ISIS SUPPORT FOR NASA MISSION INSTRUMENT GROUND DATA PROCESSING SYSTEMS. K. J. Becker[1], J. A. Anderson[1], L. A. Weller[1], and T. L. Becker[1], [1]U. S. Geological Survey, Flagstaff, AZ 86001, (kbecker@usgs.gov).

Introduction: The ground data system (GDS) requirements for a NASA mission are very extensive. Success depends heavily on the ability of science and instrument teams to process and disseminate an ever-increasing volume of image data. The complexity and costs to develop these systems continue to increase. As a result, many recent NASA mission instrument teams have chosen the Integrated Software for Imagers and Spectrometers (ISIS) [1] to provide support for the needs of their GDS and research scientists. Derived data from these systems are ultimately submitted to and released by the Planetary Data System (PDS) Imaging Node [2] to the general scientific community.

Background: Since 1971, the U. S. Geological Survey (USGS) Astrogeology Science Center (ASC) has developed cartographic and scientific software systems used to process NASA mission planetary image data [3]. The software has evolved numerous times to maintain pace with steady advances in computing technology [4]. The current version, ISIS3 [5], is integrated into several active NASA space mission instrument GDS. As a consequence, instrument team scientists use ISIS to process, analyze and conduct research with the acquired data in near real time.

Discussion: ISIS has established a significant, sustained role in NASA spaceflight missions, providing mainly cartographic support for more than thirty remote sensing instruments. Many spacecraft instrument teams and scientists are relying on ISIS to support mission operations and scientific study of our solar system. The USGS/ASC provides ISIS for many Linux and MacOSX hardware and operating system platforms.

The ASC provides guidance and expertise in the integration of ISIS into NASA mission GDS. Recent NASA mission instrument teams using ISIS in their GDS are Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) [6], Lunar Reconnaissance Orbiter (LRO) Camera (LROC) [7] and Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER) Mercury Dual Imaging System (MDIS) [8] wide angle (WAC) and narrow angle (NAC) instruments.

These configurations provide support for the derivation of high quality cartographic products for NASA mission scientists. Our ISIS and cartographic experts from ASC provide hands-on ISIS workshops [9], training scientists and users in applying ISIS in their research.

HiRISE GDS: The HiRISE instrument team worked closely with the USGS ISIS team to develop applications that allowed them to process data acquired by the fourteen charged couple devices (CCD) that comprise the sophisticated HiRISE instrument. Figure 1 (from the HiRISE Software Interface Specification (SIS) [10]) shows the design of the HiRISE GDS. Most of the HiRISE pipeline segments run one or more ISIS applications that provide HiRISE data products or information requirements for the instrument team.

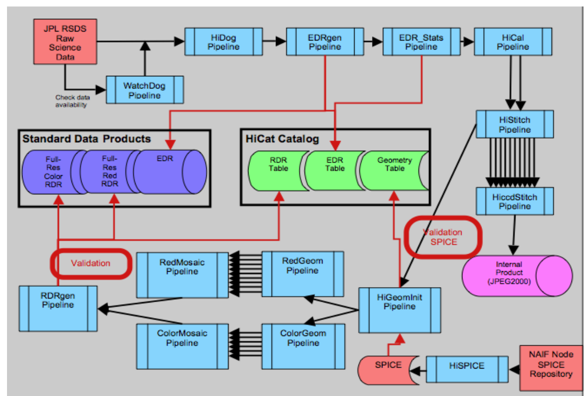

Figure 1. This schematic diagram shows the design of the HiRISE GDS used to process raw PDS EDR images into calibrated, map-projected data products.

Processing in the HiRISE pipeline begins with a PDS EDR product (an individual CCD image). A special ISIS application called *hi2isis* converts the PDS EDR image to an ISIS formatted image. Subsequent pipeline segments calibrate (*HiCal* Pipeline), apply SPICE kernels (*HiGeomInit* Pipeline), project (*RedGeom* and/or *ColorGeom* Pipelines) and then generate a combined monochrome uncontrolled mosaic. From those products, PDS reduced data record (RDR) products are generated for the public archive.

LROC GDS: The USGS and LROC teams worked jointly on creating applications specific to processing images from the LROC Wide Angle (WAC) and Narrow Angle (NAC) instruments. We provided an ISIS development environment for the LROC team allowing them to develop their own specialized applications. The LROC team developed the NAC ISIS camera model and USGS developed the WAC camera model. The USGS established a procedure for adding LROC applications into ISIS for general distribution in the ISIS public release. Figure 2 shows the LROC GDS data flow diagram. ISIS is part of the Calibrated Data Record (CDR) product generation (cdr_p10 in Figure

2). PDS [2] compliant CDRs are produced from this pipeline and archived with the PDS imaging node for public access. ISIS also contributes heavily to the generation of high quality cartographic maps and other special products by the LROC science team.

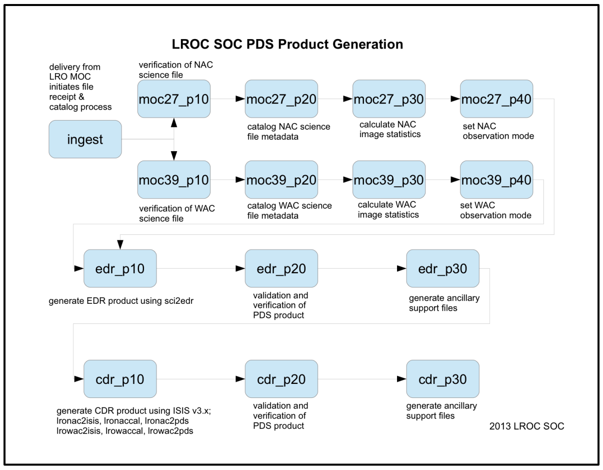

Figure 2. This diagram shows the GDS for processing of LROC data.

MESSENGER GDS: The MESSENGER Science Operations Center (SOC) contains the GDS for processing data returned by instruments on the spacecraft. The ISIS system provides support for the processing and reduction of MDIS WAC and NAC instrument data. Specialized applications, including a combined camera model for both instruments, were developed by the USGS for the MESSENGER MDIS team. These ISIS applications provide import and export of PDS products, radiometric calibration, cartographic mapping and photometric correction of MDIS images.

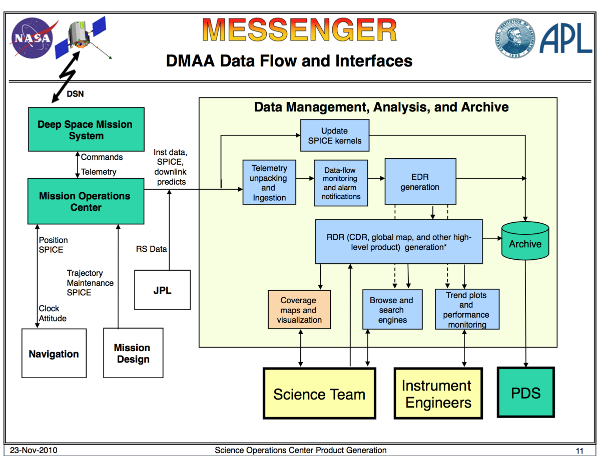

Figure 3. The MESSENGER SOC GDS flowchart for all instrument data.

Figure 3 shows the generalized flow of data through the SOC GDS. Much of the ISIS processing takes place in the RDR and PDS processing phases as well as interactions with science and instrument engineer teams.

A specialized processing sequence in the SOC GDS provides a number of geometric values (e.g., latitude, longitude, phase, emission and incidence angles) for every MDIS pixel. This data provides all the geometric properties for every pixel acquired by the WAC and NAC instruments. The MDIS team uses these data to provide specialized cartographic products in their REACT system (see http://messenger-act.actgate.com/msgr_public_released/react_quickmap.html) for research and analysis.

Results: Through the collaboration of NASA mission instrument teams and the USGS, ISIS provides comprehensive data processing capabilities. Many terabytes of data have been processed through ISIS and are now available through the PDS. ISIS' feature rich application programming interface (API) and over 300 generalized and specialized applications provide the tools that meet NASA mission requirements as well as research and analysis tools for scientists. For example, Dawn scientists have used ISIS in data production for specialized studies on dark material found on 4 Vesta [11]. ISIS also provides the basis of image data and cartographic content for the online Dawn Data Browser (http://dawn.psi.edu/data/PDS-Vesta/index.html) of 4 Vesta data from the Dawn mission.

Conclusions: The use of ISIS in NASA mission GDS processing is a mutually beneficial relationship for NASA and the USGS. Working with the mission instrument teams has resulted in major improvements to ISIS. The USGS has come to better understand the needs of NASA mission data processing requirements as a result of these working relationships. The entire scientific community benefits from this collaboration. As ISIS matures and diversifies, it provides a proven and reliable system for NASA mission instrument teams data processing and research requirements.

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