Image Science Support for Exploration Program

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The Constellation Program is using Johnson Space Center engineering imaging design as part of its design and testing for the new vehicle. This includes imaging concepts and requirements to analyze imagery acquired during laboratory and flight tests. This is especially notable as it is the first time that engineering imagery has been consistently factored for vehicle design. Traditionally, the Public Affairs Office was the key driver for vehicle imaging systems. While this type of imagery is vital for extending the space flight experience to the public, flight operations have evolved to depend heavily on engineering imagery as a data source.

Orion window photography testing

The Crew Exploration Vehicle (CEV) (Orion) underwent a review that focused on vehicle mass, resulting in a window redesign that changed the glass pressure pane to a polycarbonate pane. As part of the polycarbonate evaluation, we obtained and compared engineering photography through various Orion window configurations. Test photography using Orion and shuttle window mock-ups revealed that a polycarbonate pressure pane will not support engineering image analysis photography using long-focal-length (400 mm) lenses. The test did, however, reveal that window panes made of acrylic appear to have an optical quality comparable to the current shuttle windows and could support long-focal-length photography. These findings served as the basis for an Orion Project directive to change the pressure pane material from polycarbonate to acrylic, with further acrylic testing in 2009 (figure 1).

Imagery analysis in support of flight tests

Another task involved the CEV Parachute Assembly System Cluster Development Test-2, conducted at Yuma Proving Ground, Ariz., in July 2008. For the first parachute test, ground-tracking video of the test article, which experienced a failure of the programmer chute, was used to extract attitude and oscillation data as well as to build a failure event timeline.

We support other tests such as the test flights of Ares 1-X (new launch vehicle) and Pad Abort-1 (PA-1). All ground- and vehicle-based video acquired during Ares 1-X must undergo screening and analysis using the techniques and tools employed for each shuttle launch. In addition to extracting vehicle performance information, Ares 1-X will afford the agency an opportunity to assess how well the imagining laboratory for shuttle processes and laboratory facilities supports Ares. All PA-1 ground-tracking camera imagery are analyzed to compute attitude data and to assess system performance (figure 2).

Fig. 1. *Image Science and Analysis Group and Engineering Directorate personnel conduct Orion window photography tests.*

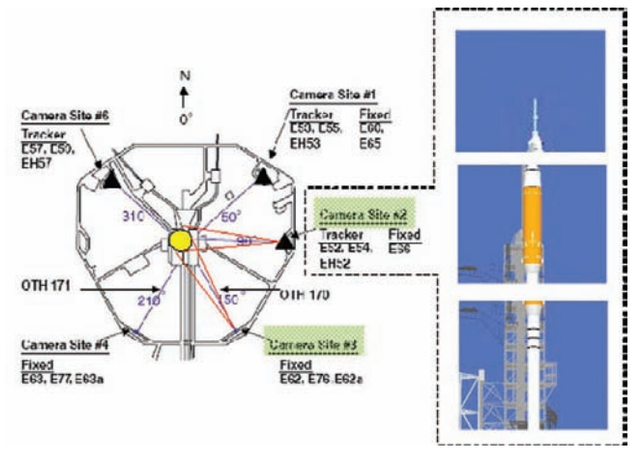

Fig. 2. *An example of launch site camera planning for Ares 1-X.*

Orion thermal protection system inspection capability studies

Our image group has extensive experience with on-orbit vehicle inspection that uses sensors and cameras to detect and measure structural damage from launch and on-orbit

debris, referred to as micrometeoroid/orbital debris (MMOD). The group's vehicle inspection skill set, which was developed and honed for shuttle, is now being applied to Orion. Block 1 missions to the International Space Station (ISS) will require that Orion be docked to the station for months, thereby exposing its Thermal Protection System (TPS) to potential MMOD damage. A verification of TPS integrity prior to re-entry will therefore be necessary.

A study revealed that existing ISS imaging resources are capable of detecting a surface feature that could indicate possible damage to the Orion TPS (assuming the currently predicted damage criteria). The group is now performing studies to identify an appropriate method of characterizing a tile cavity. Three-dimensional sensors from the shuttle are under evaluation for this purpose, as are new technologies that are currently in development. Photogrammetry techniques that extract depth data from the multiple images obtained with a conventional two-dimensional camera also continue to be refined and considered. While imaging tools and techniques can readily be implemented as Orion is docked to ISS, the team is also considering how TPS inspection can be performed on lunar missions that will not have the convenience of ISS resources (figure 3).

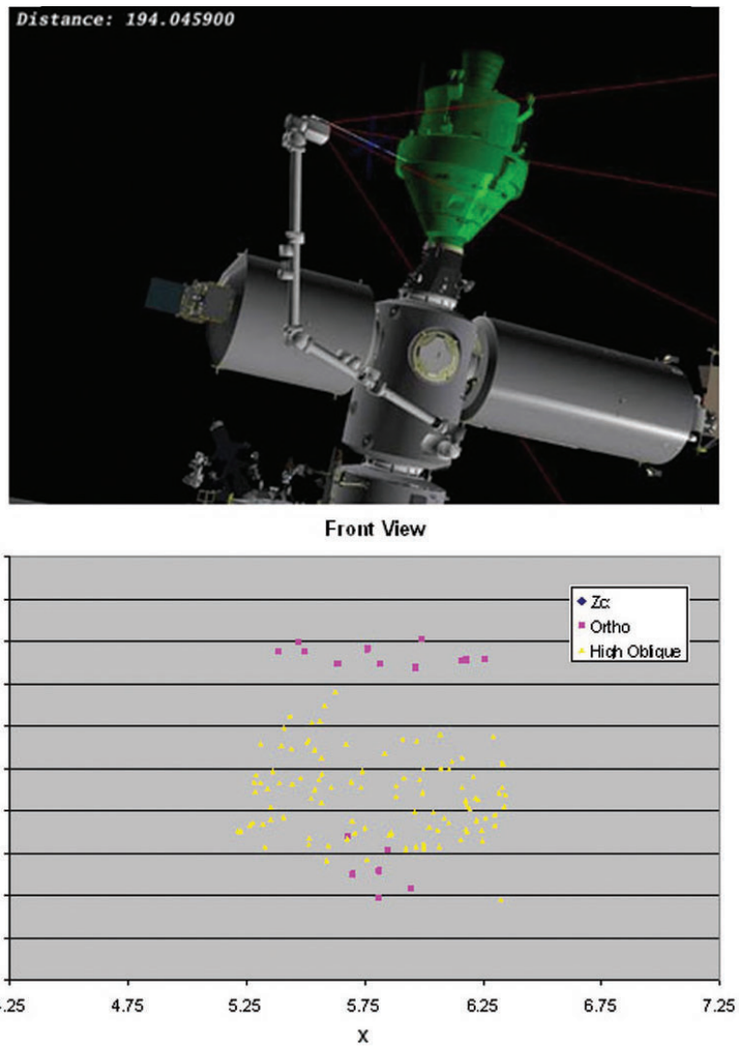

Fig. 3. *An illustration of Orion inspection for TPS damage while docked to ISS Node 2 (top). Three-dimensional Orion tile cavity characterization uses multiple images from a two-dimensional sensor. The pink points map the periphery of the entry hole and the bottom of the cavity. The yellow points map the lower extent of the sides of the cavity (bottom).*

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