THE OSIRIS-REx CAMERA SUITE CALIBRATION PIPELINE. E.K. Kinney Spano[1], J.I. Ivens[1], D.R. Golish[1], C.D. d'Aubigny[1], B. Rizk[1], University of Arizona, Lunar and Planetary Laboratory, Tucson, AZ 85721, USA (ekinney@orex.lpl.arizona.edu).

Introduction: The Origins Spectral Interpretation Resource Identification Security - Regolith Explorer (OSIRIS-REx) sample return mission launches in 2016 with the objective of returning a pristine sample of regolith from Near-Earth asteroid Bennu[1]. A key data product from the mission will be the images from the OSIRIS-REx Camera Suite (OCAMS)[2]. The OCAMS images will be the primary inputs to several key image products for the mission including image mosaics, base maps, digital terrain models and orthoimages. Additionally, images will be analyzed to identify important features on Bennu that, along with other mission-generated data products, will help guide sample site selection. Features that are of particular interest to the OSIRIS-REx sample site selection decsion makers include spacecraft hazards such as craters, large boulders and areas rich in loose sampleable regolith on the surface of Bennu.

Calibrating raw OCAMS images is the first step in creating scientifically accurate and asthetically pleasing image products. The OCAMS calibration pipeline will automatically remove instrumental noise signatutres from the raw OCAMS images and calibrate the images to provide radiometrcally corrected images in physical units of W m^{-2} sr^{-1}. These images will be futher processed into image mosaics and base maps using statndard software tools such as the U. S. Geological Survey's (USGS) Integrated Software for Imagers and Spectrometers (ISIS) digital image processing software package. Stereo data products such as Digital Terrain Models (DTM) and orthoimages will be created using the commercial photogrammetry package SOCET SET ® distributed by BAE Systems, Inc.

Methods: The OCAMS calibration pipeline has been developed using the IDL programming language. The OCAMS pipeline was developed in the IDL Development Environment and the capability to run the OCAMS pipeline in IDL's interactive environment has been very helpful during OCAMS instrument development for instrument system testing and OCAMS ground calibration. The ability to run the OCAMS pipeline interactively will be maintained thoughout the OSIRIS-REx mission to aid in the developement of the OCAMS in-flight calibration program and to assist when needed OCAMS instrument anomaly resolution.

During routine mission opeartions the OCAMS pipeline will be run automatically in the OSIRIS-REx Science Processing and Operations Center (SPOC) within the IDL Virtual machine (VM). The IDL VM will allow the OCAMS pipeline to operate in batch mode in a multi-threaded environment. This mode of pipeline operation will allow seamless creation of calibrated images within minutes of image ingest at the SPOC. Calibrated images can be evaluated using web tools provided by SPOC personnel.

The OCAMS pipeline starts immediately after the completion of image ingest at the SPOC. The SPOC ground system kicks off the pipeline using a pipeline controller. A top-level master IDL procedure controls the sequence of the calibration steps to be performed. The algorithm for each step in the pipeline process is encapsulated in individual IDL functions. Parameters controlling the operation of each step in the pipeline are supplied by a comma separated value file that is read by the master IDL procedure. The master IDL procedure passes the relevant parameters to each IDL correction function.

The first steps in the pipeline perform standard image denoising corrections such as bias and dark current subtraction, charge smear correction and flat-field division. The denoised, uncalibrated images (level 1) are stored as FITS files in the OSIRIS-REx data repository. The next steps in the pipeline apply radiometric calibration factors and perform bad pixel and cosmic ray identifcation. The calibrated images (level 2) are also stored in the OSIRIS-REx data repository as multi-extension FITS files. The first extension in the calibrated images have been cosmetically corrected for bad pixel and comsic rays and the second extension flags the uncorrected bad pixel and comsic ray with special pixel values.

Input calibration files for the calibration pipeline were derivied from OCAMS detector characteriztion and engineering testing activities.[3]

Results: The beta version of the OCAMS pipeline was delivered to the OCAMS instrument team and the OSIRIS-REx SPOC in October 2013. This initial version of the pipeline was used in early ground system development and in the OCAMS Engineering Qualification Unit testing program.

Updates to the OCAMS pipeline were delivered in September 2014 to support the OCAMS flight model testing program and in April 2015 to support continued SPOC ground system integration activities.

References:

[1] Lauretta, D. S. et al. (2013) *LPS XVIII,* Abstract #2491. [2] Smith, P. H. et al. (2013) *LPS XVIII,* Abstract 1690. [3] Hancock, J. et al. (2013) SPIE Optical Engineering and Applications, v. 8860.