SETTING IT NON-ZERO REMOVES CORRELATED NOISE BURSTS ALONG A LINE.

'DIV' OPTION IS A DIVIDE FILTER (ENHANCES LOCAL ALBEDO CHANGES)

'DIF' OPTION IS A DIFFERENCE FILTER (ENHANCES DETAILS EVERYWHERE)

'DFA' OPTION IS A DIFFERENCE WITH ADDBACK (DETAIL AND ALBEDO MIX)

'LOW' OPTION IS A LOW PASS FILTER (REPLACES PIXEL VALUE

MIDRANGE = MIDDLE OF DYNAM RANGE FOR 'DIF' & 'DFA' OUTPUT
NOMINALLY 128 FOR AN IMAGE OF 0-255 DN (IMAGES WITH
SMALLER DYNAMIC RANGE SHOULD BE CONTRAST STRETCHED
PRIOR TO FILTERING FOR BEST RESULTS -- DFA OPTION
ESPECIALLY WILL
PRODUCE DARK OUTPUT IF IMAGE DOESN'T HAVE FULL DYNAMIC
RANGE. THE DIF OPTION WILL ALSO REQUIRE A LARGER
MULTIPLIER)
= DN OFFSET FOR WINDOW ENHANCEMENT OF 'DIV' OUTPUT
(SUBTRACTED FROM PIXEL VALUES WITH SLOPE DETERMINED BY
ADB-MUL PARAMETER) (DEFAULT=160 DN IF ABM UNSPECIFIED,
OTHERWISE DEFAULT =0 DN OFFSET)

THRESHOLD = DN THRESHOLD AT WHICH ADAPTIVE FILTER SIZE
CHANGES, NOMINALLY 1-2 DN ABOVE BACKGROUND. BELOW
THRESHOLD, THE FILTER WILL SHRINK BY DECREMENT PIXELS
FOR EACH PIXEL TO A LIMIT OF 1 PIXEL IN SIZE (NO FILTER).
ABOVE THRESHOLD, THE FILTER WILL GROW BY INCREMENT
PIXELS TO A LIMIT OF LENGTH BY HEIGHT IN SIZE (MAXIMUM SIZE
IS SPECIFIED BY THE KEYIN PARAMETERS LENGTH & HEIGHT).

1) PIXEL VALUES BELOW THRESHOLD ARE NOT INCLUDED IN THE
MOVING AVERAGES.
2) A THRESHOLD SET TOO HIGH MAY CAUSE VERTICAL BLEEDING.

BLEEDBLOOM = A CONSTANT SET TO CONTROL BLEEDING FROM A
THRESHOLD OR BLOOMING AT BRIGHT LIMBS. THE NOMINAL
VALUE SHOULD BE IN THE RANGE 5-10 (DEFAULT=5). TOO SMALL
AN INTEGER GIVES SEVERE CONTOURING AND MINIMIZES THE
VERTICAL FILTERING EFFECT, WHILE TOO LARGE AN INTEGER (I.E.
>100) HAS LITTLE NOTICEABLE EFFECT AT ALL.
(SET TO 999 TO TURN OFF THIS CORRECTION)

ADDBACK = PERCENTAGE (0-100) OF ORIGINAL IMAGE APPEARING IN
DFA FILTERED OUTPUT. (100-ADDBACK IS THE PERCENTAGE OF
THE FILTERED IMAGE WHICH APPEARS IN THE OUTPUT AREA).
(DEFAULT=30)

= FOR DIV DIVIDE OPTION, SPECIFIES THE DN OUTPUT AS A RATIO
USING THE NUMBER OF PIXELS IN THE FILTER (NOMINALLY=300).
VERY LOCALLY LOW CONTRAST IMAGES, SUCH AS CLOUDS,
MIGHT REQUIRE A MULTIPLIER VALUE AS HIGH AS 900. A VERY
BUSY LOCALLY HIGH CONTRAST SCENE MIGHT REQUIRE A VALUE
AS LOW AS 20. CHOOSE THIS PARAMETER TO MAXIMIZE THE
DYNAMIC RANGE OF THE OUTPUT IMAGE WITHOUT GOING OVER
THE 255 DN LIMIT. (DEFAULT=300 DN WITH MIDRANGE=160 DN)

= FOR THE DIF DIFFERENCE OPTION, MULTIPLIES THE
DIFFERENCES. (DEFAULT=3) LOCALLY LOW CONTRAST CLOUDS
MIGHT REQUIRE A VALUE OF 10. TO GET UNSCALED OR REAL
DIFFERENCES, SET THIS PARAMETER TO 1.

LENGTH/HEIGHT = HORIZONTAL & VERTICAL FILTER DIMENSIONS
DEFAULTS ARE LENGTH=30 HEIGHT=10)

```
INCREMENT   =         \
                      FILTER SIZE CHANGE PER PIXEL AT A  THRESHOLD.
DECREMENT   =         / (VALUES 001-099 PERMITTED)
                      (DEFAULTS ARE INCREMENT=15 DECREMENT=15)
```

DEFAULTS: inarea outarea frame   OPTION=DFA   0 0 5   30 30 10 15 15
OPTION=DIF 128 0 5   3 30 10 15 15
OPTION=DIV 160 0 5 300 30 10 15 15

EXAMPLES:

FILTVGR 20 21 1 OPTION=DIV 200 0 5 600 *(filter a low contrast scene)*
FILTVGR 20 21 3 OPTION=DIF 160 0 5   1 *(look at the real differences)*
FILTVGR 20 21   OPTION=DFA   0 0 5   50 *(50% addback of image, no display)*
FILTVGR 20 21 1 OPTION=DIF 220 0 5 10 5 5 5 5 *display a low variance scene using a*
  smaller filter size)
FILTVGR 20 21 FRAME=3 LOCATE=AC XCOORD=275 YCOORD=330 MAG=2 OPTION=DFA
  (display DFA filtered image centered at line 275, element 330 in frame 3)

FINDALT - Determine the Magellan ARCDR CD-ROM volume number containing altimetry and radiometry data for a specific Magellan orbit.

FINDALT *orbit_#*

Remarks

> The orbit number passing over a given geographic location on Venus can be found using FINDFF which first locates the MIDR CD-ROM volume containing the Magellan radar image of a region of interest. The label of that image indicates the first orbit number used to create that image tile.

FINDFF - Determine the MAGELLAN CD-ROM MIDR volume numbers containing a given latitude-longitude region

---

FINDFF *lat HEM lon*

PARAMETRS:

lat = LL (two digits, must be a multiple of 5)
HEM = N or S (single letter, north or south hemisphere)
lon = LL (two digits, including leading 0, representing any longitude between 0-360 divided by 10)
[Program does a character search for records using the byte strings 'LLN', 'NLL', 'LLNLL' or 'LLSLL' assembled from keyin parameters, returns CD-ROM ID for each such record. Blank lat-lon fields are ignored, but N is assumed default.]

Examples:

FINDFF 30 S 12   *returns all MG_NNNNs for latitude -30 and longitudes between 120 and 129*

FINDFF 50   *returns all MG_NNNNs for 50N*

FINDFF 50 S   *returns all MG_NNNNs for 50S*

FINDFF LAT=50 S   *returns all MG_NNNNs for 50S*

FINDFF X S 23   *returns all south latitude MG_NNNNs for longitudes 230 to 239*

REMARKS

This is one of the possible means of locating the image data for a region of interest on the MIDR CD-ROM volumes.

FINDTM - Loate areas containing images from different spacecraft acquired within a given time window and send a string to the McIDAS Control program for execution

---

FINDTM   SS= MIN= MAX= AREAS= "string command to processor

KEYWORDS

SS	=	*s1 s2 s3 s4*	List of up to four McIDAS spacecraft SSS codes
MIN	=	DAY TIME	lower window limit) in YYDDD HHMMSS format
MAX	=	DAY TIME	upper window limit in YYDDD HHMMSS format
AREAS	=	MAX MIN	area limits to perform search. Default area limits are 1-9999.
"string	=		[string command limited to 8 tokens in length]

REMARKS

This is a macro command that is useful to locate areas from multiple satellites covering a planet for near simultaneous coverage. A command can be sent to the control program to execute once the areas are located. On example of such a command may be to remap and mosaic those areas to make a global composite, such as from earth satellite data.

FITSKEY - A program to create a translation table for FITS header keywords and the keywords in a datafile if it contains non-standard definitions for the required inoput (e.g. date, time, target etc.)

```
FITSKEY     file_name
```

REMARKS

The FITS key-words that will get scanned by GETFITS as indicated by this program will get written into the file_name specified. GETFITS will scan this file to search for keywords in the file A file can be created once for each non-standard variant of the data format.

GEOM - Remap a Voyager frame to remove vidicon geometric distortion
using the reseau locations found by the Key-in RF

GEOM   *source_area destination_area*

KEYWORDS: (all optional, only areas have to be specified as positional parameters)

SPLINE = Spline size (default=12, limits depend on area size) for remapping.

SCALE = Area size scale (Default is SCALE=1.0 for a 1000 line image)

SMOOTH = ON/OFF Smoothing option averages neighboring pixels a bit making nicer
looking limbs at the cost of some resolution and line sharpness. (Default is
ON)

REMARKS

Shading correction and or only a dark current removal (using SHADE9)
must be done before using GEOM.

GETALT - Read Magellan Radar Altimeter CD-ROM (ARCDR's) Altimetry Fta Fles (ADF's) and plot the data (along the orbit track) on a displayed Magellan SAR image.

GETALT *orbit#* DIR FP= PLOT= LIST= LAT= LON = ALTS = COLORS=

PARAMETERS

    orbit_# | orbit number for the altimetry data

KEYWORDS:

    ORBIT = 4 digit Magellan Orbit Number (nnnn)   [required either as a positional parameter or as a keyword value]

    DIR = 8 digit directory holding data (llllmmmm) [required]
      [llll <= nnnn <= mmmm]
      (CDPATH variable may be set in string table instead)

    FP = lo hi max (footprint number, range, or max points), where, lo = single footprint or lower limit (default=-2000), hi = upper footprint number limit (default=2000), max = total number of points to plot (default=hi-lo+1). [if lo & hi are defaulted, the first max points will plot]

    PLOT = NO (default)
       = YES (plots ADF data locations on navigated frame)
    SIZE = n (size of "+" footprints on frame -- default SIZE=7)
      [Sinusoidal projection is preferred to show all of Venus surface -- a 50 km/pixel scale will just fit into a 400 x 800 pixel frame.]

    LIST = HEADER (Lists Orbit Header Record)
       = LABEL   (Lists Altimetry Header Record)
       = DATA   (Lists Altimetry Data Records)
      [default is no list]

    LAT = MINLAT MAXLAT (Latitude bounds default LAT = -90 90)

    LON = MINLON MAXLON (Longitude bounds default LON = 0 360)

    [If lat-lon bounds are left unspecified, all data points will be listed for orbit nnnn, and those falling within the displayed frame will be plotted in the appropriate colors if PLOT=YES.]

    ALTS = RAD1 RAD2 RAD3 RAD4 RAD5 RAD6 RAD7 RAD8 RAD9 RAD10
    ALTS = 0 6047 6048 6049 6050 6051 6052 6053 6054 9999 (default)

    COLORS = COL1 COL2 COL3 COL4 COL5 COL6 COL7 COL8 COL9 COL10 COL11
      [Radii below RAD1 will be plotted in COL1. Radii between RAD1 and RAD2 will be plotted in COL2. Radii between RAD2 and RAD3 will be plotted in COL3. Radii above RAD(N) will be plotted in COL(N+1).

COLORS = 5 1 12 6 14 2 4 11 9 3 7 (default values)
              [low = red, magenta, orchid, blue;
              average = sky, cyan,   green, aqua;

Examples:

GETALT 2185 21812200 PLOT=YES   (plots entire orbit)

GETALT 2067 20612080 FP=-737 LIST=DATA PLOT=YES
(lists footprint -737 and plots it on displayed frame)

> The ephemeris files used to process the ADF files are not accessed by this
> program.

REMARKS

> The FINDALT cammand can be used to determine the CD-ROM volume
> corresponding to the orbit number that has a ndir pass over the region of
> interest.

> *Eventually it should be possible to determine both the MIDR and ARCDR
> volume numbers for a given geographic region directly, but as yet the two
> have not yet been linked since the altimeter measurements are made in the
> nadir look while the SAR imagery is acquired at a nominal 45 degree angle
> with the nadir in either the left or the right side. Thus the look angle for the
> SAR must be known to compute which orbit the altimetry could have been
> acquired on, however that information is not present in the MIDT labels.*

GETCPP - Import a Pioneer Venus Orbiter Cloud Photopolarimeter image from a file in the NSSDC tape archive format (roll-by-roll). Attaches navigation at the same time. Requires files orbele.cpp and contact.cpp in /mcidas/data sub-sirectory

```
GETCPP  area_#  file_name
```

REMARKS

The image can be immediately displayed and gridded using DF and MAP commands to check the navigation. Occasionally the roll angle or the look angle may have to be adjusted for a better fit. See **NAVCPP** command to accomplish this.

The program creates an image such that each image line contains a spacecraft scan (even if it is missing on the NSSDC tape) so that the time and image line numbers relate to each other through the average spin period of the s/c over the image duration. Further, the

GETFITS - Make a McIDAS area from a FITS format data file. Try to first cut Navigate, using available information. (Only a Primary HDU with a two-dimensional data array can be read by this program currently. No FITS extensions, no random groups.

GETFITS   FILE= AREA= SOURCE= OPTION= FRAME= UNSIGNED TARGET= MINDN= NORTH= SAMP= SWAPBYTE= TIMEZONE= RANGE= RATIO= HIST= DATEOBS= TIMEOBS=

KEYWORDS:

FILE = filename extension (without the period!)
  | FITS file name in /mcidas/data (case sensitive!)
  | Input as FILE=file ext (form "file.ext" assumed).
  | If input file is in another directory, or is too
  | long for the 12 character FILE= fields, put the
  | full path and file name as trailing string:
  | i.e. GETFITS AREA=122 "/user/path/file.ext
  | or: GETFITS AREA=353 "../data/verylong_name.img)

AREA = McIDAS area number (reformatted image destination)
SOURCE = IRTF | (NSFcam Superhero Camera - Hawaii)
  WFPC | (HST Wide Field Planetary Camera)
  OTHER | [May be used to convert 2-dimensional data in standard FITS
               format to a McIDAS area. This may handle some Faint Object
               Camera FOC) data.

  (Different sources use different header formats and keyword spellings,
  which are mapped in a text file named SOURCE.FIT, where SOURCE is
  input here as a keyword value. If the SOURCE keyword is not used, the
  data file must have a standard FITS header and all standard keyword
  spellings, as defined by NOST 100-0.3b.)

OPTION = LABEL | List the header label only (Default)
       = DATA | Create an area
       = HIST | List the plotted 256 bin histogram values while creating the
                  area may be useful for setting the RANGE keyword values)

FRAME = frame_number magnification
      | Frame number on which to display w/magnification

TARGET = Target Object name
       | (The program will complain if it cannot find a target
       identification in the header information, or if the header and
       user specified target are not the same. The user will then
       have to make a runtime decision!)

SKY = Minimum DN value for bright limb in unconstrained fit to locate the
      planet center.
      [Defaults to mode DN+6**(PIXSIZ*PIXSIZ), which
      is 4-6 histogram bins above the dark noise peak.]
      This is crucial to good limb points and conic fit.
      Failure to specify SKY may cause center finding
      to fail with poor or hyperbolic fit to ellipse or
      program may locate limb inside or outside the
      correct location. Image cannot be properly
      navigated if that occurs.

NORTH = North Angle (optional -- defaults to angle from a conic fit) [used to
adjust if conic fit is bad]
= HEADER means use north angle from FITS header instead of user
input value or conic fit

SAMP = Line & element sampling interval for computing brightness center of
target (default = lines/100, elements/100)

TIMEZONE = 12 to +12 (Positive Zones West of Greenwich)
Used to adjust local time in FITS header to UT. Times in
area directory and DDB are always in UT, and
TIMEZONE defaults to 0, assuming UT in FITS
header if no time correction is specified.)

SWAPBYTE = YES | Data is from a VAX, so must flip bytes
NO | Do not flip the bytes (default)
UNSIGNED = YES | Input data is 2 byte unsigned integer format
NO | Signed 2 byte, unsigned 1 byte (defaults)
(User may have to experiment with some data,
depending on how it is offset relative to zero)

RANGE = lo hi | (Dynamic range of displayed data. Often the
DATAMIN & DATAMAX in the file header include
background and spurious bad pixels, as can be seen in
the image histogram. This is the range of true useful
data you want displayed on the screen by the DF
command. A default range is set at 5% and 98%
cutoffs. User can choose more precise limits by
looking at the histogram and setting lo and hi. These
limits are disregarded during DF for | 1-byte areas.
Use MAKESU instead.

RATIO = HEIGHT to WIDTH ratio for non-square pixels (for the NAIFNAV
and NAVUTIL keyins, this keyword is inversely defined
as the width to height ratio!)
HIST = YES/NO | Turns interactive histogram on or off. Default is YES.

REMARKS

The area DDB will contain a small subset of standard FITS keywords, or
those specified by the user in the translation table file *.FIT, which is
accessed/modified via the McIDAS-eXplorer menu interface. A listing of
the current translation table file contents is obtained using keyin FITSKEY.
Two extra keywords, DATEOBS & TIMEOBS are available for when the
program cannot extract a valid date or time from the FITS header using
existing translation tables.

DATEOBS = a single date token "MM/DD/YY"

TIMEOBS = a single time token "HH:MM:SS"

GETMGXDR - Import a Magellan GxDR global composite framelet from PDS CD-ROM volumes MG_3001 or MG_3002.

GETMGXDR   *area   frame_#   directory   "File_name*

KEYWORDS:

```
TYPE = GTDR   | Global Topographic Data Record
       GSDR   | Global Slope Data Record
       GEDR   | Global Emissivity Data Record
       GREDR  | Global Reflectivity Data Record
       ERROR  | Radius Error -- Sinusoidal Proj only)
PROJ = MERC   | Mercator
       NORTH  | North Pole -- Polar Stereographic
       SOUTH  | South Pole -- Polar Stereographic
       SINUS  | Sinusoidal

  FF = 0      | extracts -8 "browse" blowdown of mosaic) [default]
       1-n    | extracts a numbered 1024 x 1024 framelet/tile, where n <= 56

       CUR    | identifies framelet from displayed browse image)
   "FILE NAME| any valid framelet or browse image file name
```

REMARKS:

There are four ways of specifying image data on a GxDR CD-ROM:

1.   Use the keywords TYPE=, PROJ=, FF=
       (The first two specify a leaf of a directory tree, while the last identifies a file in the specified directory. This is the most common way to identify data.)

2.   Load a browse image to the screen using the TILES= keyword to define the McIDAS frame and overlay a tile/framelet grid. Then use the FF=CUR option to select a tile by positioning the cursor within the tile outline on the graphic overlay.

3.   Identify the directory using the DIRECTORY= keyword and the file using the FF= keyword. (Note that DIRECTORY is limited to 12 characters, does not include /cdrom/, and you must use lower case characters.)

4.   Use the "FILE NAME string at the end of the command line (You do not need FF= or a file extension, as the program will do that for you. If you are working in the same directory all the time, you can set the CDPATH prefix to the path e.g. TE CDPATH "/cdrom/gtdr/error/ and then erely have to set the FILE NAME string to "f23 .)

       where, File_name = a valid file name containing GxDR data [OPTIONAL]. Must begin with " and be the last entry on input line).

1. If full path is given, CDPATH in string table must be ' '

2. [the GxDR CD-ROM is assumed mounted as /cdrom using the UNIX commands "mountcd" and/or "umountcd" in the directory ../bin, or the McIDAS-eXp command CHANGECD

3. (Use keyins FINDFF and FINDALT to locate a CD-ROM)]

EXAMPLES:

```
GETMGXDR  AREA=23 FF=0 DIRECTORY=gtdr/merc TILES=2
GETMGXDR  23  TYPE=GTDR  PROJ=MERC  FF=0  TILES=5
GETMGXDR  AREA=24 FF=CUR   (directory is not needed)
GETMGXDR  AREA=1211 FF=23 DIRECTORY=gedr/north
          (no leading /cdrom/ is required)

GETMGXDR  AREA=20 "/cdrom/gtdr/error/f23
          (FF is not used)
```

GETMDIM - Import Mars Explorer (USGS Processed Viking Mars Data) images from CD-ROM into McIDAS areas.

GETMDIM   *area# file_name*

PARAMETERS:

   area# | Area number into which to load the image from the CD-ROM disk

   file_name | A valid file name containing the image   [OPTIONAL]
   (Name must begin with " and be the last entry on input line)

   NOTE: If full path is given, CDPATH in string table must be ' '. The string table can be listed using the **TL** command and entries in the table can be updated using the **TE** command.

KEYWORDS:

   AREA = A valid McIDAS area number (1-9999) [REQUIRED, def=0]

REMARKS:

   This command is used to import USGS processed Viking Orbiter images of Mars from PDS CD-ROM's.

GETMGN - Import a Magellan Mosaic Image Data Record (MIDR) image from CD-ROM into a McIDAS area.

```
GETMGN  area  framelet/ff#  directory "file_name
```

PARAMETERS:

area	|	area number to import the data into
framelet or ff_#	|	frame number of the MIDR image to import (1-56)
directory	|	name of the sub-directory containing the data file
file_name	=	Any valid source file name. [OPTIONAL]
		(Must begin with " and be the last entry on input line)

NOTE: If full path is given, CDPATH in string table must be ' '. [CD-ROM is assumed mounted as /cdrom using the UNIX commands "mountcd" and/or "umountcd" in the directory /u1/mcidas/bin]

KEYWORDS:

FF	=	0	|	extracts -8 blowdown of entire mosaic [default]
	=	1-56	|	extracts numbered 1024 x 1024 framelet
	=	CUR	|	identifies framelet from displayed browse image
	=	ALL	|	extracts all 56 framelets into 56 consecutive areas starting at designated area AREA = nnnn

AREA = area number to wtite the image into   (between 1 and 9999) [REQUIRED, def=0]

FRAMELET = Any framelet number 0-56 (0 means extract blowdown) (same as FF above)

DIRECTORY = Any secondary directory in /cdrom in the 8 byte format c1LLnOOO where LL=latitude and OOO=longitude (Remember that DIRECTORY and FILE NAME are case sensitive! Also, if FRAMELET is used, DIRECTORY must be used.)

CDPATH = string table path, including directory in which desired framelet c1fFF resides (e.g. TE "cdrom/c1XXnXXX/) [this must be a blank string (e.g. TE ") if the FILE NAME in the keyin includes the path, since the FILE NAME is appended to CDPATH before the CD-ROM files are opened]

Examples:

```
GETMGN  AREA=23 FF=0 DIRECTORY=c130n333
GETMGN  AREA=1211 FF=23 DIRECTORY=c110n130
GETMGN  AREA=20 "/cdrom/c130n333/c1f23
```

REMARKS:

This command is planned to be improved so that it stays resident if the browse frame is requested so that by indicating with mouse clicks the individual tiles or framelets that make up the browse image can also be imported into McIDAS by moving the cursor and clicking over the browse frame. Individual tiles are indicated by the comamnd **TILES** which is called by GETMGN to display the numbered tiles.

GETMDIM - Reads CD-ROM format Viking Mars Digital Image Model (MDIM) or Digital Terrain Model (DTM) Images to a McIDAS-eXp Area

---

GETMDIM *area_#* "FILE_NAME (write file to area)
GETMDIM LIST "FILE_NAME (list header for image file)

KEYWORDS:

AREA = ANY VALID McIDAS AREA NUMBER (1-9999)
FRAME = ANY VALID McIDAS FRAME NUMBER & MAGNIFICATION
(defaults are no frame load and magnification -2)

REMARKS

The complete path (i.e. "/cdrom/mi30sxxx/mi30s182.img) must be included in the FILE NAME field, and/or String Table entry. CDPATH must exist and be a blank field. (To generate CDPATH, use the keyin command TE CDPATH "*path name*)

FILE_NAME = ANY VALID SOURCE FILE NAME (Must begin with " and be the last entry on input line)

EXAMPLES:

GETMDIM AREA=345 FRAME=2 -3 "FILE.NAME
write to area 345 and display on frame 2 at 3X blowdown)

GETVGR - Import a compressed Voyager image from CD-ROM and write a McIDAS area containing that image.

GETVGR KEYWORDS "FILE_NAME
GETVGR *area_#* "FILE_NAME

KEYWORDS:

CDPATH = Enter path in the string table using TE command.
Should be blank if:
(1) CD-ROM format image is in /mcidas/data,
(2) if the path is included in the FILE NAME field, or
(3) if the normally used FDS keyword option is chosen.

[A PATH IS REQUIRED, EVEN IF IT IS A BLANK FIELD]
FILE NAME = ANY VALID SOURCE FILE NAME
[OPTIONAL, if FDS is given] (Must begin with " and be the last entry on input line) (a path may be included in FILE NAME if CDPATH is blank)

FDS = mmmmm.mm nnnnn.nn
(A single FDS or a range of numbers) (A range specified will generate up to 50 areas consecutively starting with AREA unless AREA=0)
TARGET = name/NAME
(Must be specified when FDS numbers are used. TARGET is always converted to lower case internally)
FILTER = GREEN, BLUE, ORANGE, CLEAR, VIOLET, UV, CH4_JS (5410A), CH4_U (6180A)
CAMERA = WIDE or NARROW
AREA = ANY VALID McIDAS AREA NUMBER (1-9999)
[default=0. AREA=0 will allow a CD-ROM search, with no ingestion of data into McIDAS-X. *Caution*: Searching through literally thousands of FDS numbers on a CD-ROM is time consuming. Choose FDS limits as narrow as possible to reduce waiting time. Use the "?" command and the "/ pid" command to kill errant searches.)

EAMPLES

GETVGR FDS=43975.00 43985.00 TARGET=SATURN FILTER=BLUE AREA=0
GETVGR FDS=43885.65 TARGET=MIMAS AREA=NNN

GETVO - Import a Viking 1 or 2 Orbiter image from PDS CD-ROM volumes into a McIDAS-eXplorer area.

GETVO   *area_# "filename*
to import a file, or,

GETVO   LIST   "filename
to list the header for a specified image file.

KEYWORDS:

FILE NAME = ANY VALID SOURCE FILE NAME
(Must begin with " and be the last entry on input line)

AREA = ANY VALID McIDAS AREA NUMBER (1-9999)

REMARKS

The complete path (i.e. "/cdrom/f226axx/f226aNN.imq) must be included in the FILE NAME field, and String Table entry CDPATH must exist and be a blank field. If the reseau location files and the shading files are availble, the images may be processed to remove the geometric and photometric distortions and navigated if the SEDR data are also available.

The FILTER command with the MEDIAN type filter will remove most of the random noise found in these images.

GUI - Start the Graphical User Interface from the Command Window.

```
                GUI
```

REMARKS

This is the simplest way to start the GUI.

HSTTOMC - Import Hubble Space Telescope WF/PC image from a FITS format tape-file into a McIDAS area.

HST FILES ARE WFPC FITS FORMAT USUALLY WITH 4CCDS. OUTPUT AREA HAS ONE BAND FOR EACH CCD.

HSTTOMC *infile outarea*

PARAMETERS:

infile | HST FITS file (.C0H or .D0H extension).
>>**ENTER THE FIRST 8 LETTERS only** <<
outarea | MCIDAS multi band AREA.

KEYWORDS:
DATA = DATA=RAW uses .D0H raw data.
DATA=CAL uses .C0H calibrated data.

EXT = File extension after INFILE's 8 chars.
Overrides the DATA keyword value. (DEFAULT = t_cvt.c0h)

PIXSIZ = DATA TYPE OF OUTPUT FILE (1 OR 2 BYTE). (DEFAULT = 1)

HSTKNIT - Program to create a single area 1600 x 1600 containing four component 800 x 800 CCD images from WF/PC camera on HST.

HSTKNIT   *area_#*

Remarks

> This program is of limited interest because the actual alignment of the four component CCD chips is not precisely known and is significantly different from the handbook values, and worse, the calibrations of the four CCD's cannot be matched to each other, making the exercise practically useless. With the pending replacement of the WF/PC camera the four chip format will be replaced with a single 800 x 800 CCD.

IDMOON - Interactive Mcidas-Explorer routine to identify the shadows, transit locations and relative positions of galilean moons from observer. The user may also use the positions of the moons in the image to calculate the appropriate north angle and the pixel diameter of the primary (pixel degree ratio is based on the pixel diameter of the primary).

IDMOON	SCAN=CUR (default) or BRIGHT

REMARKS

This routine requires a precise time of observation, U.T., in the area to produce correct results.

If the user elects to calculate the north angle and pixel diameter for the image body he/she may use either the cursor position to identify the moon, or use a center of brightness scan over the domain of the cursor. The routine will then display the moon name at the chosen position on the display and output the calculated north angle and pixel diameter of the primary.

This routine is designed to allow a user to predict the approximate position of Galilean moons in an image. The image must be partially navigated in that the observer position vecter, the picture body center information and time are available. If the north for the image is also in the DDB then the routine can display the exact moon positions.

Caution! **Do not use when the moon is near the limb of the disc.**

IMGCTR - Determine the center (using a conic fit) of a planetary image for which limb points have been previously stored in a file (LIMBxxxx, where xxxx is the 4-digit area number) using EDGES or other programs.

IMGCTR *area_#* KEYWORDS

KEYWORDS:

FILE = usually LIMBnnnn where nnnn is the area number. Expected file format is described below.

If the displayed frame contains the image of interest, the area_# need not be specified, nor the FILE keyword as the LIMBnnnn file corresponding to the displayed image is read by default.

OPT = BAD, to list the points that deviate from the least-squares general conic fit by more than the MAXDEV (see below) pixels.

= REPLACE, to replace the limb points in LIMBxxxx file with the edited points that match the fit criteria (i.e. all points that are "bad" due to excess deviation from the fit are excluded).

COL = graphics color level for the fit quality display

GRAPH = LIMB, for displaying the limb points on the image
= CONIC, to show only the quality of the conic fit, or
= ALL, to show both the limb points and the conic fit quality (deviation in pixels for line #s of points), *default*.

MAXDEV = Maximum deviation in pixels to discriminate between valid limb points and possible erroneous limb points (default = 5).

REMARKS

An unconstrained, general conic fit in the image co-ordinates returns the ellipse center, major and minor axes, eccentricity and the tilt with respect to the line direction. The positive x-axis is along the increasing line direction and the positive y-axis is along the increasing element direction.

This is useful for navigating full disk earth-based telescopic images of solar system objects, using PLANAV if the sub-earth point is known.

The format of the LIMBxxxx files is as follows. It is a fixed length file (4001 words), with the zeroeth word denoting the maximum index number of limb points stored in the file (4-byte binary integer). The next 2000 words contain REAL*4 line numbers (x-coordinate) of limb points and the next 2000 words contain the corresponding element positions of the limb points (y-coordinate). The slots may not all contain valid limb points as some limb points may have been edited out. Only non-zero entries are taken as acceptable limb points (either axis).

IMGDAY - Write the day and time corresponding to a displayed image on the graphics in a given size at a specified location. Useful for annotation of frames being animated for videotaping.

IMGDAY *area_# graphics_frame_#* TV= SIZE=

PARAMETERS

area_# = area number whose day/time will be used to tag. Default is area corresponding to the displayed frame.

frame_# = graphic frame number on which to enter the annotation. Default is current frame.

KEYWORDS

TV | line_# ele_# spacing, where line_# and ele_# specify the frame coordinates where the label will begin. spacing is the line spacing between the day and time strings

SIZE | font size in pixels

IMGTS - compile and display Time series Data for a given geographic region from image areas

IMGTS	*filename function* KEYWORDS "text

Parameters:

filename | filename for the time series data file (default=none)
function | APPEND or PLOT, program function (default=PLOT)
"text | up to 40 characters, used if the LW file is new as the information for the first header line (default=lwfile)

Keywords:

AREA = a1 a2, sequential range of areas (default=current frame)
BAND = band number (default=current frame)
BOX = numlin numele | target box lin/ele pixel size, must be an odd number (default=cursor size)
CHECK = YES or NO, option to check LAT,LON,SSN,BAND,UNIT,FACTOR parameter values against the LW file header values (default=YES)
COLOR = color level of display symbols (default=3)
ERASE = YES or NO, erase graphic frame before plotting (default=NO)
FACTOR = internal scaling factor for calibration type (default=1.0)
GRA = specify graphics frame (default=current)
LAT = target box latitude location (default=cursor position)
LON = target box longitude location (default=cursor position)
MAX = upper value range limit (default=+1.0E+35)
MIN = lower value range limit (default=-1.0E+35)
PAN = graphics panel selection 0,1,2,3,4 (default=0 full screen)
FORM = NPT AVG STD MIN MAX, plotting format options (default=AVG)
SYMB = plot symbol can be any single alphanumeric character or DOT (1x1 box) (default=DOT)
TITLE = dispaly title up to 12 characters (default= blank)
UNIT = internal calibration type unit (default=BRIT)
XL = x-axis label up to 12 characters (default=X)
XP = min max div sdiv, x-axis (area1 file) plot parameters
YL = y-axis label up to 12 characters (default=Y)
YP = min max div sdiv, y-axis (area2 file) plot parameters, where: div - # of divisions sdiv - # of sub-divisions
ZERO = zero pixel value option as MISSing or DATA, or can indicate a specific non-zero integer as the missing value code (default=MISS)

REMARKS:

1) If areas given, then the program will calculate the average, standard deviation, minimum, and maximum values for a user specified UNIT= calibration type within a user specified target box location and size.

2) If no areas given,then program will display the selected PLOT= option values of the user specified LW file.

3) The program appends new values onto the specified lwfile.

4) The location and size of the target box can be defined several different ways: using the LAT/LON/BOX keywords, using the LIN/ELE/BOX keywords, using the LIN/ELE keywords with double entries representing TV line and element ranges, or using no keywords and defaulting to the current cursor's position and size (note the BOX keyword can be used to override the default cursor size).

5) Lat/Lon values may be entered in either a DDD.xxx format or a DDD:MM:SS format.

6) The program will display a time series of all LW file entries up to a maximum of 5000.

7) The program can be set to screen for a user defined range of pixel values using MAX/MIN keywords to define the upper and lower limits.

8) The program calculates the LW entries for a range of areas and stores them in the LW file in the order that the areas are sequenced regardless of the area's date and time.

9) The program is designed to order the LW entires before it plots their time series from lowest to highest date.

LIMBPT - Program to determine the limb points from an area containing a planetary image for finding the center for the purpose of image navigation. Particularly useful for ground based telescopic images of the planets as no navigation data are required either for EDGES or for IMGCTR.

LIMBPT *option*

Parameters:

option | one of the following:

FIN | Find limb points from a displayed image and create a new limb points file to store the points and display them on the graphics frame
ADD | Append more limb points to an existing file
DEL | Delete limb points for locations within the cursor from the limb points file and erase them from the graphics display (not in McIDAS-X)
PLT | Plot the limb points for the diaplayed image from the corresponding file
LIS | List the limb points file corrresponding to the displayed image

KEYWORDS:
DER = TOT for total derivative (actually max of gradient in the line or element direction
DER = ELE to compute derivative in the element direction dB/dE
DER = LIN to compute derivative in the line direction, dB/dL

Remarks:

Limb points are found along the longer dimension of the cursor. This is crucial when finding limb points near the top or the botom of the image when the planet's visible (bright) limb is almost tangent to one of the sides of the rectangular cursor (box). This command is useful when there is excessive noise in the background or when there are rings present such that automatic limb determination is problematic. Use IMGCTR to determine the shape, size and center of the object by a general conic fit to the image frame limb co-ordinates.

LIMPRO -   Determine and plot the Limb Profile of a Planetary Image along a radial direction. Also plots the derivative profile on the next frame

---

LIMPRO   *option* **KEYWORDS**

Parameter:

> *option* | CUR a line plot using data through center of cursor
> | SEG a line segment of the image
> | RAD a radial plot at a given azimuth

KEYWORDS:

AXIS	=	LIN or LOG for y-axis scaling
COLOR	=	color (def=3)
PLOT	=	plot type: SLD, DOT, or any ASCII char (def=SLD)
MINDN	=	data <= the specified value are set to 0.5 for the case when Y-axis is log for clarity.
BAND	=	band (def=current frame)
UNIT	=	calibration units (def=original from area)
	=	BRIT RAW RAD or TEMP
SCALE	=	ylo yhi xlo xhi |modify x and y scales to new values

Remarks:

> Draws a line plot, on the graphics, of the data along the line at an azimuth of (from the scan direction) 135 deg and a distance of 200 pixels from the planet center, to the planet center. Only the first 100 pixels along that line from the point are to be plot. The derivative of this profile is displayed in the right panel. Three files are also created that contain the profile data: LIMPRO, LOGPRO and DERPRO. These files are tagged by the FDS count and the scan end (image) co-ordinates.

Example:

> LIMPRO RAD 135 200 SCALE=10 1000 0 100

LISCOM -   Lists contents of PLAN navigation common from navigation blocks

LISCOM *area* CUR/COD *blknum*
LISCOM *area* CUR/COD *blkname*
LISCOM *area* CUR/COD, (lists all blocks in CURRENT or CODICIL)
LISCOM *area*
        (default is COD and all blocks)

(NOTE: All three parameters are positional only, no keywords are used in this command)

Block Numbers (blknum) and Names (blkname):
1. SECTID (Image identification)
2. COMMVN (Image geometry input)
3. NAVVEC (Navigation input)
4. VNEDGE (Bright limb points)
5. VNTERM (Terminator points)
6. MOSTIE (Mosaic link points to frames)
7. MISLEN (Odds & ends)
8. VNCOMM (Navigation output constants)
9. A   (Inverse navigation matrix)
10. B   (Navigation matrix and vector)
11. D   (Inverse vector)
12. SQUASH (Oblate planet correction)

LISTAUD - List the audit (processing) trail for a McIDAS area.

LISTAUD   *area_#*

Remarks

Most McIDAS-eXplorer applications programs that modify the contents of an area make entries in the audit trail. The processing that an image has undergone can be determined by examining the processing trail.

LISTDDB - List the Data Description Block for a McIDAS-eXplorer area.

LISTDDB *area_#* *type*

PARAMETERS

type	MAN to list the mandatory data (target, source) block
type	SC to list the spacecraft and camera specific block
	BOD to list the target object specific block
	GEOM t list the map projection and image geometry block (SPICE)
	USER to list user computed quantities for that area
	NAV to list the older PLAN type navigation block
	ALL to list all blocks

LISTNAV - Lists any or all planetary SPICE navigation blocks for an area

---

LISTNAV *block_type area#*

PARAMETERS:

block_type can be any of the following:

      SC | spacecraft & camera block)   [default block]
    BOD | central & picture body block)
    IMG | imaging geometry block)
  USER | user computed quantities block)
    ALL | list all SPICE blocks for area: SC,BOD,IMG,& USER) (area navigation
                   block words 128-511)
    CUR | list current navigation block if PLAN, otherwise uses the LWU LIST
                   AREAXXXX 64 191 format
  PLAN | list PLAN navigation block 512-639)

    area# = area number for which to list the blocks specified (defaults to displayed
              frame)

EXAMPLES:

LISTNAV   *(defaults to SC and displayed frame)*

LISTNAV BOD   *(displays picture body block for displayed frame)*

LISTNAV USER 2335 *(displays user block for area 2335). If there is no displayed frame, will try
                last accessed area*

KEYWORDS:

    AREA =   area number whose blocks are to be listed (area defaults to displayed frame
             image)

LISZEN - A command to enable conversion between planetary coordinates and image coordinates assuming image is navigated. Will also provide zenith satellite sub-solar zenith angles at a given image location and the location of the sub-solar and sub-spacecraft points

---

LISZEN *opt x-coord   y-coord area_#*

Parameters:

opt |	PLA to convert image coordinates (line, element numbers) to planetary coordinates (latitude and longitude)
|	IMG to convert planetary coordinates (latitude, longitude) into image coordinates (line, element)
|	ZEN to determine the spacecraft and solar zenit angles at a given image location
|	SP to print the sub-spacecraft and sub-solar locations (image and planetary coordinates)
x-coord |	latitude in degrees if opt = IMG
|	line number if opt =PLA or opt=ZEN
y-cood |	longitude in degrees if opt = IMG
|	element number if opt = PLA or opt = ZEN
area_# |	area number corresponding to the image

REMARKS

This is a macro command that invokes area navigation to do the transforms. The area need not be displayed. A second area number can be specified following the first one if the same coordinate is to be converted for a consecutive range of areas (all areas need not be present).

LOCATE -   Identify the geographic locations on a displayed image by a graphic symbol as overlay graphics. As an option, the names of the locations can be annoated on the graphics in a specified font size. The font type can be externally selected using the XFONTS command.

LOCATE   *filename symbol fontsize*

---

filename | text file contaning the latitude and longitude locations
symbol | any key-board character to be plot
fontsize | size of the symbol (1> n > 99)

REMARKS

This command is useful when a large number of locations are to be identified on the displated image. The annotations are made only on the overlaid graphics display and do not affect the digital area containing the image data.

For a very small number of points the annotation can be accomplished using the PC E and ZA commands.

LODSSP - Display a single planetary image or a sequence of planetary images from a block of areas such that the center of the planetary disk is in the center of the frame. Useful for registering a sequence of earth-based or far-encounter images for looping.

LODSSP	*first_area last_area frame_# magnification*

PARAMETERS:

first_area | first area to display
last_area | last area to display (total number of areas to be displayed should not exceed the number of frames available for display. *(No check is performed to verify this, excees areas are not displayed)*.
frame_# | first frame to show load the first area on.
magnification | blow up or blow down factors (+ve or -ve integers respectively).

REMARKS

This is a useful command to display a sequence of registered images for animation, or for verifying the consistency of navigation between two or more frames in terms of center finding. The program queries the navigation to determine where the sub-spacecraft point is located in the image and uses the DF command to display using the EC option. For close encounter images the disk-center is usually not likely to be in the image but outside of it, hence the display may look blank if a blow-down factor is not specified such that the sub-point is actually within the frame dimensions.

LINPLT - Display the data along a segment of a displayed image as a X-Y plot. The segment can be along an image line, two arbitray points or restricted to the width of the cursor and along the line where the cursor center is located.

LINPLT *option* KEYWORDS

Parameter:

    option | *none*, to plot data along the line where cursor is located
           | SEG a line segment of the image
           | CUR a line plot using data through center of cursor

KEYWORDS:

    COLOR = color (def=3)
      PLOT = plot type: SLD, DOT, or any ASCII char (def=SLD)
     BAND = band (def=current frame)
      UNIT = calibration units (def=original from area)
      UNIT = BRIT RAW RAD, TEMP, dB as applicable
    SCALE = ylo yhi xlo xhi | x and y plot limits

Remarks:

    A graph of image data is drawn on the graphics along a scan line either over the entire displayed line or within the cursor or between two points chosen with mouse-clicks.

    If Magellan radar data is displayed (MIDR's or GxDRs, the the proper units are automatically chosen depending on the data type (dB for radar reflectivity, km for topography, deg/km for slope and rms slope.

    If the frame/area is navigated the distance scale by default is km, else pixels.

Examples:

    LP CUR

        Draws a line plot, on the graphics, of the data on the line through the center of the cursor

    LP SEG

        prompts you indicate the end points using cursor locations through mouse movements and button clicks.

MAKESU - Make a stretch table for a McIDAS area containing FITS data. The table displays saturation, and user can either define a percent "ends-in" stretch or approximately define a slope (gamma) at the center of the transfer function for the sigmoid, inverse sigmoid, logarithmic or exponential curves. The program pauses to let the user look at the transfer function and requires a mouse click in the graph window to resume.

MAKESU   NAME= TYPE=   (AREA= FRAME= LIMITS= HIST=)

KEYWORDS:

NAME = stretch table name for SU= keyword in DF keyin (8 characters maximum length)

TYPE = SIGMOID gamma horiz_dn_value
gamma approximates the tangent of the slope at the 128DN output level (2.0 is default, 10 is steep, 1.2 is shallow) horiz DN value (offset) of center of curve (default is center of the dynamic range)

= INVSIG gamma vert_dn_value
gamma approximates the tangent of the slope at the 128DN input level (0.5 is default, 0.9 is steep, 0.1 is shallow, slopes larger than 1.0 give a poor shape) vert DN value (offset) of center of curve (default is center of the dynamic range)

= ENDSIN lo% hi% lodn hidn
(percent ends-in stretch, defines limits where linear transfer function saturates) lo% and hi% are the input histogram limits where saturation begins (default=10 90) lodn and hidn are the output DN values where saturation begins (default=30 225)

= LOG gamma vert_dn_value
gamma approximates the tangent of the slope at the 128DN output level -- (for the LOG function a gamma of 2.0 is default, 10 is steep, 1.2 is shallow) vert DN value (offset) of center of curve (default is center of the dynamic range)

= EXP gamma horiz_dn_value
gamma approximates the tangent of the slope at the 128DN output level -- (for the EXP function a gamma of 2.0 is default, 10 is steep, 1.2 is shallow) horiz DN value (offset) of center of curve (default is center of the dynamic range)

= BRKP i1 o1 i2 o2 i3 o3 i4 o4 i5 o5 i6 o6 i7 o7 i8 o8 i9 o9 i10 o10
manually defines a set of 10 or fewer breakpoints which the keyin will insert into the SU table (no offsets are used here)

AREA = input_area calib_type band
(defaults are: displayed area, BRIT, band 1, except for 2-byte data where calib_type=2BYT)

FRAME = frame magnification
(frame on which to display image using NAME=)

LIMITS = oDNin hiDNin loDNout hiDNout
input and output limits for stretch function (defaults are: 0 255 0 255)

REMARKS

A stretch table is generated using the plotted function and is stored under the indicated NAME=. That name can be used as the SU= argument to the DF keyin to guarantee that the dynamic range of the display is used to maximum advantage. If FRAME= and AREA= are set, the DF keyin will automatically load the area to that frame using the NAME stretch table. It is often useful to iterate several times in order to reach an optimum set of parameters for the stretch table.

Tutorial:

Often, one has to compress or expand the dynamic range of an image to fit the dynamic range of the display screen or printer output. This is often referred to as changing the "gamma" of the display medium. Many times this is true for one-byte data, but it is especially true for two-byte data, which generally has a dynamic range much too large for a CRT to adequately display with good contrast resolution. One then has to choose what small portions of the brightness dynamic range in the original image will be displayed on the CRT. McIDAS merely defaults to a simple one segment linear enhancement from the frame buffer to the screen, which may be modified with the EB command. The trouble with the EB command, therefore, is that it enhances the DN values of the pixels already in the BRIT screen buffer, when they are mapped to the CRT screen, and when the two-byte brightness resolution is already lost. We would like some way of putting a limited larger or smaller segment of the image's dynamic range into that screen buffer before we apply EB enhancement. The MAKESU command permits this by utilizing the SU command of McIDAS in a sophisticated way.

The SU command is designed to generate a table of 1-60 breakpoints describing a transfer function of contiguous line segments. This transfer function is stored in a file /mcidas/data/---.ST under whatever stretch table name, *, one cares to assign. When the DF command loads an image to the display screen with the SU= keyword set to the appropriate stretch table name, that lookup table is applied to transform the image data on disk to the output data in the screen buffer and on the screen, independent of how EB is applied. The D key keyin will show the effect of such a stretch table by converting the BRIT screen pixel values (BRIT is a linear mapping of -32K to 0 and +32K to 255) to MODB pixels which are the stretch table output. It is the MODB DN values which then are placed into the screen buffer, instead of the BRIT values. Note that the stretch table must correspond to the McIDAS area calibration type and band number, or it will not be used by DF. Those values are normally correctly defaulted by MAKESU for one- or two-byte-per-pixel areas, but can be overridden by the user with the AREA= keyword.

MAKESU contains five possible transfer functions, SIGMOID (the default, middle level expanding), EXP (exponential, or high end expanding), LOG (logarithmic, or low end expanding), INVSIG (inverse sigmoid, or range compressing), and ENDSIN (the "industry standard" percent ends-in transfer function using the image histogram). If an unrecognized TYPE= is input, a simple one segment linear function is generated.

The ends-in stretch generates a five-segment linear function, with the middle segment being the largest (covering the part of the histogram between the two percent values), and the end segments displaying a mild degree of saturation. The other four functions have a "gamma" parameter which changes the slope of the transfer function, and a vertical or horizontal dn_value which controls the offset. SIGMOID and EXP offset in the horizontal direction, while LOG and INVSIG offset in the vertical. Because of their shapes, you will find that EXP and LOG are more effectively

controlled by the gamma value alone, while you will often use both the offsets and slope for SIGMOID and INVSIG.

It will probably be necessary to iterate MAKESU several times to obtain the desired transfer function. This is accomplished as follows:

1) Keyin DF to load the desired area to a frame, then keyin SF to display that frame.

2) Set up a call to MAKESU with FRAME= set to that frame number. Remember to click the mouse in the histogram window to restart the program after the program pauses to let you look at the histogram and transfer function.

3) Thereafter, you iterate by simply hitting SHIFT-& to recall the previous MAKESU command into the McIDAS command window, using the editing keys to modify the parameters. The program will continue to reload the displayed frame with each newly generated transfer function till you are satisfied.

It is best to modify the MAKESU parameters one-at-a-time until one has feel for how the transfer functions are generated. Once you understand what is happening, you can usually select the proper function and get the parameters you want with three or four iterations within a minute or two.

MCLIMB - Simulate view from orbit of a planet from a nadir looking instrument and plot instrument IFOV's.

MCLIMB	*inarea outarea*	.

PARAMETERS:
    inarea | MAP AREA TO USE
    outarea | OUTPUT AREA WITH ORBIT TRACKS

KEYWORDS:
    ECCEN = ECCENTRICITY OF ORBIT   (DEFAULT=0)
    INCLIN = INCLINATION OF ORBIT (deg) (DEFAULT=155)
    PREC = PRECESSION OF ORBIT, deg/day (DEFAULT=AUTO)
    ORPSOL = ORBITS PER SOL \ choose 1 (DEFAULT=7)
    PERIOD = ORBIT PERIOD   /   (DEFAULT=211.0)
            2ND PARAMETER = UNIT (min,hr,day) (DEFAULT=MIN)
    GRAPH = PLOT, L=LIMB ELLIPSE, V=VIEW, VL=VIEW WITH LIMBS. B=BOTH (ALL)
            (DEFAULT=VL)
    NUMPER = NUMBER OF PERIODS DRAWN   (DEFAULT=1)
            2ND PARAMETER = PERIOD AFTER START TO BEGIN PLOTTING (DEFAULT=1)
    TIMET = TIME PER ORBIT TICK (min) (DEFAULT=2)
    CROSST = DRAW EVERY NTH CROSS TRACK (DEFAULT=100)
    IROTRAT = INSTRUMENT ROT RATE (rpm) (DEFAULT=2)
    FOVSTEP = DRAW EVERY NTH FOV   (DEFAULT=1)
    PLOTLON = LON PLOT TYPE (PLA OR SUN) (DEFAULT=PLA)
    DATE = TEXT STRING OF START DATE (DEFAULT=1/JAN/2001)
    TIME = TEXT STRING OF START TIME (DEFAULT=00:00:00.0)

REMARKS

    This command is useful for determine the coverage obtained by an orbiter around a solar system object with a given orbit from nadir pointing spacecraft. A newer version will also compute the spacecraft visibility windows from a given set of surface locations.

MDCLAS -   Spectrally classify a multi-band image using mean distance statistics

---

MDCLAS *inarea outarea sigarea*

PARAMETERS:

     inarea = area to be classified
   outarea = Output classified area with the FINAL N spectral classes.
   sigarea = AREA WITH .SIG STATISTICS FILE

KEYWORDS:

  BANDS = BANDS= BAND1 BAND2 ... BANDN
            Bands to classify, default is all bands in the area.

    NULL = DATA DROP-OUT DECISION.
            ANY: classify as ZERO if ANY band in image = 0.
            ALL: classify as ZERO if ALL bands = 0.

MGNORB - IS AN EXPERIMENTAL(!) PROGRAM TO PREDICT WHEN THE MAGELLAN ORBITER WILL SCAN A GIVEN SITE ON VENUS WITH EITHER NADIR, LEFT OR RIGHT POINTING SENSORS. THE PREDICTION IS MADE IN REFERENCE TO A GIVEN ORBIT PRESENTLY DEFAULTED AT ORBIT 2667. THE PRESENT FORM LIMITS THE ORBIT PREDICTION TO ONE PERIOD OF VENUS AXIAL REVOLUTION (1 VENUS DAY), BUT THE USER MAY INPUT THE ELEMENTS FOR A DIFFERENT ORBIT

MGNORB	KEYWORDS

THE PROGRAM DEFAULT IS TO USE THE MOUSE TO SELECT A POINT ON THE IMAGE

KEYWORDS

OPT = scan_option (ALTIM. LEFT, RIGHT, determines which scan path to test for the given site. ALTIM is the nadir pointing sensor for altitude, LEFT is the left looking SAR, RIGHT is the right looking SAR)

EXAMPLE: MGNORB OPT=RIGHT asks for a prediction when the right pointing SAR will scan a location selected with the mouse.
(default = ALTIM)

When the ALTIM mode is used, a field of view ellipse will be projected on the surface centered on the nadir location closest to the site of interest.

LOC = lat lon (degs) (direct input of location)
EXAMPLE: MGNORB LOC = -15 22 asks for a nadir predication at: -15 deg latitude, 22 deg longitude

A = semimajor_axis_of_orbit
ECC = eccentricity_of_the_orbit
INC = inclination (degs)
NODES = longitude_of_nodes (degs)
ARGPER = argument_of_the_periapsis (deg)
NUMORB = mission orbit number corresponding to the orbital elements
PERIAP = periapsis_time_J2000 (not functional at this time)

AS STATED THE REFERENCE DEFAULT ORBIT IS # 2667.

MINFIT   Determine Minnaert scattering Coefficients (Io and ß) for a navigated image (I = Io μμß).

MINFIT   *area_#* LIN= ELE=   SAMP=

KEYWORDS:
```
    AREA  =  Navigated McIDAS AREA  (no default, must be specified)
     LIN  =  BEGL ENDL (IMAGE LINES) (default uses brightness center)
     ELE  =  BEGE ENDE (IMAGE ELEMENTS) (default uses brightness center)
    SAMP  =  SAMPL SAMPE (SAMPLING INCREMENT) (defaults: SAMPL=1 &
             SAMPE=SAMPL)
     LAT  =  MIN MAX  (LATITUDE EXTENTS)  (defaults=-90.0 90.0)
     LON  =  MIN MAX  (LONGITUDE EXTENTS)  (defaults=-180.0 180.0)
   COLOR  =  COLOR OF POINTS ON MINNAERT PLOT (default=3)
    MUMU  =  LIMITS FOR LOG(MUMU0), X-AXIS (FROM STRING TABLE)
     IMU  =  ACCEPTABLE RANGE FOR LOG(I*MU)
             (Plot is not drawn if no limits are specified)
```

REMARKS:

Works either with 1 or 2-byte data. As currently set, 2-byte raw data must be in the 0-4095 DN range. **Needs a change so that the calibrated data units are used such that the raw data range can be -32767 to +32766 and calibrated data in any units.**

NAIFNAV - Command to calculates position of an observer and the sun with respect to a target body (planet or spacecraft) via the SPICE SP kernels and/or the body center and body pixel diameter from a limb point file. These values are then written to the DDB for access by the nvxnaif.dlm navigation routine. If the spacecraft is Voyager 2 and the target body is Uranus or Neptue, the C (pointing) matrix is alo retrieved from the SPICE C kernel and placed in the DDB.

| NAIFNAV | *area_number* RATIO = pixel_ratio |

Defaults:

area_number | currently_displayed_image
pixel_ratio | ratio of width_to_height (default = 1 1)

REMARKS

This routine may not return the correct state information for narrow angle cameras data if the data was obtained during a simultaneous narrow/wide camera exposure. The FDS number of both images should match, but this is not usually the case. The fit made to the limb point data is an UNCONSTRAINED fit. USE IMGCTR to perform a constrained fit.

NAMES - Lists & plots Planetary Feature names on displayed images. (Currently the name is GEOB and contains only the Venus database) (MIDR = Mosaic Image Data Record)

NAMES   (Lists all features only)
NAMES   LAT = *minlat maxlat* LON=*minlon maxlon*
                     (Selects features in region for plotting. (Features crossing 0
                     longitude must use -180.0 < LOW < 0.0). Default search bounds
                     are LAT = -90.0 90.0 LON=0.0 360.0)
NAMES   "name (searches for all feature name/fragment matches)
NAMES   P   (Plot all features on displayed MIDR image)
NAMES   PLOT   (Plot all features on displayed MIDR image)

REMARKS

There are 592 features named on Venus -- too many for a sceen printout -- to use DEV=PPP to get a permanent listing if lat-lon bounds aren't used, or do a search using names or name fragments (case sensitive) to reduce number of features returned.

The names are stored in a file called geo.tab on each MIDR CD-ROM volume.

NAVUTIL - Utility to list and/or modify selected entries in an area's data DATA DESCRIPTION BLOCK (DDB) and audit trail intact.

NAVUTIL   AREA = area_number KEYWORDS

NAVUTIL
               will list the current DDB values

Defaults

        area_number : area corresponding to current frame

Parameters:

    function   SEE to list an entry or PUT to change (see below)
    entry_type : format used to store data in entry (see below)

KEYWORDS

   CENTER = line# element# pixel_diam_of_body
          changes the pixel location of body center, and the pixel diameter of the
          body
      NAV = type (NAIF, PLAN, RADC)
          changes the type of navigation to the indicated format
    NORTH = angle_degrees
          changes the north angle

          Example:
          NAVUTL NORTH=330.5
          (north angle value in the displayed area:
          DDB is set to 330.5 degrees)

      RDC = right_ascension declination (degrees)
          changeopti axis right ascension and/or declination entries
   RATIO = Width_to_Height_ratio_of_image_data
  FILTER = name_of_filter
      ID = area_number
          some Mcidas or UNIX utilities that copy areas may not change the area
          number stored in the navigation block to the new area number, correct with
          this keyword option.

    COPY = source_area destination_area
          copies the source area to the destination area while preserving all data and
          the audit trail, but updating the user identifier and the area numbers stored
          in the DDB and directory

**Note: The use of the COPY keyword superceeds any other command. COPY
should be used alone.**

      Example: NAVUTIL COPY=9050 9060 (copy area 9050 into 9060)

    DDB = function entry_type entry_size DDB_address new_value

The DDB option allows the user to directly see or alter ANY DDB entry. Extreme care is advised when using this option. Consult PLANAREA documentation for type size and adress information

entry_size | REAL, CHAR or INTG
size of entry on DDB in bytes
4, 8, 12, 16 etc. (4 bytes = 1 DDB word)
DDB_address | address of the beginning of the entry
new_value | value to be placed in the DDB (only valid for PUT)

Examples: To see the integer value stored in DDB address 200

NAVUTIL DDB=SEE INTG 4 200
To see the double precision value stored in DDB address 517:

NAVUTIL DDB=SEE REAL 8 517

To input a double precision value of 100 into DDB address 517:
NAVUTIL DDB=PUT REAL 8 517 100

To input a 12 charcter string PARKER into DDB adress 142:
NAVUTIL DDB=PUT CHAR 12 517 PARKER

Note: FOR ENTRY TYPE "CHAR", WHEN THE OPERATION IS "SEE" THE ENTRY SIZE MAY BE ANY ARBITRARY VALUE EVENLY DIVISIBLE BY 4, WHEN THE OPERATION IS "PUT" THE ENTRY SIZE MUST BE 12, 8 OR 4

SHIFT | shift_command (L, R, U, D, B, S)

The SHIFT option allows the user to interactively alter the stored values for the line, element coordinate of the body center and the body pixel diameter. A shift in any value will change the value by 0.5 pixels. The effect of these changes is most easily seen with the MAP command.

L, R: move the center left or right
U, P: move the center up or down
B, S: increase or decrease the body pixel diameter

Note: When modifying the ddb of a displayed area, the user should

NRMIMG - Brightness Normalize an image using an analytical limb darkening function. Minnaert Scattering Law is the preferred function (default), but the extended Minnaert and Hapke functions can also be used. The Minnaert function can be fit to a given image using MINFIT.

NRMIMG	INPUT=source_area OUTPUT=dest_area FUNC= SPLINE=spline_size STRETCH=scale
	or,
NRMIMG	*source_area dest_area spline intcpt slope stretch*

Use the first format for Pioneer Venus images

KEYWORDS:

INPUT = Source area number
OUTPUT = Area into which the output image will be written
SPLINE = Spline size for the remapping, usually 4 or 5
FUNC = MINN intercept slope (Default)
      = HAPKE a b c
      = EXMINN intcpt slope muoffset, where,

MINN | Minnaert Intercept and Slope coefficients
EXMINN | Extended Minanaert function for thick atmosphere bearing bodies
HAPKE | Hapke Photometric function

STRETCH = Linear contrast stretch factor (try between 1.2 and 3)
SATMAX = Maximum S/C zenith Angle allowed for output image
SUNMAX = Maximum solar zenith angle allowed for output image

SPLINE - SPLINE SIZE (DEF=1)
A0 - Minnaert Intercept for that image
A1 - Minnaert Slope for that image
SCALE - Contrsat stretch factor (linear multiplicant, default is 1.5)

REMARKS

This command removes the limb darkening by the additive method, i.e. by adding the deviation from the limb darkening function to a constant value, rather than multiplicatively (which would produce a true image brightness normalization). The reasons for doing so are purely cosmetic. The additive method does not blow up as soon as the multiplicative one at very high solar and viewing zenith angles.

NXTARA - Find the first available or free area or a number of areas in the default data directoruy. Locates the next available area or a consecutive block of (number) areas between the start and end area numbers specified (default is between 1 and 9999). Useful before importing a lot of images from CD-ROMs etc.

NXTARA	*number starting_at endging_at*

PARAMETERS:

number	# of free areas to search for (default is 1)
starting_at	first area number to begin search at
ending_at	last area number to end search for a block *'number'* of free areas

KEYWORDS

FREE	Number of free areas to search for
BEGIN	Starting area number of the range of areas within which find the free area(s). Default is 1.
END	Ending area number for the range of areas within which to locate the block of free areas (Default=9999).

PHYSCON - Program to obtain the Physical constants of an object. Either the NAIF ID (preferred) or its name (capitalized) can be entered. Radii and length-of-day are currently listed.

PHYSCON *naifid*
PHYSCON OBJECT

Parameters:

> naifid | the NAIF identificaiton # for the solar system object **or its name in UPPER CASE!**
>
> *OBJECT* | If the NAIF identification # is not known, the name of the object can be specified in UPPER CASE. Only the first three characters are significant, except for PHOBOS and PHOEBE, TITAN and TITANIA!.

EXAMPLES

PHYSCON 399 to list constants for earth
PHYSCON PHOBOS to list constants for Phobos

Remarks:

> 1. NAIFID is determined from the name by subroutine BODCON. Only the first 4 characters of the object name are significant and must be in upper case.
>
> 2. For bodies with massive atmospheres, the radii are defined separately for solid surfaces and atmospheres at the cloud-top level. In such cases the NAIFID is modified by multiplying by 10 and adding 1. Thus Venus (NAIF ID = 299) atmosphere becomes 2991 (299 * 10 + 1). In general the NAIF ID's for planets and satellites can be entered as the actual NAIF_ID multiplied by 10 without any confusion.
>
> 3. The NAIF ID's for asteroids are defined differently As of May 4, 1993, no asteroid data is available.
>
> 4. PHYSCON also prints the acceleration due to gravity (m/sec^2) and the escape velocity for the object (km/sec) along with the length of the day (hours) and the triaxial radii and equator/pole eccentricity for the spheroid.
>
> 5 If a new object is to be added to the McIDAS-eXplorer environment, or if any of the current parameters need to be updated, the subroutine BODCON needs to be edited and recompiled. Naturally, all commands that call BODCON need also to be relinked. This is done primarily to ensure that the change is made deliberately and not inadvertently by editing constants from a file as with the NAIF physical constants kernel file (pck00003.tpc) which can be edited at will.
>
> Note that BODCON constants are based on the pck00003.tpc file except when more current data has been available in scientific literature.

PLAEDG - Find or list limb points in a displayed planet image or area, calculate a best fit planet center, and store the data with the area. Gradients are calculated in vertical and horizontal at each pixel, and the largest average gradient above the GRAD threshold is taken as the limb point.

```
PLAEDG  area_#          NUM=
PLAEDG  area_#          BOX=YES      NUM=
PLAEDG  area_#          BLOB=mindn maxdn lskip ieskip    NUM=
PLAEDG  area_#          POINT  GRAD=  LIN=  ELE=    NUM=
PLAEDG  LIST          Lists limb points for current area
```

NOTES

1. If keyword BLOB= is specified, center of brightness and DN bounds are used to compute search limits for LIN= & ELE= .

2. If BOX=YES, the box bounds define search limits.

3. AREA specification is optional if a displayed frame exists on which to plot limb points.

4. area_# must be > 30 if specified as a positional parameter to search for points (def=displayed area for frame, in which case the first positional parameter is treated as a limb point number).

5. If AREA is specified as keyword, then it may be any valid area 1-9999)

6. POINT = 0 to FIND MULTIPLE limb points in area (default) > 0.

7. To find a SINGLE limb point on the line LIN= lin (added after last valid limb point found, so number may be lowered on graphics overlay)

8. POINT < 0 to delete a SINGLE limb point

KEYWORDS:

ADD	=	point	add a point 1-30
DELETE	=	point	delete a point 1-30
LIN	=	beg end	line bounds (default beg=50 end=last line-50)
ELE	=	beg end	element bounds (def beg=50 end=last ele-50)
NUM	=	n	number of limb points to find (default=15)
			(maximum is 30, higher numbers interpreted as area id)
BLOB	=	mindn	minimum dn bound for brightness center
		maxdn	maximum dn bound for brightness center
		lskip	line skip increment for sampling dn's (def=5)
		ieskip	element increment for sampling dn's (def=5)
BOX	=	YES	finds NUM limb points within cursor defined box bounds
			(Follow the program's instructions to define box size & location. This option is useful to exclude triggering on large gradients near reseaus, terminators, shadows.)
GRAD	=	threshold	local dn gradient threshold defining the bright limb (default=50 for 2 byte pixels, 10 for single byte pixels)

REMARKS

This command adds limb points to the older, PLAN navigation block for the purpose of finding the image center by the use of constrained fits for objects of known shape and size. For constrained fits such as these, a small number of points is frequently sufficient. It has been modified recently to also create a limb point file (LIMBnnnn) in the same format as the other limb point finding programs (LIMBPT, EDGES, BRTCEN).

EXAMPLES:

To add limb points for image navigation:

PLAEDG   (tries to find 15 limb points distributed throughout the lines of the displayed frame)

PLAEDG NUM=25   (tries to find 25 limb points in the frame)

PLAEDG BOX=YES   (tries to find 15 limb points within a box)

PLAEDG BLOB=20 180   (tries to find 15 limb points between the bounds of brightness contours 20 and 180 DN)

PLAEDG 6465   (tries to find 15 limb points for area 6465)

To edit limb points:

PLAEDG L   (lists all points in navigation block)

PLAEDG 5   (add or replace point 5 within the cursor)

PLAEDG ADD=5   (add or replace point 5 within the cursor)

PLAEDG DELETE=3   (remove point 3 in the displayed frame)

PLAEDG -3   (remove point 3 in the displayed frame)

PLAEDG -30   (remove any normally non-existent point to see the plotted points & trial fit once again)

PLAEDG 5 LIN=230   (point 5 added, as found on line 230)

PLAEDG 200 3   (add point 3 within the cursor to area 200)

PLAEDG AREA=22 DELETE=3 (remove point 3 from area 22)

PLANAV - Generate a new area for a perspective view of an image and attach navigation so that a given area can be remapped into it using REMAP command.

PLANAV   *area Planet angle* VIEWPOINT= DIRECTORY= REPLACE= NAV=

Keywords:

    AREA = AREA -- Area to define navigation for (required)
    LINES = line dimension if a new square area is to be created. (Default is LINES=1000, a 1000 x 1000 pixel area)

    PLANET = Name/ID# of a solar system object (either the NAIF ID number or name is required). RADIUS & ECC will default correctly if the value of PLANET is specified. They can be forced to other values by the user. For Venus, use VENUS_SFC (297) or VENUS_CLOUDS (298).)
    diam | Planet diameter in pixels (default is LINES-50)
    radius | Planet equatorial radius (km)
    ecc | Planet eccentricity (oblateness parameter 1-a**2/b**2)

    ANGLE = north nadir na_azim
    north | Spin axis tilt (deg.) clockwise from vert (def=0.0)
    nadir | off_axis tilt of optic axis from planet-to-   spacecraft translation vector (nadir angle)
    na_azim | Rotation angle of nadir angle about optic-axis

    VIEWPOINT = lat lon dist
    lat |Planetocentric latitude at s/c subpoint (default=0.0)
    lon | Planetocentric longitude at s/c subpoint (default=0.0)
    dist | Distance s/c to planet center in RADIUS (def=10.0). DIST=1.000 is at planet or cloudtop surface! Infinite distance yields orthographic projection.

    LINE = Line in area to put subpoint (default=area LINES/2-20)
    ELE = Pixel in area to put subpoint (default=area ELES/2)

    SUN = sub_sun_lat sub_sun_longitude

    DIRECTORY = ss yyddd hhmmss
    ss | McIDAS Spacecraft ID (Default=50)
    yyddd | Image day & year (default is current day & year)
    hhmmss | Image time (default is current time)
           (If the area exists prior to PLANAV call, the existing SS, YYDDD, HHMMSS will be used as defaults).

    REPLACE = NAV/NO/AREA
           REPLACE=NO merely generates CRT output of the navigation parameters. [default is REPLACE=NO, with default NAV=128 just lists nav]
    NAV | (REPLACE=NAV replaces only current nav block for area)
    AREA | (destructive: REPLACE=AREA (re)generates area & nav)
    NAV = Display NAV words of current PLAN navigation only. (Maximum useful number and default is NAV=128)
    MORE = 0-3 (Adds additional output for detailed nav diagnosis)

NOTE: AREA, PLANET, and NORTH angle may be specified as positional parameters. Indeed, the area and planet identification are required, but if you misspell keywords, they will be ignored and the default parameter values will apply!

Examples:

    PLANAV
           (Lists current navigation for last accessed area)
    PLANAV 23 VENUS_CLOUDS 180.0 REPLACE=AREA
           (Venus upside down in area 23)
    PLANAV 23 SATURN REPLACE=AREA VIEWPOINT=90.0 180.0 15
           (north polar perspective view at a distance of 15 planetary radii)
    PLANAV AREA=23 500 500 PLANET=JUPITER REPLACE=AREA
           (default projection of Jupiter is generated in a 500x500 size area)
    PLANAV 23 EARTH VIEWPOINT=-23.5 10 1.025 ANGLE=0 50 20 REPLACE=AREA
           (-23.5 lat, 160 km above earth surface, looking leftward toward limb)

NOTES

If the remap runs too fast and gives a black image, you do not have a destination location which ought to contain any source data -- typically you are on the back side of the planet or are using incompatible parameters which the program resolves in a way you don't expect. The trouble could be in either the source area or the destination area navigation. Destinations with all data within a single spline domain may also truncate to black. Try DF's and grid both images with MAP LALO for analysis.

MAP LALO will show a lat-lon grid even on a completely black image, unless the planet surface lies completely outside the image boundaries.

EARTH is a Special Case!

One must remap images using the right-handed transformations generated by PLANAV (we don't spatially invert clouds in the real world), but the lat-lon grid (being left-handed) must be inverted. This is accomplished post-REMAP by using keyin PLAREV to interchange east and west longitudes.

PLANAV area EARTH ANGLE=0.0 REPLACE=AREA
REMAP source_area area
PLAREV area
DF area frame; MAP LALO
(Always DF and MAP after navigation mods to check results)

PLAREV - Flip the longitude system (east positive to west positive or vice versa) for an area with PLANAV created navigation. Useful for mapping earth data in the generalized perspective projection.

PLAREV *area_#*

Remarks

McIDAS uses a 0 - ± 180 longitude system for navigation, and for earth, the longitudes west of Greenwich meridian are considered positive and negative to the east. This convention is contrary to general usage and can create a reversed map than one intended if using PLANAV to attach navigation. PLAREV will reverse the convention.

This should normally be started by PLANAV if the TARGET is specified as EARTH.

POLEN - Program to convert Image Co-ordinates to RA-DEC (Vogager Images)

```
POLEN  FDS LINE ELE OPT = TOEME  AREA=  SEDR=  LOC=
POLEN  FDS  RA DEC OPT = TOIMG  AREA=  SEDR=  LOC=
POLEN  FDS OPT = TOIMG POLE
POLEN  FDS OPT = TOIMG POLE C
```

OPT is one of the following:

TOEME | conversion option for Line, Ele ---> RA & DEC (default)
TOIMG | conversion option for RA & DEC ----> Line, Element
TOIMG POLE | Calculates picture body POLE (default is ' ')
TOIMG POLE C | Corrects C-matrix for pic body (default is ' ')

Required arguments:

- *FDS* = FDS number of the Voyager image (default=0.0)
- *LIN* = Star or planet center line position in image
- *ELE* = Star or planet center element position in image
- *RA* = Input Right ascension for conversion (default=297.0)
- *DEC* = Input Declination for conversion (default=-18.1)

OPTIONAL KEYWORDS:

- AREA = Area number (default is 0, which implies displayed frame)
- SEDR = SEDR file name (default is 'VGRNSEDR')
- LOC = CURSOR, next uses LIN,ELE keywords
  (Default = 500.0 500.0)
- IMAGE = RAW/GEOM (default is GEOM)
- SKIP = Skip lines in searching for star centroid (default=1, no skip)
- POLE = Source of pol RA & DEC
  (default=SEDR values, else 42.81179327 & 298.857487705 satellite orbit).
  SEDR values currently default to 42.8 & 298.9 respectively.
- STARLOC = OPNAV (File containing star location)
- SKY = HIST/AVG Method for subtracting background (AVG is default)
- ROT = Roll angle offset (default=-0.91)
- POLRAD = Polar radius of planet in image (Neptune default=24414.0)
- STAR = Star identification (12 characters)
- RA = Right ascension   (default = 297.0)
- DEC = Declination   (default = -18.1)
- COLOR = Plot color (3 is default)
- TSIZE = Text size (default is =6 4)
- SIZE = Star search region size (default is current cursor size)
- LIST = 0,1,2 (Generates more debugging output, 0 is default)

These Keywords may be stored in the string table by using the TE command.

REDISP -   Re-display an image being viewed such that it is centered (in the McIDAS image display window) over a point identifed by the cursor location on a specifed frame at a specified integer magnification or a blow-down factor.

REDISP -   *frame_#   magnification*

---

frame_# | where to display the frame
mag | blow-up or blow-down factor (non zero integer, +ve for a blow-up, -ve for a blow-down).

REMARKS

The area corresponding to the image to be re-displayed must not have been quit!

RESEAU - Lists and/or plots reseau data for Voyager spacecraft

---

RESEAU	*option coord spcft camera* KEYWORDS=

---

option = LIST   - Lists coordinates on crt (or DEV=P,S)
            BOTH   - lists coordinates and plots on graphics.
                  May be abbreviated to "L", "P", OR "B".

coord = "NOM", "OBJ", OR "FND"
           Default is FND for raw images, OBJ for GEOMED images.
             May be abbreviated to "N", "O", OR "F" .

spcft = "A" = VOYAGER 1, "B" = VOYAGER 2 [def=current frame]

camera = "WIDE" or "NARROW" angle,   [def=current frame] May be abbreviated to "W" OR "N".

KEYWORDS:

AREA = Area number for "FND" reseau marks
            (found reseaus are stored with area calibration)

RANGE = sets a min/max range of reseau marks to use in plotting; range must be
            1..202.

COLOR = plotted reseau box & label colors (defaults=1 2)

HEIGHT = height of reseau box label (default=5)

EXAMPLES:

RESEAU
(Plots reseaus on the current displayed frame)

RESEAU P N
(Plots nominal reseaus on the displayed frame)

RESEAU P RANGE=20 40 COLOR=3 3
(Plots reseaus 20-40 in yellow)

RF - Locate reseaus in a Voyager image so that the vidicon geometric distortion can be removed using GEOM command

RF	*area_#*
RF	*area_#* RES=RBEG REND TOL=X.XX BOX=15 NOM=NO ZERO= GEOM= YES/NO

KEYWORDS:

AREA = UnGEOMed area in which to find reseaus (required)

RES = n1 n2 | Reseau number range (Default is: RES=1 202)

TOL = x.d | Threshold displacement from polynomial fit above which reseaus will be adjusted to line up along line with neighbors (default is TOL=0.6, so all reseaus deviating from polynomial by more than 0.6 pixels will be shifted)

BOX = n | Maximum box size within which to search for a reseaux, centered at its nominal position

NOM = YES / NO | to file nominal reseau locations instead of the fitted locations (default=NO).

This implies reseaus are being found well beyond their nominal locations and we are having trouble fitting to specified tolerance. The image may be of poor quality, and the reseaus cannot be easily located in noisy or low contrast dark noise backgrounds.

ZERO = YES | default, initializes area storage block to zero before adding found locations

= NO | overlays found locations on previous ones

GEOM = ON | Tests if word GEOM appears in audit trail (default). RF will not modify the found reseau locations)

= OFF | Turns off GEOM test, so found reseau locations can be modified (default=ON)

SCANA -   Create a visual index of images contained in McIDAS ar· ·s by writing a thumbnail image of each area into the index area. As ma:· as **484** areas can be scanned in a grid as large as **22 x 22**. The output ·s another area which can be displayed withe the DF key-in. The SCANE command allows the particulars of selected (using the mouse) area to be accessed. A variety of options for annotating each thumbnail image are available.

SCANA	*first_area last_area*	*output_area* GRID= SIZE= KEYWORDS
SCANA	*range1 range 2... rangeN*	*outpur_area* KEYWORDS

PARAMETERS:

first_area | first area number to begin scanning
last_area | last area number to scan if only one range of ares is to be scanned
range(s) | source area range(s)
 | (format: beg_area-end_area (No spaces between the area numbers!)
 | (default=1-9999)
output_area | destination area (default=first unused area)

KEYWORDS:

IMA = frame_# | image frame number for display (default = no display)

GRID = #_row #_col | set the number of rows/columns of thumbnail images in darea (def = 5 x 5). For a display frame size of 900 x 1200, a grid of 15 x 20 is a practical limit. The SIZE should correspond to the frame size so the index area can be displayed at full resolution.

SIZE = lines elems | set the size of the destination area in lines and elements (def = display line x display elem). See comment about the GRID above.

POS = position type | image positioning: ABS=absolute REL= relative (def)
LABEL = ltype ltype | label for each thumbnail, one from:

AREA	area number (nnnn def ie. 9999)
TIME	time of image (hh:mm ie. 12:01)
BAND	band number (bb ie. 08)
DAY	date of image (dd mm yy ie. 4 NOV 93)
JDAY	date of image (yyddd ie. 93287)
MEMO	memo field from area (1-32 characters: what ever fits)
TYPE	satellite type (12-characters: from sss code in area)
	text - plain text (12-characters: not any of the above)
BAND	bands	specify band(s) to display or "ALL" for all bands (def = first band in channel map)
MISS = brit	specify the brightness value (0-255) used for missing data (def=128)

OPTS = opt ... opt | set program options from the choice below:

```
GF  |   Group Filter -> splits the dynamic brightness range
    |                  between the source range groups
AX  |   Aspect Ratio Fill -> keep origional image aspect ratio
FX  |   Fill All -> best fit image to grid.
HS  |   Histogram Stretch -> stretch the brightness range using
    |                  the histogram of the data.
SF  |   Set to image frame (if IMA= keyword is entered)
```

Notes:

1. BAND= uses range format described above.
   example: BAND=1-12 15 -> bands 1 through 12 and 15
2. A negative "darea" signifies that the destination area should be overwritten if it already exists.

REMARKS:

This command allows one build a visual index of the images imported or processed into McIDAS areas. The output should be displayed using the DF key-in at full resolution so that my using the mouse each image can be queried using the SCANE command.

SCNCPP - Scan the file containing a Pioneer Venus Orbiter Cloud Photopolarimeter (OCPP) image of Venus in the NSSDC tape format to determine the average spin period, look angle, roll angle changes and log the information to a file.

SCNCPP *(area#) (filename)* LOG=logfilename

KEYWORDS:

HELP = print the TEXT file containing the explanation of the CPP data.

REMARKS

This command is useful for diagnostic purposes if, after importing the image into eXplorer using GETCPP, some discrepencies are found in the data or navigation.

SCANE - This command allows one to query the contents of the index frame created and displayed from the output of the SCANA command. A command string relating to that area can be specified containing an '*' as a replaceable character for the area number corresponding to the image selected by positioning the cursor with the mouse and clicking on the right button. The command will stay resident for 30 minutes or unti ALT-G key-stroke is entered while in the command window. Command should be entered when an area created using SCANA is being viewed on a specific frame.

SCANE	"mcidas_command *

EXAMPLE: SCANE "WHERE AREA *; DF * 5

This assumes that the frame being viewed corresponds to the SCANA area. Choose a particular thumbnail image in that frame and click the right mouse button. The output of the WHERE command corresponding to that area is displayed in the text window and displayed on frame 1.

SEDRIN - Reformat SEDR data into navigation block for raw image

---

SEDRIN *area# fds# sedrfile target camera* REPLACE=

Program will attempt to pick up all parameters from the area or displayed frame. If navigation information already exists for   the image the program will halt. Use keyin PLANAV to view the information SEDRIN stores in the navigation blocks for an area.

EXAMPLE:

SEDRIN 465
will search for a SEDR entry consistent with information stored with the image in area 465)

SEDRIN   465 FDS=4386645 REPLACE=YES
(repeat search with user specified FDS number)

KEYWORDS:

REPLACE = YES Forces rewrites of navigation block for area

AREA = Area number to add navigation (def=displayed frame)
(If navigation data already exists for the area, the REPLACE=YES keyword must be used.)

FDS = FDS number WITHOUT embedded decimal point (a range of acceptable values may be specified to adjust for varied data rates, since SEDR entries are given in starting FDS counts, not ending counts). **Defaults to word 20 in area directory)**

SEDRFILE = VGR1J, VGR2J, VGR1S, VGR2S, VGR2U, VGRNXXX

TARGET = JUPITER, SATURN, URANUS, NEPTUNE, TITAN_CLOUDS, TITAN_SFC, other moons

		Voyager 1	Voyager 2
CAMERA = NAIF_ID	Wide =	-31002	-32002
	Narrow =	-31001	-32001

Note that if the frame is not reloaded, the new navigation parameters will not be available for the displayed frame.

Always reload a frame after navigation is completed for an area, before running the MAP or PC keyins, or using the E key.

SEDRRD Load Voyager SEDR tape file records into LW file

SEDRRD *sedrfile_name* LWFILE PLANET= HEAD= "NO" (NO HEADER)
                FDS=beginning_fds# ending_fds#

KEYWORDS:

INPUT	=	SEDR FILE NAME
LWFILE	=	MCIDAS LW FILE NAME FOR INDEX & DATA
PLANET	=	NEPTUNE or OTHER (OTHER IS DEFAULT)
		(Neptune SEDR has a larger record size than others)
HEAD	=	YES/NO INDICATES PRESENCE OF HEADER RECORD IN FILE. (YES IS DEFAULT)
FDS	=	RANGE OF FDS COUNTS TO ENTER INTO LW FILE (omit period). (DEFAULT IS ALL RECORDS IN TAPE FILE)
COUNT	=	RANGE OF RECORDS TO ENTER INTO LW FILE (DEFAULT IS ALL RECORDS IN TAPE FILE)
DEBUG	=	YES (Display INT, HEX, and ASCII listing of each record)

Remarks:

This command creates an indexed LW file from the SEDR tape records. As there is no on-line 9-track tape drive available on the system, it is assumed that SEDR file is copied onto disk first. The command actually accesses this file to create the LW file. The purpose of this command is to provide access to all of the SEDR words (which vary depending on the encountered planet) so that the pointing of the camera system can be up-dated, particularly the roll angle.

SPICENAV - utility to calculate the position of an Voyager 2 with respect to a target body via the SPICE SP kernels, retrieve the C pointing matrix from the SPICE C kernel and calculate inertial frame to body centered frame rotation matrix for the target body at image time. These values are then written to the DDB for access by the nvxspce.dlm navigation routine.

The utility may also be used to fine tune the C-matrix to improve the accuracy of the navigation.

SPICENAV   *area_number* (default displayed_image) OPT=option (no default)

KEYWORD

OPT = UPDATE *line_adjust element_adjust roll_adjust* (in degrees)
Applies small rotations to an existing C matrix to translate or rotate the expected center of the picture body to better fit the data image. After the new matrix is calculated the user may either replace the existing matrix with the new or store the new in the users section of the DDB

REMARKS

This routine may not return the correct state information for Voyager wide angle narrow angle cameras data if the data was obtained during a simultaneous narrow/wide camera exposure. The FDS number of both images should in principle, be the same. However, because the narrow angle frame is always the first one read out, the wide angle frame gets tagged with a later time stamp or FDS number where the delay depends on the data rate. Since the NAIF SPICE kernels are computed for the FDS time, this results in a an ambigous kernel set for the wide angle BOTSIM frame. The SEDR information is actually more reliable in this instance.

Example:

SPICENAV   OPT=UPDATE 10 10
move the calculated center up 10 lines, 10 elements right with no rotation

STAR - Determine the location of a star in an image in a region defined by the cursor. Several options are availabel to determine the center-- center of brightness within the cursor, edge detection. or a brightness shape profile

---

STAR   AREA= SKY=

KEYWORDS

AREA = Area number of the displayed frame
SKY = Brightness value for the background sky

REMARKS

The location of a star (or a planetary moon, if the image signature is small enough_ is frequently needed for the purpose of (optical) navigation. The star signatures in most planetary image data do not appear as points, but as bright blobs against a noisy background. This command estimates the center of this signature as the best guess for the star location.

TGET - Restore one or more McIDAS area files from tape to disk (i.e. in /mcidas/data sub-directory) from a DAT or an Exabyte cartridge written using **TPUT**.

TGET *tarea1 tarea2 darea* DEVNUM =

---

tarea1 = beginning tape area   (required)
tarea2 = ending tape area   (DEFAULT=tarea1)
darea = beginning tape area   (required)

KEYWORDS

    DEVNUM = i
           (DEFAULT=0)

REMARKS

       TPUT writes the McIDAS area directory as well as the Data Description Block (DDB) attached to the area directory when saving the data to tape. **TGET** performs the reverse task, i.e., it copies the directory and the DDB from tape to the McIDAS data subdirectory when restoring the area. Thus all of processing history and navigation data are restored as they were when the data were initially written to tape.

TILES - Display a Magellan BROWSE format image from an area and show the constituent sub-frames (or tiles or framelets)

```
    TILES       area# frame#
```

PARAMETERS:

area# | Area containing browse image
frame# | Frame to load and grid

KEYWORDS

AREA	=	area_#		area containing the Magellan browse frame
FRAME	=	frame_#		frame # on which to display the browse area
COL	=	level		color to write the sub-frame id's in
OFF	=	linoff ieloff		pixel offset for the id#
SIZE	=	pixels		size of the sub-frame id label characters. Default is 7 pixels high

Remakrs:

This program is a combination of the DF keyin and a special gridding routine specifically used for Magellan browse images. Normally, this keyin is started by GETMGN, but you may call it separately to restore the browse image to the McIDAS screen if the browse frame was overwritten. 7 x 8 tiles assumed.

The display frame can be any size. TILES will display the area to fit the frame by appropriately scaling it down. The location of the component tiles (or sub-frames or framelets) is shown by a grid and the tile numbers are shown as well.

Currently TILES does not check the area to see if it indeed contains a browse frame.

TLST   -   Lists areas on a tape saved using **TPUT**. SCSI tape drives only.

TLST   VOLNAM= DEVNUM=

KEYWORDS:

VOLNAM= s   (DEFAULT s=UNKNOWN)
DEVNUM   = i   (DEFAULT i=0)

TLST lists the contents of an area save tape written with **TPUT** on either the Exabyte or the DAT drive   The device number is likely to be site dependent.

TPUT - Save one or more McIDAS area files from disk to tape (i.e. in /mcidas/data sub-directory).

TPUT *darea1 darea2* **KEYWORDS**

---

darea1 = beginning disk area (required)
darea2 = ending disk area (DEFAULT=darea1)

KEYWORDS:

    APPEND = Y/N (DEFAULT=Y)
               APPEND should be N for Exabyte and 1/4 inch

    DEVNUM = i (DEFAULT=0)

REMARKS

When the areas are written onto the tape, all of the navigation information related to that area that is accessible using the LA or the LISTNAV commands is also stored along with it. Thus, the navigation, processing history etc. can be restored with the **TGET** command at a later date.

This utility is similar to the **PUT** and **GET** commands available on the mainframe system, except that it is currently restricted only to area format data files. The other difference is that it is assumed that the user will physically interact to mount and dismount the tape cartridge from either the DAT or the Exabyte drive.

The data can be "restored" by using **TGET** onto another workstation if McIDAS-X and the the eXplorer extensions have been installed.

USCLAS - Spectrally classify a multi-banded image using unsupervised multispectral classification.

USCLAS	*inarea outarea KEYWORDS*

PARAMETERS:
  inarea - area to classify
  outarea - Classified area with M spectral classes.

KEYWORDS:
  BANDS = BANDS= BAND1 BAND2 ... BANDN
        Band numbers from the area to classify (up to 6). Default is all bands
        present in the area.

  CLASES = initial# of classes presented. Default is 100
    SKIP = Pixel skip factor for iterative classification Specified numbers of lines and
        elements are skipped. MUST BE < 8. DEFAULT IS 4

    ITER = Maximum # of iterations allowed. Default is 35.
  MERGE = Cluster Merging factor, 0 TO 2000, If a divergence < MERGE then merge
        two classes.
        0 = NO MERGING. DEFAULT IS 1400
    SPLIT = SPLITTING FACTOR, 1 TO 10, IF BIG/SMALL DIMS. > SPLIT ==
        SPLITTING
        0 = NO SPLITTING. DEFAULT IS 3.0
    NULL = DATA DROP-OUT DECISION.
        ANY: CLASSIFY AS ZERO IF ANY BAND HAS 0.
        ALL: CLASSIFY AS ZERO IF ALL BANDS = 0.
        DEFAULT IS ALL
  MINPIX = smallest # of pixels required in a class. DEFAULT = 0.01% OF DATA
  STRETCH = LINE or STRETCH. *Output color stretch type.*
        LINE: Linear stretch for class colors
        HIST: histogram equalization stretch
        DEFAULT = HIST

WHERE - List inventory of the image data imported within McIDAS-eXplorer as identified by target object, spacecraft source and selected image identifiers such as filter, camera etc. for areas, displayed frames and limb point files (LIMBnnnn)

WHERE	FRAME *1st_frame last_frame* **KEYWORDS**
WHERE	AREA *begin_area_# ending_area_#*
WHERE	LIMB *begin_area_# ending_area_#*

KEYWORDS

MISSION = mission ID (VGR, VO, GO or MGN)
TARGET = name of a solar system, target

Remarks:

If the FRAME option is used, each of the displayed frames are annotated on the graphics frame with a one line summary of the displayed image (if any) and the area_# which was used for that frame display. Similarly, if the AREA option is specified, then if that area has been displayed on a particular frame, then that frame number is also indicated on the one line summary of each area.

XPORT - Routine to write a Mcidas area into a FITS format file.

XPORT	*source_area_# FITS_file_name*

Paramaters:

source_area_# | area number from which to copy the image data into a file with a FITS header

FITS_file_name | name of the output file containing the image data with the FITS header

REMARKS

> This command allows images stored in the eXplorer area format to be converted into a file with a FITS header that contains the pertinent image information from the area DDB.

Example

XPORT 9999 image.dat

APPENDIX II

McIDAS-eXplorer Data Files

A number of data files are required by some of the commands that form McIDAS-eXplorer in addition to those files required by the core McIDAS. These files exist in /mcidas/data sub-directory. McIDAS generally uses standard prefixes (always UPPER CASE!) for its standard data files. The convention is as follows:

Digital images	AREAxxxx
Gridded data files	GRIDxxxx
Random ordered data	MDxxxxxx

In addition, McIDAS-eXplorer uses similar convention for the files used in some solar system applications programs. They are:

LIMBxxxx	Image edge points
xxxx.ET	Enhancement tables created by USCLAS
xxxx.LOG	A log file of the USCLAS multispectral classification program

There are many data files associated with specific missions and instruments that are useful in using McIDAS-eXplorer. These are also in /mcidas/data sub-directory. Their names and brief description are given below.

file_name	*Remarks*
acumdir.tab	Magellan Mission cumulative directory for the ARCDR data (PDS CD-ROM Volumes MG2001 through MG2015). This is the version from MG2015 volume.
attsppin.pvo	Pioneer Venus Orbiter Spin axis pointing log. Needed for navigation of OCPP images.
cumindex.vo	Viking Orbiter cumulative index for the PDS CD-ROMs
de118.bsp	JPL Planetary ephemeris file (NAIF)
de202.tsp	JPL planetary ephemeris file (NAIF)
etopo5	NGDC global topography and bathymetry file with 10 minute resolution (ibmints).
gazetter.tab	Gazetteer table for Mars from the USGS Digital Image Map CD-ROM Volumes.
geo.tab	An ASCII file containing the names of the geographic features on Venus. This file is found on all PDS Magellan CD-ROM volumes through MG0080.
JSEDR1	Voyager 1 Jupiter encounter SEDR file
JSEDR2	Voyager 2 Jupiter encounter SEDR file
jup035-5.bsp	P kernel file for Galilean moons of Jupiter for 1990-2010

jupitertapes	A catalog of Voyager 1 and 2 Jupiter EDR tape cartridges. Each cartridge contains 240 images (10 1600-bpi original EDR tapes).
mcumdir.tab	Magellan Mission cumulative directory for the MIDR data (PDS CD-ROM Volumes MG0001 through MG0080). This is the version from MG0080 CD.
NSEDR2	Voyager 2 Neptune encounter full SEDR file.
neptapes	A catalog of Voyager 2 Neptune EDR tape cartridges. Each cartridge contains 240 images (10 1600-bpi original EDR tapes).
orbele.pvo	Pioneer Venus Orbiter orbital elements file (text).
pck00003.tpc	The NAIF kernel file containing the planetary physical constants and other data used by NAIF software. Other NAIF data files are also copied into this directory.
pvocpp.img	Catalog of Pioneer Venus Orbiter Cloud Photopolarimeter images (text).
RESEAUDATA	This is a binary file containing nominal reseau locations for Voyager 1 and 2 NA and WA cameras. The structure of this file is described elsewhere. Used by **RF** and **RESEAU** commands.
SSEDR1	Voyager 1 Saturn encoutner SEDR file
SSEDR2	Voyager 2 Saturn encounter SEDR file
uranustapes	A catalog of Voyager 2 Uranus EDR tape cartridges. Each cartridge contains 240 images (10 1600-bpi original EDR tapes).
vgr1_jup.bsp	SP kernel file for Voyager 1 Jupiter encounter (limited coverage)
vgr1_sat.bsp	SP kernel file for Voyager 1 Saturn encounter (limted coverage)
vgr2_jup.bsp	SP kernel file for Voyager 2 Jupiter encounter (limited coverage)
vgr2_sat.bsp	SP kernel file for Voyager 2 Saturn encounter (limited coverage)
vgr2_ura.bsp	SP kernel file for Voyager 2 Uranus encounter (complete)
vgr2_nep.bsp	SP kernel file for Voyager 2 Neptune encounter
vgr1n0 through vgr1n7	Voyager 1 narrow angle shading files for filters 1 - 7.
vgr1w0 through vgr1w7	Voyager 1 narrow angle shading files for filters 1 - 7.
vgr2n0 through vgr2n7	Voyager 2 narrow angle shading files for filters 1 - 7.

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vgr2w0 through vgr2w7	Voyager 2 narrow angle shading files for filters 1 - 7.
vgr1j	Extracted Voyager 1 Jupiter encounter SEDR file (JPL)
vgr2j	Extracted Voyager 2 Jupiter encounter SEDR file (JPL)
vgr1s	Extracted Voyager 1 Saturn encounter SEDR file (JPL)
vgr2s	Extracted Voyager 2 Saturn encounter SEDR file (JPL)
vgr2u	Extracted Voyager 2 Uranus encounter file (JPL)
vgr2n	Extracted Voyager 2 Neptune encounter SEDR file

In addition, SPICE kernel files available from NAIF are required for navigation of Voyager and Galileo images using SPICE kernels.

APPENDIX III

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McIDAS-eXplorer commands are described briefly below in alphabetical order. Some often used core McIDAS commands are also included in the list below. These commands are in addition to the core McIDAS-X commands supported. Many of these commands can also be accessed via the eXplorer GUI and the core McIDAS GUI's.

AA - Copy an area containing image data to another. This is a core McIDAS command

ANGLE - Determine the north angle, i.e. the orientation of the spin axis of Jupiter in an image by determining the slope of the zones and belts from cursor selected points on the zone/belt boundary. Useful when the north angle must be estimated from the image.

ASTAT - Measure image statistics from a displayed image e.g. histograms, outlines, etc.

AVG2D - Average multiple areas (1 or 2-bytes per pixel), perform n x n averaging of data about each point and write the resulting output in a 2-byte per pixel area. Useful for averaging Voyager dark frames.

BILIN - Enlarge/Reduce and image by any arbitrary scale factor(s), real or integer in either direction by bilinear interpolation

BLEMEDIT - Edit blemishes interactively in a displayed image by replacing the data within the cursor with a spatially weighted average of points within a larger box.

BOTSIM - Navigate simultaneous Wide-Angle/Narrow-Angle Voyager Image pair with one of them navigated.

BROWSE - Normally called by GETMGN, BROWSE is designed for Magellan MIDR browse image files. It calls DF to scale the MIDR browse image to the current frame and displays the 7rows x 8 column tile grid to identiffy the component tiles.

BRTCEN - Determine the center of the image of a disk by first finding the centroid of brightness of the image data in an area and then determining the limb points from radial brightness profiles. The limb points are stored in LIMBxxx file where xxxx is the 4-digit left-zero-padded area number in the same format as used by EDGES command. The file can be interactively edited using EDGES. A least-squares general conic fit is used to determine the center. Multiple passes allow exclusion of deviant limb points and he edited points can be stored in the file as an option.

CALCMA - Calculates Transform Matrix for Planetary Navigation for framing camera image navigation. Currently it is set up for Voyager images for PLAN navigation type only.

CHANGECD - Unload/load or load/unload CD-ROM in the CD-ROM drive from within McIDAS. **The disk of course has to be manually removed and replaced!**

CLEAN - Clean up a Voyager raw image to remove cosmic ray noise and replace any 'bad' lines

COMBIN - Make a multiband area from several single band area. May also be used to reduce 2-byte data to 1-byte data using the calibration constants in the area directory. Useful for multispectral classification, remapping of multi-filter images such as Voyager or Viking.

COMP - Compress the image data contained in a digital area file using the Huffman coding (lossless) or DCT (lossy) coding. The former is reversible, whereas the the latter is not. The compressed file is given a different name. Use **DECOMP** to decompress the data. The directory and DDB attached to the area is left untouched.

CONFIT - Fit a general conic to a set of points stored in a limb points file created using the key-in **LIMBPT**. Primarily useful for planet center determination if the pointing data is accessible. Constrained fits are also used if the planet orientation and size are known.

DBI - Import tabular data into a database format. Assumed that a separate file specifying the structure and field names is available. Use DBL to search the database created.

DBL - List specified fields from a database file.

DBU - Database utility program

DDBUTIL - A utility to insert entries into the Data Description Block or copy the entries from DDB for one area into the DDB for another area

DECOMP - Decompress an image compressed by the **COMP** command and write the output in a new area.

DF - Display a frame, i.e. load the digital image data from an area onto a McIDAS display frame. Various coodinate and scaling options are available to control the exact registration and resolution of the image within the frame. This is a core McIDAS command. The displayed frame's navigation can be displayed by overlaying the map or latitude longitude outlines with the **MAP** command.

DF3 - A version of DF for the 24-bit version of McIDAS (-bp 24 option when starting a McIDAS session) that allows 3-color composites. DF3 will load a given frame in a specified color (Red, Green or Blue). Three separate calls (one for each color) to three different colors will produce a color composite on a display frame. DFC will accomplish the same if the three images are in a single multibanded area (and hence the same navigation)

DFC - A three color version of DF to display a color composite of 3 bands from the same area for the 24-bit display mode (-bp 24 option)

DSTNCE - Measure distances on any navigated solar system image either between a pair of points or along a trajectory to determine the cumulative distance and segment lengths.

EDGES - FInd the edge points (bright limb) in an image using a 3 x 3 local maximum brightness gradient method. Edge points are written to a LIMBxxxx file and can be edited, plotted or listed. Uses a different algorithm from LIMBPT and is best used with the key-in assigned to a function keys using TE KEYFnn for deleting, adding limb points.

ELLIPS - Draw signature ellipses from a USCLAS spectral classification to see the spectral class distribution for a specific classified area.

EXPDOC - List the User guide and command help documentation in an X-Window that can be scanned using vi editor commands.

FILHOL - Interpolate missing data in an image by two dimensional interpolation over a specified box

FILL0 - Fill in the alternate line data compression gaps in Voyager 2 images of Uranus and Neptune by interpolation across lines for each missing element.

> NOTE: The line prefix bytes are set to zero in the area directory by FILL0.

FILTER - Spatially filter a digital image stored in a McIDAS-eXplorer area using one of several two dimensional masks: Left or Right edge enhancement, smoothing, Laplace gradient, 3x3 high pass, 3x3 convolution and sharpen. A new output area is created, the input can be either 1 or 2-byte per pixel data.

FILTERS - List just the filters through which images in a range of areas were acquired. WHERE also provides this information along with other relevant information

FILTVGR - Originally written for Voyager images, this is a spatial contrast sensitive digital filter that is less sensitive to sudden brightness transitions e.g. in the neighbourhood of a bright limb. The filter size shrinks as the domain approaches a sudden brightness transition.

FINDALT - Determine on which PDS CD-ROM volume Magellan Altimeter data from a particular orbit can be found. *As yet there is no command to determine the orbit number corresponding to a given Venus location.*

FINDFF - Find the names of the Magellan MIDR framelets containing a given geographic feature or a latitude-longitude region on MIDR CD-ROM's

FINDMDIM - FInd a Mars Digital Image Model frame corresponding to a given latitude or longitude or containing a specified named surface feature

FINDVGR - Search the CD-ROM index file(s) for a Voyager image to determine which CD-ROM & sub-directory it resides on. The index is in /mcidas/data/ sub-directory.

FINDVO - Locate a Viking Orbiter image of Mars on the PDS CD-ROM volumes (VO001 - VO0012).

FITSKEY - This command maps the keywords contained in a pseudo FITS label to the standard FITS keywords expected by the GETFITS command.

GEOM - Remove the geometric distortion in a Voyager image for which the reseau locations have been measured (RF command) and write a new area .

GETALT - Read Magellan Radar Altimeter CD-ROM (ARCDR's) Altimetry Data Files (ADF's) and plot the data (along the orbit track) on a displayed Magellan SAR image.

GETCPP - Import Pioneer Venus Orbiter Cloud Photopolarimeter (OCPP) images from NSSDC tape archive files into McIDAS areas.

GETFITS - Import an image stored in a FITS format file into a McIDAS area. Useful for importing earth-based telescopic images of solar system targets. This program attempts a first guess image navigation by determining (i) the image center from limb points using the **BRTCEN** command, (ii) computing the sub-earth and sub-solar points on the target from the observation time contained in the label if they are not contained in the label, and (iii) attaching the navigation to the data using the **PLANAV** command. Both the **BRTCEN** and the **PLANAV** commands are issued internally by the **GETFITS** program.

Since not all earthbased data files available conform to the FITS keyword and value standard, some known variations of the format encountered are recognized by the command. Minor deviations of the keywords contained in the label can be accounted for by the **FITSKEY** command.

GETGO - Import Galileo SSI images of the Earth, Moon and Venus from PDS CD-ROM volumes GO_002 - GO_006.

GETMDIM - Import a map tile from Mars Digital Image Model (MDIM) CD-ROMs published by USGS in PDS compatible format.

GETMGN - GETMGN can import mounted MIDR CD-ROM into an area - (i) all the browse frames contained on a as a composite browse view, (ii) a single browse frame and display the 7 x 8 framelet grid on the frame on which the browse frame is displayed, and, (iii) a Magellan Mosaic Image Data Record (MIDR) image from CD-ROM into a McIDAS area.

GETMGXDR - Import Magellan Global composites of topography, surface reflectivity, slope and emissivity from the PDS CD-ROM Volume MG_3001 and MG_3002.

GETSEDR - Attach to Voyager images the full SEDR data from Voyager SEDR files for PLAN navigation type.

GETVGR - Import compressed Voyager 1 or 2 images from CD-ROM and write a McIDAS area containing that image.

GETVO - Import Viking Orbiter 1 & 2 Mars images from CD-ROM into McIDAS areas.

GRADNT - Create an image that shows the local brightness gradient of an image

GUI - Start the Graphical User Interface (assumiong X-window workstations have Tcl-Tk installed)

HELP - List the help instructions for a McIDAS key-in

IDMOON - Identify a moon in an image of Jupiter and/or use its position to determine the north angle as well as the image pixel scale.

IMGCTR - Determine the center of a planetary image for which limb points have been written to a file (LIMBxxxx, where xxxx is the area #) using the LIMBPT command (or any other process if the file conforms to the format) by using a general conic fit. The image center, the two axes, the orientation of the ellipse and the eccentricity of the ellipse are returned. These values can be used in the PLANAV key-in to attach navigation to an image (e.g. ground based for which SPICE kernels may not be available) if applicable.

IMGDAY - Annotate a displayed frame with the day and time of acquisition (default location is upper right hand corner). This is useful for images which may be videotaped or published

IMGTS - compile or display a file containing a time series of data from digital areas

LA - List area directory entries. Compared to WHERE, LA provides less information in a compact format

LIMBPT - Locate the planet's bright limb interactively using directional derivatives from displayed image and store the points in a file. Primarily useful for planet center determination (CONFIT) for the purpose of image navigation. Determines the limb location using the maximum local brightness gradient method and write the locations in a file (LIMBxxxx, where xxxx is the four digit area number. Usually a first step in image navigation (see IMGCTR and PLANAV).

LIMPRO - Plot radial scans of data from a planetary images from the planet center to the planet limb.

LISTAUD - List audit trail for a McIDAS area.

LISTDDB - List the various Data Description Blocks (DDB) such as planetary SPICE navigation block, etc. for an area.

LISTHEAD - List the text (ASCII) header of a FITS format file in the McIDAS text window.

LISZEN - Compute solar and observer zenith angle for specified image coordinates for a single image or multiple images contained in a single area or sequential areas.

LOCATE - Plot as an overlay graphic on a navigated image display the co-ordinates of points from a text file.

LODSSP - Display a sequence of navigated planetary image such that the image center is at the frame center beginning at a specific frame. **Can also be used to sub-sect images into another area.**

LP - Line-plot of Image Data at Cursor Location or between any two points on a displayed image.

MAKIMG - Import an image from a TIFF format file into an area. (This is a McIDAS-X command).

MAKNAV - Attach navigation for a cartographic projection to an area. (This is an adaption of the core McIDAS-X version).

MAKOUT - Create a new (blank) output area and attach the directory and teh DDB from another area. This is useful for projection of images so that the supplementary information is tracked with the image. This can also be accomplished with the AA command, but avoids the overhead of actually moving the data.
NOTE: The line prefix bytes are delared as zero in the area directory.

MAKESU - Create an enhancement table for 2-byte images. The default conversion to brightness value is a linear function. MAKESU allows different curves for the data number to image brightness conversion for display purposes.

MAKOUT - Create an output area with the same directory entries as a given area. Useful in setting up remaps

MCLIMB - Simulate view from orbit of a planet from a nadir looking instrument and plot instrument IFOV's.

MDCLAS - Spectrally classify a multi-band image
- MDM CLASSIFICATION USING .SIG STATISTICS ---

MINFIT - Determine Minnaert scattering Coefficients (I_0 and ß) for a navigated planetary image ($I = I_0 \, \mu\mu^ß$) by both least squares and minimum absolute deviation methods.

MGNORB - Plot Magellan spacecraft's orbit track on a displayed MIDR image. The program attempts to determine the orbit number based on a nominal orbit model.

MOONSTAR - Pinpoint the location of a star image (brightness centroid), a small moon or its shadow in an image. Useful for optical navigation of the data.

NAIFNAV - Attach navigation based on the NAIF SPICELIB toolkit to an area.

NAMES - Plot the names of Venus features on a displayed image.

NAVCPP - Refine the navigation for a Pioneer Venus OCPP image by interactively determining the required adjustments for look angle and roll-angle offsets.

NAVUTIL - A utility to access the navigation parameters contained in the DDB for an area. Also activate or change the navigation type or cordinate system attached to the area when multiple coordinate frames are possible, e.g., native body fixed system to celestial (Right Ascension, Declination), or swtiching from RING to central body system for ringed planets (RING navigation type has yet to be implemented).

NRMIMG - Brightness normalize a planetary image, i.e. remove the brightness variation due to scattering geometry. Minnaert or a modified Minanert are the only functions used for the normalization, others can be introduced later. The image is produced as a deviation from a bias brightness rather than by multiplicative scaling.

NXTARA - Determine the first available free area or a block of areas between a specified range of valid area numbers. Total number of areas containing digital data in the specified range is also returned.

ORBVIEW - Determine the sky-view for specified surface loations to see if an orbiting spacecraft is visible from the surface.

PHYSCON - Program to obtain the Physical constants of an object. Either the NAIF ID (preferred) or its name (capitalized) can be entered. Radii and length-of-day are currently listed.

PLAEDG - Determine a limited number of limb points within the cursor positioned on the limb in a displayed planetary image for the purpose of navigation.

PLANAV - Create a general perspective view navigation codicil for a given area for any object.

PLAREV - Flip the longitude convention for the navigation created using PLANAV. *This is required for earth views because of the McIDAS longitude system convention which is opposite to the general planetary longitude convention.*

POLEN - Refine the C-matrix for a Voyager image by using a known star which can be located in the image. Will also optionally determine the pole position for Neptune.

POPVAL - List the digital data at the cursor location continuously in a separate window.

QA - Quit an area. Releases up the disk space occupied by the area. This is a core key-in, and does not delete any area associated files (e.g. LIMBnnnn).

REDISP - Re-display a displayed frame from the original given area at the cursor co-ordinates on the same or another frame using an integer blow-up or blow-down factor. Similar to BU on the McIDAS-MVS system.

REDONAV - Update the target/observer ephemeris and the image center information. Use this command if the time of image acquisition is changed. The ephemeris is computed using NAIF P-kernels. Use RENAVF if only the center is to be updated

RENAVF - Update navigation for a planetary image, usually an earth-based telescopic that has PLAN type navigation that requires updating the center

RESEAU - Lists and/or plots reseau data for Voyager spacecraft

RESREM - Remove the reseau marks in Voyager images by interpolation of brightness from their immediate neighborhood.

RF - Determine the locations of the reseaus in a Voyager image which may or may not be displayed

SCANA - Generate a snapshot view of images contained within McIDAS areas. Up to 484 areas can be scanned at a time in a grid as large as 22 x 22. Once this area is displayed, the particulars of the images can be listed using the SCANE command. SCANE also allows subsequent processing of the areas when the command is entered.

SCANE - Access the digital areas corresponding to the image representation of the digital areas as displayed on a particular frame. This is an interactive program which stays resident until the ALT-G key-stroke and can be used to query the contents of the individual images.

SCANG - Access information about individual thumbnail images contained in an area previously created by the CDBROWSE option in GETGO, in a manner similar to SCANE.

SCANM - Access information about individual thumbnail images contained in an area previously created by the CDBROWSE option in **GETMGN**, in a manner similar to **SCANE**.

SCANV - Access information about individual thumbnail images contained in an area previously created by the CDBROWSE option in GETVGR, in a manner similar to SCANE

SEDRIN - Reformat SEDR data into navigation block for raw image

SEDRRD - Load Voyager SEDR tape file records into LW file

SHADE9 - Remove the photometric distortion in a Voyager image if the appropriate dark noise frame and the shading file for the specific camera/filter combination is available in /mcidas/data sub-directory and write the output in a new area.

SPICENAV - Attach the NAIF provided SPICE kernels to a given GEOM'ed Voyager frame. The frame must be re-displayed to activate the navigation

STAR - Determine the center of a star signature in a displayed image.

STRIPX - Strip or fuse an area into or from the DDB and image data component files (DIRCxxxx and IMAGxxxx, where xxxx is the original 4-digit area number. Currently used for data compression experiments.

SUBPNT - Compute the observer and solar sub-point locations on a target object using the SPICE kernels for a given date.

TGET - Restore one or more McIDAS area files from tape to disk (i.e. in /mcidas/data sub-directory) from a DAT or an Exabyte cartridge written using **TPUT**.

TILES - Displays the framelets or tiles that make up a Magellan browse image created from C1-MIDR's as a grid pattern and numbers the tiles. Normally started by GETMGN during retrieval of browse and full resolution images. Will scale the displayed image to the frame size by integer sampling appropriately.

TLST - Lists areas on a tape written by TPUT. SCSI tape drives only (either DAT or EXABYTE). Use TGET to restore data from tape to disk in the /u1/mcidas/data sub-directory.

TPUT - Save one or more McIDAS area files from disk to tape (i.e. in /mcidas/data sub-directory).

TRACK - Track cloud features in a sequence of images and determine the mean velocity by regression and robust estimation.

TRIM - Trim the spline-sized rectangular edges at the limb of a remapped planetary image.

USCLAS - Spectrally classify a multi-banded image using unsupervised multispectral classification. Currently assumes 1-byte per spectral band data. 2-byte data can be used after using COMBIN to use the calibration to convert to 1-byte data.

WHERE - List image identifiers for a range of frames, areas or limb points files (LIMBxxxx format) contents in the text screen using data specific information.

XPORT - Export a McDAS-eXplorer area into a FITS format file by writing the DDB information in a FITS compatible header so that other programs may be able to access the image data (unlike a GIF format file created by SVGIF key-in)

GLOSSARY

Glossary

Animate

McIDAS display is a multiframe display. A time sequence can thus be displayed on the available frames as a loop. The loop bounds can be set with the **LB** command for sequential frames to be displayed or with the LS command for arbitrary frame numbers to be displayed in a sequence. The animation can be started or stopped with the "L" key entered either as $L_{[cr]}$ or **ALT-L**. The dwell rate can be controlled using the **DR** command.

Altimeter Radiometer Composite Data Record (ARCDR)

The Magellan Mission Altimeter data on Venus surface topography is archived for altimeter footprints under the Magellan orbit track on PDS CD-ROM Volumes MG_2001 through MG_2015.

Area

Digital images stored in files in McIDAS or McIDAS-eXplorer format are called *areas*. The digital image data are preceded by a binary header called the *area directory* that contains information about image data, image navigation, and calibration. The files are generically named AREAxxxx where xxxx is a 4-digit left-zero-padded integer number. On a given system only 9999 areas can be resident in the default data sub-directory (˜mcidas/data). Additional areas following the same naming convention can exist on other sub-directories, where they are accessible to McIDAS commands by setting the proper path with the REDIRECT command.

The same numbered areas in different sub-directories cannot be accessed simultaneously because the ROUTE command will accept only the first path for a given area. Thus, accessing both areas is possible by resetting the path with the ROUTE command for each area for each use.

The offsets for each of these quantities are flexible and are contained in the directory. McIDAS-eXplorer areas also contain a Data Description Block immediately following the 64-word directory that contains additional information about the target object contained in the image, the imaging geometry, as well as the details of the imaging instrument. The image data is followed by an ASCII label that includes any text labels originally present, information as to whether the image was imported from some standard format, from a PDS CD-ROM volume, or from a FITS file, as well as comments regarding the processing history. See Data Directory and Data Description Block for the explicit format of the area layout.

The following list includes some general commands that pertain to areas or how to obtain information about the images contained in the areas:

AA - Copy an area or part of it into another area

AA will create an exact copy of a given area by copying the calibration, navigation, and processing history. The destination area that is created can be smaller or larger than the original in terms of the image extents.

ASTAT - Measure area statistics

ASTAT measures the area (or, strictly speaking, the number of pixels) at specified brightness thresholds within an arbitrary outline or cursor or within the whole area.

CA - Change area
Some entries in the area directory can be changed manually through the command CA (Change Area). Only the satellite identification number (SS), day and time when the original image acquisition began (YYDDD, HHMMSS), the area start coordinates (upper-left-hand line and element coordinates), area sampling factors (LRES and IERES), and the MEMO fields can be changed.

DF - Display the contents of an area on a given frame

FILTER - Digitally filter an image contained in an area

LA - List area
LA lists the area directory. Several options permit varying amounts of detail to be listed for a given area or all valid areas within a range of numbers.

MA - Modify an area
MA digitally modifies the contents of an area. Options include one-dimensional (along the scan-direction) low-pass and high-pass filters, shot noise removal, and histogram equalization.

QA - Quit an area
QA deletes an area from the -mcidas/data directory, i.e. deletes the file AREAxxxx, where xxxx is the area number to be deleted. Upon quitting an area, the space occupied by the area is immediately available for use.

NOTE: The area cannot be un-deleted once it is quit!

XPORT - Copy the image contained in an area into a pseudo FTTS format file an attach an ASCII header describing the image.

WHERE - Lists frame/area/limb points file contents
Where lists target and mission specific details of the images in areas or displays them on a frame. WHERE also lists the image indentifiers if a limb points file exists for a given area.

BAND
Some instruments acquire image data in more than one spectral wavelength. Except for interferometers and specrtrometers, this number is usually small for instruments that use spectral filters; the GOES VISSR has 12 spectral channels. These spectral channels are sometimes referred to as *bands*. Since areas can contain multibanded images, some McIDAS commands that operate on a single channel require that the band number be specified.

Calibration
The digital data corresponding to an image is generally stored in McIDAS areas in *raw* counts as returned by the instrument (after the telemetry decoding has been done).

Calibration is the process that converts the raw data counts into physical units. This also includes the conversion of the counts into a single-byte integer number that is used to represent the brightness on the video display for a given image pixel. An example is the infrared data that is stored as a digital number which with appropriate calibration information (such as wavelength and conversion factors) can be converted to a brightness temperature or an image brightness. The name of the sub-program unit that performs this conversion is stored within the area directory for an image.

CD-ROM

Compact Disk-Read Only Memory - the media format that is compatible with the audio Compact Disks on which the digital data is stored. NASA's Planetary Data System (PDS) has published a large amount of digital data acquired from Data planetary missions on such disks. A current list of CD-ROM's containing planetary data is available from the National Space Science Data Center (NSSDC) located at the Goddard Space Flight Center (GSFC), Greenbelt, MD 20771.

Command

A command is an instruction to McIDAS-eXplorer to execute a process. The name of the command is the name of a FORTRAN subroutine or a C-procedure that is compiled and linked with the McIDAS main.o and all the associated libraries. In McIDAS-eXplorer the command name can be as long as allowed by the native operating system. A command can accept positional, as well as keyword, parameters. The names can be one character or as long as allowed by the native system but preferably short and mnemonically representative of the process.

McIDAS has several single letter commands (entered either as *letter* followed by a [cr], or by the ALT-*letter* key-strokes from the keyboard). Other commands can be entered in the command window using the key-board with associated parameters (positional or key-word oriented) followed by a [cr]. Alternately, the commands can be entered using the graphical user interface (GUI).

Single letter Commands

Single letter commands can be entered using the ALT-*letter* combination and generally control the terminal (display) state. The most often used are:

A - Step to the next frame in the frame display loop. The loop bounds are between the first and the last frame defined by default when the McIDAS session is started. The begining and ending frame number bounds can be changed using the LB command, or a random sequence of valid frame numbers can be set using the LS commmand. The loop bounds are circular, so if the 'A' key is entered while displaying the last frame, the next frame displayed is the first frame in the sequence. In McIDAS-X the graphics frame is part of the image frame, and the graphics will also switch. The graphics loop bounds can be set independently using the GRA option in LB and LS and can also be decoupled using the 'J' key-in. This allows the image and graphics to be looped independently or simultaneously.

B - Back up the display to the previous frame in the frame loop. Essentially, this is the reverse of the 'A' key.

C - List in the text window current contents of the frame in terms of satellite id, day and time of acquisition, source area number, display resolution (sub-sampled or repeated), and the upper-hand-corner load point coordinates (image).

D - Display the digital data brightness data number in calibrated (as appropriate) and raw units at the cursor location in a displayed image.

E - List the planetary coordinates (latitude and longitude) of the cursor in a displayed image if the navigation transform is defined. The latitude listed in McIDAS is always planetocentric and the default format is DD:MM:SS for both latitude and longitude. The format can be set to decimal degrees by entering the following command:

UCU POKE 17 1

F - Display the McIDAS display status. The number of frames and their specified sizes, cursor size, and current cursor location are listed in the text window.

G This keystroke is used by some resident programs (e.g. SCANA, SCANG, DSTNCE, PCMW, wtc.) to exit in lieu of a double mouse-click.

H - Toggle between host mode and local mode. Most McIDAS-eXplorer workstations will not have a host on which to log on. When the host mode is set, the Command Window status reflects it, and it can also be discerned with the "." in the first column of the Command Window. Unless the workstation is logged onto a host McIDAS CPU, all commands are executed locally. When the workstation is logged on to a host McIDAS CPU, the commands can be executed either locally or on the host CPU.

I - Currently obsolete. It used to display the image coordinates of the cursor, now folded into E-keyin.

J - Image frame/graphics frame toggle. It is not available in McIDAS-X unless the independent graphics are running.

K - Toggle the image display on or off. When it is 'off', the display is set to black (and cannot be set to any other color). Any graphics, if drawn and displayed, remain visible.

L - Start and stop animation of frames within the frame loop set by LB or LS commands. If viewing a single frame, 'L' starts animation, and the next 'L' stops it. The frame dwell rate can be changed in units of 1/15th of a second using the DR command from 1/15th of a second (DR 1) to as long as desired. Different dwells can be specified for each frame in the loop. If the workstation has insufficient memory for the number of frames activated, then the animation may seem sluggish and the frames may 'drag' for the faster animations. The only solution then is to reduce the required display memory or upgrade the workstation CPU, either by reducing the number of frames or by reducing their sizes.

O - Switch to opposite frame. The specified number of frames is split evenly into two groups --- a displayed frame and its "opposite". Thus frames 1 and 3 and frames 2 and 4 are linked as opposites if the McIDAS session has 4 active frames. This is a leftover from the days when an analog disk was used to

display the imagery. The disk had two surfaces which were recorded and read independently.

P - Toggle command to freeze/free the cursor position as controlled by the mouse (OS/2 version only) on the image.

MACRO Commands

A macro command is created by using a precompiler (fx *name* mac, assuming the source file called *name* is in the ˜mcidas/src sub-directory). As far as the user is concerned, there is no noticeable difference in the entering or the execution of the macro commands as compared to the regular McIDAS commands. The macro commands are used to chain several McIDAS commands into a specific sequence for a particular application, but if a component command terminates abnormally for some reason, then the entire macro command may abort. Examples of such commands are AAMAP and LODSSP. Explanation of how to use a given macro command can be obtained in the same way as a regular McIDAS command by typing:

HELP *command_name*

Key-ins

A complete list of core and eXplorer McIDAS key-ins can be found in the User's Manual.

Batch mode

Commands can be executed in the batch mode from a text file by typing:

RUN *"file_name*

The text file containing the commands must reside in the ˜mcidas/data sub-directory.

Coordinate Systems

McIDAS recognizes several coordinate systems for the data. Typically they are the instrument coordinates (which usually are the same as image coordinates or there is a one-to-one relationship between them), area coordinates (which locate the data in a McIDAS area), Earth or planetary coordinates (which locate data in the target object's native coordinate system of latitudes and longitudes), the display frame or TV coordinates (which tell about where the data are displayed in the frame), and finally, window coordinates (which locate a frame within the X-window).

McIDAS generally does not do anything with the window coordinates, and the display MUST be left with the default settings. If not, the mapping of the frame coordinates to planetary or area coordinates will not be correct.

Area - Line and element units. These are the same as the image coordinates if the data are not sub-sampled or oversampled (replicated in line or element direction).

Celestial Coordinates - Used for stellar and planetary positions in the sky as Right Ascesion (given in hours, minutes and seconds) and Declination (given in degrees). NAVUTIL command can be used to change between palnetary and celestial coordinate systems.

Earth - Latitude and longitude. Only in the case of the Earth is the latitude system **geographic** rather than **geocentric.**

FRAME or TV - Display line and element coordinates.

Image - Original image line and element coordinates that have a unique relationship to the acquiring instrument's natural coordinate system.

Planetary Coordinates - Latitude and longitude. Unless the target object is Earth, the latitude is **planetocentric.** For spherical objects the planetographic and planetocentric systems are one and the same. NAVUTIL command can be used to change between palnetary and celestial coordinate systems.

Satellite (instrument) coordinates
see image coordinates above.

Window coordinates
Under the X-windows system, the display buffer can be located anywhere in the window.

Cursor
In X-windows, the cursor is software generated and can be positioned within the display using mouse movements. McIDAS uses this cursor for the purpose of locating image coordinates upon demand. The cursor type can be set to cross-hair, open box, filled box, and open box with cross hair. X11Release 5 restricts the maximum cursor size to 63 lines by 63 elements. The cursor type, size, and color can be selected using the **CUR** command.

D
"D" is a single letter command that lists the digital value of the image data at the cursor location in raw and calibrated units. The OD command lists the data within the cursor in specified units.

Data
Data within McIDAS implies digital information accessible to the McIDAS system that can be displayed as an image or displayed as a profile or listed as an observation. Thus the data can be station data, a profile or a two or multidimensional image.

Data Directory
For each area, a 64-word directory is used to identify the contents of the area. The directory entries are as follows:

Data Description Block (DDB)
The Data description block is a collection of numeric data in INTEGER*4, REAL*4 or REAL*8 numeric format that describes the attributes of a digital image stored in a McIDAS-eXplorer file called an "area". These are frequently called metadata about the particular image. The DDB as used within McIDAS-eXplorer can have different types depending on the source and nature of the image data. Typically each instrument has a characteristic set of parameters required for calibration, navigation and analysis of the image, and a specific type is defined for the corresponding data. As many types of DDB can

be defined within McIDAS-eXplorer as required and affected McIDAS-commands modified as necessary. **LISTDDB, WHERE** are two specific commands which list information contained within the DDB and will need to be modified to reflect a new addition of a DDB type.

Specific formats of the different DDB's currently defined within McIDAS-eXplorer are found in the document PLANAREA.

Data Number

Data number generally refers to the raw value corresponding to a point in an image that is converted into a visual brightness. For one byte image data the DN and the brightness value are generally the same. For 2-byte image data the raw image data can have a value between -32766 and +32766, while the brightness value can only be between 0 and 255, a one byte number due to the video display restrictions. A "calibration block" tells McIDAS how to convert the two-byte data into a 1-byte brightness value so that any specific part of the entire dynamic range of the data can be displayed as an image. Normally, the conversion is linear so that the entire 2-byte range is scaled into a 1-byet brightness value. However, other scalings are possible through the SU command so that the raw data conversion into the image brightness can be arbitrarily set.

Directory

Directory for areas or grids refer to the descriptive elements of the respective data types. See Area Directory or Grid Directory.

Area Directory

McIDAS uses 64 4-byte integer words to describe the contents of an area. The words are defined as follows:

Frame Directory

Whenever an area is loaded or displayed onto a McIDAS frame, the area directory is copied into the directory for that frame. Word 17 in the frame directory contains the area number that was displayed in that frame.

Sub-directories (OS)

McIDAS and McIDAS-eXplorer use several sub-directories in the native workstation's default drive/directory. The binaries (.mx files in UNIX) are stored in the ~mcidas/bin subdirectory

Directory - *Virtual Graphics*

All vector graphic output can be saved in "virtual graphics", a specific file format. Many graphic images can be stored in a virtual graphic file. A directory lists the contents of the stored vector graphics.

Enhancement

Most video systems are capable of displaying a maximum of 256 monochrome or color brightness levels. Frequently the data has more or less dynamic range than that