AN OVERVIEW OF THE INTEGRATED SOFTWARE FOR IMAGING SPECTROMETERS (ISIS). Lisa Gaddis, J. Anderson, K. Becker, T. Becker, D. Cook, K. Edwards, E. Eliason, T. Hare, H. Kieffer, E. M. Lee, J. Mathews, L. Soderblom, T. Sucharski, J. Torson, *U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ, 86001, USA, lgaddis@flagmail.wr.usgs.gov*, A. McEwen, *Lunar and Planetary Laboratory, University of Arizona, Tuscon, AZ, USA*, and Mark Robinson, *Northwestern University, Department of Geological Sciences, Evanston, IL, USA.*

INTRODUCTION: The Integrated Software for Imaging Spectrometers (ISIS), developed by the Astrogeology Program (AP) of the USGS, is available for use by the planetary science community. ISIS is a UNIX-based system that combines basic capabilities of image processing, scientific analysis, and display of 2- and 3-dimensional data (both multispectral and hyperspectral) with the specialized planetary cartographic functionality required for processing complex planetary datasets [1]. ISIS is a public-domain software package available via the World Wide Web at: http://wwwflag.wr.usgs.gov/ISIS. Extensive documentation on ISIS architecture [2], application programs (including cookbook-style instructions for processing Clementine, Viking, and Voyager data), and software acquisition is also provided at this Web site.

Many planetary scientists require access to digital planetary image data. As part of the Planetary Data System (PDS), the vast majority of the data are distributed via CDROM in raw form; no processing is performed other than organizing the original digital data into raster image files. In addition to expected enhancements in data quality and availability as a result of future space missions, frequent improvements in techniques for image processing, precision of information on spacecraft position and pointing, and quality of calibration data are anticipated. ISIS is designed to assist planetary scientists in maintaining the highest level of processing quality for their data by making continually improving image processing capabilities available to researchers.

BACKGROUND: PICS (Planetary Image Cartography System), VMS-based software tailored for planetary digital cartographic production, was the workhorse of the USGS Planetary Cartography effort for much of the last 20 years. Examples of major cartographic projects completed at the USGS using PICS are the Viking-based Mars Digital Image Maps (MDIMs), Venus Magellan Radar Maps (or F-Maps), Voyager-based controlled digital mosaics for satellites of Jupiter, Saturn, Uranus, and Neptune, irregular satellite image bases including Phobos, Deimos, Gaspra, and Ida, as well as special products such as globes and wall charts.

ISIS was originally developed for the VAX/VMS operating environment, with interactive display capabilities requiring the use of an International Imaging Systems IVAS image display device. ISIS extended our capability in data processing and analysis beyond the standard two (x,y) dimensions of PICS to the third (z) spectral dimension. Also, ISIS combined standard image processing and spectral analysis methods with new techniques developed specifically for the analysis of 3-D image cubes. ISIS was specifically designed to facilitate visualization and analysis of hyperspectral data from instruments such as the Galileo Near-Infrared Mapping Spectrometer (NIMS; 408 bands) and the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS; 224 bands). Like the PICS software, the VAX/VMS version of ISIS is still available to users.

During the last 5 years, there has been a major effort within the AP to combine PICS and ISIS functionality and to increase the efficiency and portability of the unified system by making it available on a variety of lower cost, UNIX-based computer platforms. The new software system retains the ISIS name but offers enhanced capabilities for interactive cartographic and scientific processing of monochromatic, multispectral, and hyperspectral image data or cubes (individual 2-D images are viewed as single-band image cubes). ISIS provides a powerful, user-friendly tool for processing, analyzing, and displaying digital remote sensing data. The data may be of virtually any size, and data types from a variety of Earth and space science missions are supported. Mission-specific software and documentation for producing cartographic products, or Digital Image Models (DIMS) [1], from data for Clementine, Galileo NIMS, Galileo SSI, Mariner, Viking, and Voyager is provided. The unique data storage capabilities of ISIS [2], in which additional data (image or non-image) may be stored as cube backplanes, sideplanes, and bottomplanes, also permit straightforward storage, display, and processing of ancillary information.

APPLICATIONS PROGRAMS: ISIS currently contains more than 130 application programs, many of which were adapted and improved from PICS and the older ISIS. ISIS applications include software for data ingestion and translation, establishing geometric control and sub-pixel-level image coregistration, defining instrument behavior, image geometry, map projection and mosaicking, performing mathematical and statistical operations, spatial and spectral filtering, radiometric calibration and photometric correction, spectral processing and image classification, as well as a variety of utility programs and mission-specific software. Development of additional user-specific application software is facilitated by the availability of programs in the Interactive Data Language (IDL; from Research Systems, Inc.) to read and write ISIS files; these may be easily incorporated into IDL programs that manipulate image data.

IMAGE DISPLAY: Several X Window System-based interactive display programs [2] are included in ISIS. The most basic and portable program ("qview") allows display of 3-band color composites, detailed examination of core and backplane pixel values, coordinate reporting, linear stretch-

ing, and viewing of histograms and other statistical information. Most other ISIS display programs are written in IDL. These programs provide: the capability to interactively define control points and match points for establishing geometric control and producing an image mosaic ("tvtie"); sophisticated visualization of image cubes and backplanes ("cv" includes views of spatial-spatial and spatial-spectral slices and profiles, movies, and spatial coordinates); analyses of spectra (including plotting spectral profiles, and extraction of single and multiple spectra from arbitrary spatial regions); and text or hardcopy output of spectra and images.

CURRENT PRIORITIES: The USGS Astrogeology Program is a major contributor of software for digital data processing in support of a variety of NASA programs, including the Planetary Cartography and Geologic Mapping (PCGM) Program, Code S flight programs, research and data analysis projects, and the Planetary Data System. In planning and implementing software development for ISIS, emphasis is placed on supporting data processing and analysis tasks for current and future NASA missions. Many ISIS programming efforts are in direct support of the PCGM Program and they focus on software development for cartographic data processing by the USGS. Additional ISIS software development priorities include (1) ingestion and analysis of data from current and near-future NASA missions; (2) incorporation and refinement of programs and procedures from our older VAX/VMS-based PICS (Planetary Image Cartography System) software on an as-needed basis; and (3) data transfer and processing software to facilitate photogrammetric data processing with our Digital Photogrammetric Workstation. Current plans include ISIS programming efforts in support of several ongoing and near-future NASA space missions, including Galileo, Mars Pathfinder, Mars Global Surveyor, and Cassini. As a result of our involvement as cartographers and scientists in these and other current and future NASA missions, the PCGM program and members of the Planetary Geology community enjoy the benefits of an integrated software system for sophisticated processing, display, and analysis of planetary remote sensing data.

REFERENCES: [1] Eliason, E., Production of Digital Image Maps with ISIS, this volume; [2] Torson, J. and K. Becker, ISIS - A Software Architecture for Processing Planetary Images, this volume.