CATEGORY 1 - HARDWARE SYSTEMS

Coherent Doppler Lidar for Automated Space Vehicle Rendezvous, Stationkeeping and Capture

by James Bilbro, MSFC

The inherent spatial resolution of laser radar makes ladar or lidar an attractive candidate for Automated Rendezvous and Capture application. Previous applications were based on incoherent lidar techniques, requiring retro-reflectors on the target vehicle. Technology improvements (reduced size, no cryogenic cooling requirement) have greatly enhanced the construction of coherent lidar systems. Coherent lidar permits the acquisition of non-cooperative targets at ranges that are limited by the detection capability rather than by the signal-to-noise ratio (SNR) requirements. The sensor can provide translational state information (range, velocity and angle) by direct measurement and, when used with an array detector, also can provide attitude information by doppler imaging techniques. Identification of the target is accomplished by scanning with a high pulse repetition frequency (dependent on the SNR). The system performance is independent of range and should not be constrained by sun angle. An initial effort to characterize a multi-element detection system has resulted in a system that is expected to work to a minimum range of 1 meter. The system size, weight and power requirements are dependent on the operating range; 10 km range requires a diameter of 3 centimeters with overall size at 3x3x15 to 30 cm, while 100 km range requires a 30 cm diameter.

Video Guidance Sensor

by Richard Howard, MSFC

A Martin-Marietta study comparing the application of laser, video, or RF sensors was conducted in 1982. The study concluded that video was the most attractive sensor (the video also could be used for operator monitoring). The Retro-Reflector Field Tracker from the Solar Array Flight Experiment was chosen as a "first generation" sensor and integrated with guidance algorithms for evaluation on the air-bearing vehicle. Results indicated that this sensor was not applicable for the noise environment posed by the multi-layer insulation used on most spacecraft. A "second generation" sensor was developed to be used with a modified RMS target. This sensor utilized two sets of laser diodes to acquire three optically filtered targets. The targets were illuminated first with a 780 nanometer diode, followed by illumination with a 830 nm diode. The second digitized picture was subtracted from the first to get a low-noise image. The centroids of the retroreflectors were used then to uniquely derive target attitude and range. The sensor presently operates to 80 feet and within ± 40 degrees in pitch and yaw. Sensor operability is a concern if the sun is within a ±40 degree cone angle of the target. The present sensor performance characteristics are less than 1% range error and less than 1 degree angle error. Future sensor development is anticipated to extend the operating range to 150 feet and reduce the cone angle of sensor inoperability to within ± 10 degrees of direct sunlight. Performance improvements also are anticipated. TRW currently is developing a system that utilizes dual cameras with simultaneous diode illumination. Although further development is being pursued, the basic system has proven sound and the sensor is essentially ready for application.

Approach Range and Velocity Determination Using Laser Sensors and Retroreflector Targets

by W. J. Donovan, Rockwell International

A laser docking sensor study currently is in the third year of development. The design concept is considered to be validated. The concept is based on using standard radar techniques to provide range, velocity, and bearing information. Multiple targets are utilized to provide relative attitude data. The design requirements were to utilize existing space-qualifiable technology and require low system power, weight, and size yet operate from 0.3 to 150 meters with a range accuracy greater than 3 millimeters and a range rate accuracy greater than 3 mm per second. The field of regard for the system is +/- 20 degrees. The transmitter and receiver design features a diode laser, microlens beam steering, and power control as a function of range. The target design consists of five target sets, each having seven 3-inch retroreflectors, arranged around the docking port. The target map is stored in the sensor memory. Phase detection is used for ranging, with the frequency range-optimized. Coarse bearing measurement is provided by the scanning system (one set of binary optics) angle. Fine bearing measurement is provided by a quad detector. A MIL-STD-1750 A/B computer is used for processing. Initial test results indicate a probability of detection greater than 99% and a probability of false alarm less than 0.0001. The functional system is currently at the MIT / Lincoln Lab for demonstration.

Contact Dynamics Testing of Automated Three-Point Docking Mechanism

by Kenneth H. Rourke, TRW

An evaluation of an OMV docking mechanism, based on an adaptation of the Shuttle Flight Support System Pallet Berthing Mechanism has been completed. The mechanism uses automatically actuated motorized latches to engage towel bars on the target satellite. LED sensors establish the towel bar position within the capture envelope and the latch capture commands are issued. Then, locking pawls engage the bar, locking and pre-loading the mechanism. Two series of tests were conducted to test nominal and failure mode captures and to evaluate design parameters such as LED sensor locations, automatic closure algorithms, latch closure velocity, position/velocity entry envelopes, and closure method. The first test series involved single latch testing on the Flat Floor Facility, 6 DOF Facility and an analytic simulation model. The intent was to compare results in order to validate the various facilities. Reasonably good agreement was achieved. The second test series repeated the single latch testing on the refurbished 6 DOF Facility to validate the facility modifications. The individual latches were tested under free-drift conditions for functionality and performance. Next, the three-latch configuration underwent parametric testing. Test results validated the improved fidelity of the 6 DOF Facility and verified successful docking at the required entry velocity. The tests determined the "best" design parameter definitions and concluded that the locking pawls should not lock until all three latches completely close.

TRAC Based Sensing For Autonomous Rendezvous

By Louis Everett Texas A&M University, and
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The Targeting Reflective Alignment Concept (TRAC) sensor is to be used in an effort to support an Autonomous Rendezvous and Docking (AR&D) flight experiment. The TRAC sensor uses a fixed-focus, fixed-iris CCD camera and a target that is a combination of active and passive components. The system experiment is anticipated to fly in 1994 using two Commercial Experiment Transporters (COMETs). The requirements for the sensor are: bearing error less than or equal to 0.075 deg; bearing error rate less than 0.3 deg/sec; attitude error less than 0.5 deg. and; attitude rate error less than 2.0 deg/sec. The range requirement depends on the range and the range rate of the vehicle.

The active component of the target is several "kilo-bright" LEDs that can emit 2500 millicandela with 40 milliwatts of input power. Flashing the lights in a known pattern eliminates background illumination.

The system should be able to rendezvous from 300 meters all the way in to capture.