System for Measuring Flexing of a Large Spaceborne Structure

NASA's Jet Propulsion Laboratory, Pasadena, California

An optoelectronic metrology system is used for determining the attitude and flexing of a large spaceborne radar antenna or similar structure. The measurements are needed for accurate pointing of the antenna and correction and control of the phase of the radar signal wavefront. The system includes a dual-field-of-view star tracker; a laser ranging unit (LRU) and a position-sensitive-detector (PSD)-based camera mounted on an optical bench; and fiducial targets at various locations on the structure.

The fiducial targets are illuminated in sequence by laser light coupled via optical fibers. The LRU and the PSD provide measurements of the position of each fiducial target in a reference frame attached to the optical bench. During routine operation, the star tracker utilizes one field of view and functions conventionally to determine the orientation of the optical bench. During operation in a calibration mode, the star tracker also utilizes its second field of view, which includes stars that are imaged alongside some of the fiducial targets in the PSD; in this mode, the PSD measurements are traceable to star measurements.

This work was done by Carl Christian Liebe, Alexander Abramovici, Randy Bartman, Keith Coste, Edward Litty, Jacob Chapsky, Raymond Lam, Sergei Jerebets, John Schmalz, and Lars Chapsky of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45076

Integrated Formation Optical Communication and Estimation System

Formation estimation couples estimation algorithms, sensing topology, and communication topology.

NASA's Jet Propulsion Laboratory, Pasadena, California

An architecture has been designed that integrates formation estimation methodologies, precision formation sensing, and high-bandwidth formation communication into a robust, strap-on system that meets knowledge and communication requirements for the majority of planned, precision formation missions. Specifically, the integrated system supports (a) sub-millimeter metrology, (b) multiple >10 Mbps communication channels over a large, 10° field-of-view (FOV), and (c) generalized formation estimation methodologies. The sensing sub-system consists of several absolute, metrology gauges with up to 0.1 mm precision that use amplitude-modulated lasers and a LISA-heritage phase meter. Since amplitude modulation is used, inexpensive and robust diode lasers may be used instead of complex, frequency-stabilized lasers such as for nanometer-level metrology. The metrology subsystem laser transceivers consist of a laser diode, collecting optics, and an avalanche photo diode (APD) for detecting incoming laser signals. The APD is necessary since received power is small due to the large (for optical applications) FOV. The phase meter determines the phase of the incoming amplitude modulations as measured by the APD. This phase is equivalent to time-of-flight and, therefore, distance.

By placing three laser transceivers on each spacecraft, 18 clock-offset-corrupted distances are calculated. These measurements are communicated and averaged to obtain nine correct distances between the transceivers. From these correct distances, the range and bearing between spacecraft and their relative attitude are determined.

Next, communication is integrated on the laser carrier through spectral separation. Metrology amplitude modulations are limited to the 45–50 MHz band, leaving 0–45 MHz for communication. Through careful design of coding scheme, error correction, and filters, six independent 10 Mbps receive channels are possible. Hence, a spacecraft can simultaneously broadcast at 10 Mbps and listen to six other spacecraft.

The integrated sensing and communication architecture has been developed, as have formation estimation methodologies that allow the sensing topology to reconfigure as spacecraft maneuver. A bench-top implementation of the integrated sensing and communication architecture is in progress. The final, multiple sensing/communication systems will be tied together via formation estimation algorithms that are also undergoing further development.

This work was done by Daniel Scharf, Andreas Kuhnert, Joseph Kovalik, Fred Hadaegh, and Daniel Shaddock of Caltech for NASA's Jet Propulsion Laboratory.

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44558.