ISIS Support for Dawn Instruments. Kris J. Becker[1], Jeffery A. Anderson[1], Janet M. Barrett[1], Stuart C. Sides[1] and Timothy N. Titus[1], [1]Astrogeology Science Center, United States Geological Survey, Flagstaff, AZ 86001 (kbecker@usgs.gov)

Introduction: The Dawn mission [1] spacecraft is now in orbit around 4 Vesta and returning spectacular scientific data from its instrument payload. On board the Dawn spacecraft is a framing camera (FC) [2] and a hyperspectral spectrometer with imaging capability (VIR) [3]. Scientists in the USA and Europe are using the Integrated Software for Imagers and Spectrometers (ISIS) [4] developed by the U. S. Geological Survey (USGS) Astrogeology Science Center to process and analyze these data.

ISIS Overview: The ISIS system is designed to support various NASA spacecraft missions such as Voyager, Viking, Galileo, Mars Global Surveyor, HiRISE, MESSENGER and many others. ISIS provides three major functions: (1) ingestion and conversion of raw instrument data into ISIS format, (2) radiometric calibration from raw to I/F (generally), and (3) a camera/sensor model to geometrically render raw data into commonly used map projection products. One of ISIS's major strengths is it provides a flexible, object oriented, application programming interface (API) implemented in C++ that supports manipulation of a variety of simple and complex image devices [5]. As such, ISIS provides the necessary framework to provide support for the Dawn FC and VIR instruments.

FC Instrument Overview: The FC is a multispectral high resolution framing camera. It can take images in a broadband visible filter and 7 narrow band filters ranging from 450 to 980 nm with an IFOV of 96 millirad x 96 millirad. The camera is composed of a Camera Head and an Electronic Box. The head contains a 1024 x 1024 front lit CCD with its proximity electronics and its radiator, the filter wheel, the lens barrel, a baffle and the protective front door. A complete description of the FC and its performance are in [2].

VIR Instrument Overview: VIR is a linescan imaging spectrometer having moderate spectral resolution that combines two data channels in one instrument. The two data channels, Visible (spectral range 0.25-1 micron) (VIS) and Infrared (spectral range 0.95-5 micron) (IR), are committed to spectral mapping and are housed in the same optical subsystem.

VIR has 10 operative modes depending on the spatial and spectral resolution. The maximum total resolution includes 432x256 pixels (high spectral and high spatial resolution), while the minimum total resolution includes 144x64 pixels (low spectral and low spatial resolution). For each acquisition, one of the possible operative modes is selected and should be the same for the IR and VIS channel.

Each focal plane is divided in 432 bands (spectral dimensions) and 256 samples (slit dimension). A Full Frame (FF) is composed by (432x256) pixels. A Sub-Frame (SF) is composed by (144x64) pixels while a Reduced Frame (RF) is composed by (432x64) pixels. A complete description of the VIR instrument and its performance can be found in [3].

Image Data Ingestion: To begin using ISIS, users typically ingest raw instrument data using a specially designed ingestion application that is tailored to each mission instrument dataset. The majority of NASA mission data are available in Planetary Data Systems (PDS) [6] format but other formats can be supported.. The FC and the VIR data are delivered in this format.

FC Ingestion: The ISIS application, *dawnfc2isis*, is provided to read FC PDS experiment data records (EDR) and reduced data records (RDR). RDRs for FC are radiometrically calibrated data. The FC instrument team provides both EDRs and RDRs so there is no radiometric calibration application in ISIS for the FC filters. Each of the eight FC filters is contained within their own PDS file and they end with a .IMG file extension.

VIR Ingestion: The ISIS application, *dawnvir2isis*, is provided to ingest VIR VIS and IR instrument data. This dataset is understandably different than the FC.

The VIR instrument team provides both EDR and RDR data for the VIS and IR detectors, as does the FC. There is an additional ancillary data file, stored in a PDS table format, which accompanies each VIR EDR data cube. This table file and the EDR are required inputs of the *dawnvir2isis* application. The VIR RDR image data also requires this table file as input into the ingestion application. As with the FC, there is no VIR ISIS calibration application. Currently, the required VIR table data files are only provided with the EDR dataset. The VIR image data ends with a .IMG file extension and the table files end with a .TBL extension.

In addition to raw or calibrated .IMG and ancillary .TBL files, each one has a label description file ending with a .LBL extension. This file is a valid PDS formatted file that describes the contents of each file. These files are also required by *dawnvir2isis* for the conversion to ISIS format.

Therefore, each VIR VIS and IR image data cube requires four input files. If all four files exist in the same directory, then only the EDR or RDR .LBL file name is required in the *FROM* parameter of *dawnvir2isis*.

Image Calibration: As indicated above, there is no need for an ISIS calibration application for either the FC or VIR as the respective instrument teams provide calibrated data in PDS (RDR) format. RDRs are the recommended dataset for ISIS processing of Dawn FC and/or VIR image data.

Camera Models: ISIS provides camera models for both the FC and VIR (VIS and IR) datasets. Development of these models is provided in ISIS as a plugin. The ISIS camera model plugin architecture provides a flexible development and distribution mechanism. This method allows for complete development of the camera model with very little ISIS dependencies, typically relying only on the ISIS Camera C++ class. The ISIS build system creates a plugin, a specialized dynamically shared library of the complete instrument camera model. These plugins can be easily modified and shared with ease outside the normal ISIS distribution. This allows for rapid and efficient development and support for highly sophisticated imaging devices such as the VIR.

Processing with ISIS: Most NASA sponsored missions provide spacecraft ephemeris (location and attitude) data via the Navigation Ancillary and Information Facility (NAIF) spacecraft, planet, instrument, camera-matrix, and event (SPICE) [7] kernels. Dawn utilizes SPICE kernels to provide geometric rectification of both FC and VIR data.

After FC and/or VIR data is ingested, users must run the *spiceinit* application to associate the proper SPICE kernels with each image. Processing of the SPICE kernels for a given image observation provides, at a minimum, latitude and longitude coordinates of the observed body. Using a series of other ISIS applications such as *cam2map*, *photomet, map2map* and *automos*, users can create geologic maps of different projections and pixel resolutions.

Figure 1 shows FC and VIR images with common geometric coverage projected to the same mapping parameters. Combining many images under these conditions creates a mosaic that can be used, for example, to study the same geologic areas under different observing conditions.

All the necessary SPICE kernels for FC and VIR support are shipped with the ISIS system. Users need only install the latest version of the ISIS system and base and Dawn mission ancillary data to begin processing Dawn data.

Acquiring ISIS: The ISIS system is freely available for download and installation supporting a variety of Linux and Mac operating systems. See http://isis.astrogeology.usgs.gov/ for instructions on how to acquire ISIS. Documentation for *dawnfc2isis* (http://isis.astrogeology.usgs.gov/Application/presentation/Tabbed/dawnfc2isis/dawnfc2isis.html) and *dawnvir2isis* *(http://isis.astrogeology.usgs.gov/Application/presentation/Tabbed/dawnvir2isis/dawnvir2isis.html)* as well as all ISIS applications are provided from our web site and within the ISIS distribution after installation.

There is also an active ISIS Support Board located at http://isis.astrogeology.usgs.gov/IsisSupport/ where users can search or post problems and solutions.

Summary: The ISIS system fully supports the Dawn FC and VIR instruments. Users can ingest PDS image data containing these data and generate high quality geologic maps. When the Dawn mission publically releases PDS data for these instruments, ISIS can used to ingest, manipulate and analyze this new and exciting data.

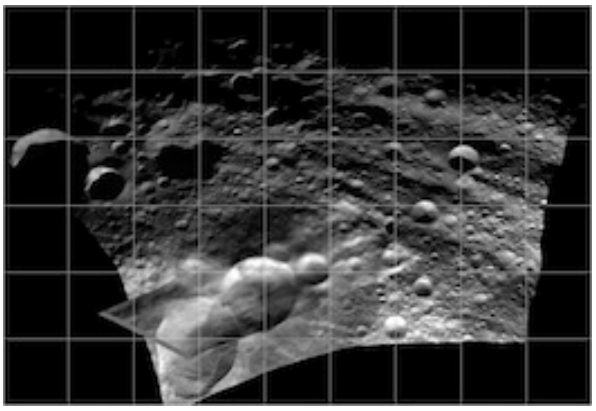

Figure 1. FC (FC21B0004565_1122692657F1A.IMG) and VIR (VIR_VIS_1B_1_366641356_1.IMG) images projected and overlaid showing geometric alignment between the two datasets.

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