HiRISE Data Processing and Standard Data Products. E. M. Eliason[1], B. Castalia[1], Y. Espinoza[1], A. Fennema[1], R. Heyd[1], R. Leis[1], G. McArthur[1], A. McEwen[1], M. Milazzo[1], T. Motazedian[1], C. Schaller[1], I. Spitale[1]. [1]University of Arizona, Department of Planetary Sciences, Tucson, AZ, 85721 (email: eeliason@lpl.arizona.edu).

Introduction: The Mars Reconnaissance Orbiter (MRO) mission completed important milestones in 2006 including Mars Orbit Insertion in March, a 6-month Areobraking Phase from March through September achieving a 250 x 315 km orbit, a Transition Orbit Phase in October moving to a 3:00PM equator-crossing orbit, and the start of its 2-year Primary Science Phase (PSP) at the beginning of November when the science payload instruments were turned on for continuous operations. For the Transition Orbit Phase and the first 65 days of PSP operations, the High Resolution Imaging Science Experiment (HiRISE) has been actively observing Mars and has acquired 750 observations. Over the next two years we expect to acquire about 10,000 images covering about 1% of the Martian surface. The nominal raw science data return for HiRISE is expected to be more than 12 Tb in the PSP.

HiRISE science results during the first months of operations are discussed in several LPSC abstracts [1-17]. In this abstract, we present the data processing activities at the HiRISE Operations Center (HiROC) located at the Lunar and Planetary Laboratory, the University of Arizona. HiROC is responsible for commanding HiRISE, processing returned data to produce scientifically-useful products, and delivering an archive of its data products to the Planetary Data System (PDS) and the science community.

Instrument Overview: HiRISE [18] is a "push-broom" imaging system featuring a 0.5 m aperture telescope with a 12 m focal length and 14 CCD detectors capable of generating images of up to 20,048 crosstrack pixels (exclusive of overlap pixels) and 63,000 unbinned downtrack lines for 14-bit pixel imaging or 126,000 scan lines for 8-bit data. HiRISE samples the Martian surface at scales as small as 25-32 cm/pixel depending on spacecraft altitude and off nadir roll angle. Observations can be acquired in three spectral wavelengths: blue-green (~536 nm), red (~692), and near-infrared (~874 nm). Ten detectors are employed for red-filter imaging and two detectors each for the blue-green and near-infrared filters. At 300km orbital altitude the crosstrack aerial coverage is ~6.0 km for red-filter imaging and ~1.2 km for three-color imaging. Downtrack coverage depends on the number of scan lines commanded, varying from a few kilometers to a maximum of ~39.0 km (126,000 lines) for unbinned images. A key instrument design feature employs detectors with up to 128 lines of Time Delay and Integration (TDI) to create high signal-to-noise ratio (up to 300:1).

Several data compression methods can be employed to optimize data return. Pixel binning (permitted values: 1,2,3,4,8,16) is used to reduce data volume but increases the pixel scale (m/pixel). A second data compression method employs a lookup table (LUT) to convert the 14-bit data dynamic range (16-bit/pixel storage) to 8-bit pixels thereby reducing the data volume by half. A third data compression method employs FELICS [19] lossless data compression providing compression ratios of about 2:1 for most HiRISE observations. To maximize aerial coverage for the available downlink most HiRISE images are acquired using 8-bit LUT imaging and FELICS compression.

The 14 CCD detector arrays can be independently commanded offering flexibility on how an observation is acquired. Any combination of CCDs can be commanded to acquire imaging. Often, center red-filter CCDs are commanded for bin 1 while the blue-green, near-infrared and peripheral red-filter CCDs are commanded for higher binning.

Downlink Ground Processing: Science data from the MRO payload experiments are packetized on the spacecraft, transmitted to Earth through the Deep Space Network, then sent to the Jet Propulsion Laboratory (JPL) through ground communications. The JPL Multi-Mission Operations Facility then converts the packetized data back to the original science data format as produced by the instrument. The data are then stored at JPL's Raw Science Data Server (RSDS) for access by the science teams.

At HiROC we have developed a ground data system that provides automated methods for retrieving and processing our images. Science data are automatically retrieved from the RSDS then passed to a series of pipeline procedures for generating standard data products and entering product information in the HiRISE catalog system. Products are validated by the HiRISE operations team to verify the observations were properly acquired and the science objectives were achieved. Missed targets or observations with poor viewing conditions are flagged in the catalog to be reacquired at a later time.

The HiRISE team uses the Integrated Software for Imagers and Spectrometers (ISIS) system [20] in the pipeline processing. ISIS contains a wide range of tools including radiometric calibration and cartographic processing procedures.

Standard Data Products: The HiRISE team is responsible for maintaining an updated dataset of the best version of its science data until meaningful changes in data calibration no longer occur and to release data in an appropriate manner for public access including their final deposition to NASA's Planetary Data System. In carrying out these responsibilities, the HiRISE team creates two standard data products. Experiment Data Record (EDR) products are raw images in original instrument viewing geometry. Reduced Data Record (RDR) products are radiometrically-corrected images resampled to a standard map projection. The data collection is formatted and organized according to the standards of the PDS [21].

EDR Products: EDRs [23] are the permanent record of the raw images obtained by HiRISE. The products contain the properties of unprocessed and unrectified imaging maintaining the original spacecraft viewing orientation and optical distortion properties. As part of the EDR generation process, FELICS-compressed images are decompressed and organized as raster images. EDRs are organized at the channel level with two EDRs needed for each operating CCD. As many as 28 EDR products are needed to capture a single HiRISE observation. Maintaining an archive of EDR products enables reprocessing of the raw science observations as calibration and geometry processing routines improve. Investigators interested in applying advanced calibration methods or needing to understand the properties of the raw imaging may find the EDRs a useful product. However, most researchers will use RDR products. At the end of PSP the EDR product archive is expected to be approximately 3,700 GB.

RDR Products: RDR [22] processing includes radiometric correction, geometric transformation to remove optical spatial distortion, resampling to a standard map projection, and creating JPEG2000-formatted images (HiRISE products use lossless JPEG2000 image compression). In the geometric processing step, individual channel images are stitched together to form CCD images. CCD images are individually map projected then mosaicked together forming an image of the entire observation. The resulting images can be very large, at times exceeding 30,000 x 70,000 pixels. Observations with mixed binning modes are resampled to a constant resolution depending on the minimum binning used in the observation. Observations with unbinned imaging are uniformly mapped to a constant 0.25 m/pixel resolution (0.50 m/pixel for minimum binning 2 and 1.0 for binning 4). For three-color imaging additional processing steps are required. Spacecraft jitter can result in color misregistration. To minimize this problem, the blue-green and near infrared imaging is spatially correlated with and empirically registered to the red imaging. The three colors are then identically resampled to form the map-projected product. Images are projected to the Equirectangular projection for observations between -65 and 65 degrees latitude. The Polar Stereographic projection is employed for observations at latitudes above 65 degrees. HiRISE and CRISM data products use the same map projection scheme and cartographic assumptions. One team product can be registered to the other by rescaling the products to the same resolution. At the end of PSP the expected RDR product archive is expected to be approximately 18,000 GB.

Data Release and Access: The first data product release to the PDS occurs by June 2007 following a 6-month data validation and assessment period. However, interim HiRISE products are available to the science community through the team's web distribution services (http://hirise.lpl.arizona.edu). Full resolution RDR products can be accessed through a JPEG2000 Internet Protocol (JPIP) Server. JPIP is a client/server communication protocol enabling the server to transmit only those portions of a JPEG2000 image that are applicable to the client's needs. This capability results in a significant improvement in bandwidth efficiency while reducing the storage and processing requirements of the client. Users can efficiently pan and zoom through the image then save those portions of an observation that are of interest.

References: [1] McEwen et al., this conference; [2] Kirk et al., this conference. [3] Gulick et al., this conference; [4] Keszthelyi et al., this conference; [5] Jaeger et al., this conference; [6] Byrne et al., this conference; [7] Grant et al., this conference; [8] Weitz et al., this conference; [9] Okubo et al., this conference; [10] Alonso-Martinez et al., this conference; [11] Chuang et al., this conference; [12] Hansen et al., this conference; [13] Bridges et al., this conference; [14] Kolb et al., this conference; [15] Dundas et al., this conference; [16] Banks et al., this conference; [17] Tornabene et al., this conference. [18] McEwen A.S. et al. (2007) *JGR, in press*. [19] Howard P., et al. (1993) *IEEE Comp. Society, Data Compression Conf.* [20] Becker K. et al. (2007) this conference. [21] Planetary Data System Data Standards Reference, Version 3.6, JPL D-7669, Part 2 (2003). [22] SIS for HiRISE EDR Products, JPL D-32004 (2006). [23] SIS for HiRISE RDR Products, Draft JPL D-32006 (2007).