MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

Author: Dr. Jae Jun Kim
Naval Postgraduate School, United States

Dr. Brij Agrawal
Naval Postgraduate School, United States

DEMONSTRATION OF SPARSE APERTURE CONFIGURATION FOR IMAGING SATELLITES

Abstract

Several future imaging missions will require large space mirrors, 10-20 m in diameter. This is a challenging problem on how to build cost-effective large aperture mirrors with surface error accuracy in the rage of 30 nanometer RMS. In order to achieve these performance, use of several smart structures technologies are proposed. One concept is to use multiple satellites, called collectors with small apertures and coherently combines the images by a combiner spacecraft, so the system acts like a large aperture satellite. However, the technologies for coherently combing the images are challenging. First, the collector satellites have to operate in orbit formation flying with nanometer level position control. Attitude control for the satellites will be needed in micro-radian level. Next, accurate metrology system is needed for measuring the distance and angular motion between collectors and combiner. Technologies have been demonstrated at component level. However, they have not been demonstrated at system level. At NPS, a test bed is under development to demonstrate sparse aperture concept at system level. This paper will discuss the design of sparse aperture testbed. In the sparse aperture test bed, white light point source and scene images are used to measure the performance of the sparse aperture system. Initially, multiple satellites are simulated with two separate spacecraft simulation platforms with 6 axis translational and rotation actuation. 6-Axis NanoMax^{TM} NanoPositioning Flexure Stages by ThorLabs could provide a maximum travel range of 4 mm in translation and 6 degrees in rotation with a minimum resolution of 1.0 nm in translation and 0.018 micro- rad in rotation. Since the combiner spacecraft can be placed far away from each aperture, spherical mirrors with a long focal length (f ¿ 2 meters) will be used as a sparse aperture on each simulated spacecraft platform. This will reduce the complexity of the phasing and alignment compared to the parabolic or hyperbola mirror aperture system. The combiner spacecraft platform will include a delay line, fast steering mirrors, and deformable mirrors to compensate optical path variations. The metrology system is located on the same platform as a beam combiner platform. Real-time on-board processing system will be investigated and developed to seamlessly combine metrology system as well as alignment and phasing of sparse aperture system.