SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Detection and Characterisation (6)

Author: Dr. Mark Mulrooney
National Aeronautics and Space Administration (NASA), United States

Dr. Paul Hickson
University of British Columbia, Canada
Mr. Eugene Stansbery
National Aeronautics and Space Administration (NASA), United States

LEO ORBITAL DEBRIS TRAJECTORY ASSESSMENT UTILIZING A LIQUID CRYSTAL SHUTTER

Abstract

The National Aeronautics and Space Administration (NASA) and the Air Force Research Lab (AFRL) will utilize the Meter-Class Autonomous Telescope (MCAT) to detect and track earth orbital objects at all inclinations and at altitudes from 200 km to geosynchronous. MCAT is a 1.3m f/4 Ritchey-Chrétien on a double horseshoe equatorial mount that will be deployed in mid-late 2011 to the western pacific island of Legan in the Kwajalein Atoll. MCAT's primary objective is the detection of new orbital debris in both low-inclination low-earth orbits (LEO) and at geosynchronous earth orbit (GEO) down to 2 and 10 cm diameters respectively. MCAT's primary detector is a closed-cycle-cooled 4Kx4K 15m pixel CCD camera that yields a 0.96 diagonal field. MCAT's 4-port camera operating from 100 kHz to 1.5 MHz per port at 2 and 10 electron (e-) read noise respectively enables low-noise multi-second exposures for GEO observations as well as moderate (one frame per second) exposures for LEO. The LEO observations are particularly demanding due to the high angular rates involved (up to 2.2 deg/sec) and the commensurate requirement for rapid image processing to execute detection, assess trajectory, and coordinate telescope tracking to enable photometric data acquisition for determination of key metrics (e.g. color, phase function, rotation rates). Multi-frame observations are generally required for an initial trajectory assessment (rate and position angle of motion), but such instances occur only serendipitously during a LEO Stare and Chase Mode (SCM) survey irrespective of telescope survey motion (static, sidereal or orbit scan). Therefore a means is required to segment the image in a single frame. Since conventional large format mechanical iris shutters suffer from exposure non-uniformity (pupil effect) and are incapable of cycling at sufficient speeds (due to open/close times of order 100 milliseconds), an alternative is needed. High speed blade shutters offer one solution but can be weight and cost prohibitive. NASA is considering a solid state solution consisting of a large Liquid Crystal (LC) shutter that can be cycled from 0 to 20 Hz, has millisecond rise and decay time, and has broadband optical transmittance of order 80