CMSC Abstract

Title: Close Range Photogrammetry in Space -
Measuring the On-orbit Clearance between Hardware on the International Space Station

Author: Donn Liddle
Lead Photogrammetrist
Image Science and Analysis Group
NASA - Johnson Space Center
(Employed by HX5, under contract to NASA)

Contact Information
Donn Liddle
414 Overlook Dr.
Friendswood, TX 77546
Office: 281-483-9355 Cell: 281-515-2365
Email: donn.a.liddle@nasa.gov

Topic Category: Application

Purpose:

Document how close-range photogrammetric analysis was used to prove positive clearance between existing on-orbit hardware on the International Space Station and a thruster bell on a cargo vehicle schedule to arrive at the space station later in the year.

Abstract:

When photogrammetrists read an article entitled “Photogrammetry in Space” they immediately think of terrestrial mapping using satellite imagery. However in the last 19 years the roll of close range photogrammetry in support of the manned space flight program has grown exponentially. Management and engineers have repeatedly entrusted the safety of the vehicles and their crews to the results of photogrammetric analysis.

In February 2010, the Node 3 module was attached to the port side Common Berthing Mechanism (CBM) of the International Space Station (ISS). Since this was not the location at which the module was originally designed to be located on the ISS, coolant lines containing liquid ammonia, were installed externally from the US Lab to Node 3 during a spacewalk. During mission preparation I had developed a plan and a set of procedures to have the astronauts acquire stereo imagery of these coolant lines at the conclusion of the spacewalk to enable us to map their as-installed location relative to the rest of the space station. Unfortunately, the actual installation of the coolant lines took longer than expected and in an effort to wrap up the spacewalk on time, the mission director made a real-time call to drop the photography. My efforts to reschedule the photography on a later spacewalk never materialized, so rather than having an as-installed model for the location of coolant lines, the master ISS CAD database continued to display an as-designed model of the coolant lines.

Fast forward to the summer of 2015, the ISS program planned to berth a Japanese cargo module to the nadir Common Berthing Mechanism (CBM), immediately adjacent to the Node 3 module. A CAD based clearance analysis revealed a negative four inch clearance between the ammonia lines and a thruster nozzle on the port side of the cargo vehicle. Recognizing that the model of the ammonia line used in the clearance analysis was “as-designed” rather than “as-installed”, I was asked to determine the real clearance between the ammonia lines and expected position of the thruster bell using existing on-orbit imagery.

Imagery of the area of interest, taken several years earlier from the Space Shuttle during a fly-around of the ISS, was found and used to set a stereo pair. Space Vision System Targets and Handrail bolts measured in the ISS analytical coordinate system (ISSACS) prior to launch, were used to obtain an absolute orientation so all photogrammetric measurement’s would be in the ISSACS coordinate system. Coordinates for the design location of the edges of the thruster bell, when the cargo vehicle was fully berthed to the ISS, were displayed in 3-D relative to the as-installed ammonia lines. This immediately revealed a positive clearance, which was later quantified to be a minimum of 10” +/0.5”. The analysis was completed over a single weekend by a single analyst.

Using updated imagery, acquired from the station’s robotic arm, a complete as-installed model of the coolant lines was generated from stereo photography and replaced the design model in the master ISS CAD database.