The SRTM Sub-arcsecond Metrology Camera

Riley Michael Duren
Carl Christian Liebe

Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Dr, Pasadena CA 91109-8099

Abstract

The Shuttle Radar Topography Mission (SRTM) payload was flown on the Shuttle Endeavor STS-99 February 11-22, 2000. Interferometric Synthetic Aperture Radar (IFSAR) techniques were used to successfully acquire data necessary for generating a topographic map covering 80% of the earth's land surface to an absolute accuracy (1.6 sigma) of 30 meters in azimuth and 16 meters in height. To achieve the necessary interferometric baseline, an outboard radar antenna was deployed using a 60 meter mast from a main radar antenna in the shuttle payload bay. While fairly rigid, the mast nonetheless behaved as a flexible structure with tip displacements on the order of several centimeters in response to shuttle thrusters. Knowledge of the mast tip position to an accuracy of 1 mm and mast tip orientation to an accuracy of 100 arcseconds (1.6 sigma) was required in order to meet the baseline metrology error budget (a key to meeting the overall height accuracy) and to support on-orbit alignment of the two radar antennas. Knowledge of mast motion was also necessary in order to perform on-orbit system identification of the mast/shuttle system to optimize the shuttle's attitude control system and to verify mast integrity was sufficient to meet safety requirements during orbit trim maneuvers. The SRTM Attitude and Orbit Determination Avionics (AODA) subsystem was responsible for providing these measurements. The solution consisted of an optical metrology camera which tracked three LED targets located on the outboard antenna structure. The state of the outboard antenna could be determined in 6 degrees of freedom using the metrology camera. Due to physical constraints on LED target separation, the line-of-sight component of mast tip position could not be determined to the required accuracy using the metrology camera alone. This required the addition of a rangefinder instrument, described elsewhere. The metrology camera was referred to as the ASTROS Target Tracker (ATT). In order to meet the above system requirements, the ATT had to provide knowledge of target centroid position on the CCD with a relative accuracy of 0.8 arcsec, 1 sigma. Providing sub-arcsecond accuracy given the tight SRTM schedule and budget constraints necessitated maximum reuse of existing hardware. The ATT was implemented as a modified version of the Advanced Stellar and Target Reference Optical Sensor (ASTROS), a sub-arcsecond star tracker developed by JPL in the 1980's and flown previously on the shuttle for the Astro-1 and –2 missions (STS-35 and –67). ASTROS was chosen due to its proven flight-worthiness and superior accuracy. The modifications included electronic and software changes to improve the tracking rate and new optics to provide a 60 meter focus and stray-light rejection. The LED targets consisted of commercial off-the-shelf LEDs mounted to the outboard radar antenna on custom-designed tubes. This paper provides a description of the ATT, the process used to modify it for flight on SRTM, the LED target development effort, test and alignment issues, and the observed in-flight performance. The challenges in modifying a heritage instrument in this fashion were significant and lesson's learned for future efforts will be presented.