

A Distributed Ranging and Relative Attitude Determination Sensor for Spacecraft Proximity Operations

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The determination and control of the relative attitudes of two spacecraft during the final phase of approach and docking requires the highest precision. All current docking sensor systems use some type of computer vision or other digital optical sensing technology to determine the relative attitudes of the two spacecraft. The configurations of current systems however, result in precision which generally decreases with increasing range which, while generally acceptable for docking maneuvers, limits the utility of the sensor in other proximity operations.

This research investigates a novel, laser-based, distributed, optical docking sensor system whose precision increases with increasing range, rather than decreasing, without compromising precision at very close ranges, where it is most critical. Rather than illuminating a passive target and imaging the reflection, this system images the points of incidence of lasers fired from the maneuvering spacecraft onto the docking target plane with a camera mounted directly on that target spacecraft, eliminating the natural loss of precision caused by placing the camera on the maneuvering spacecraft.

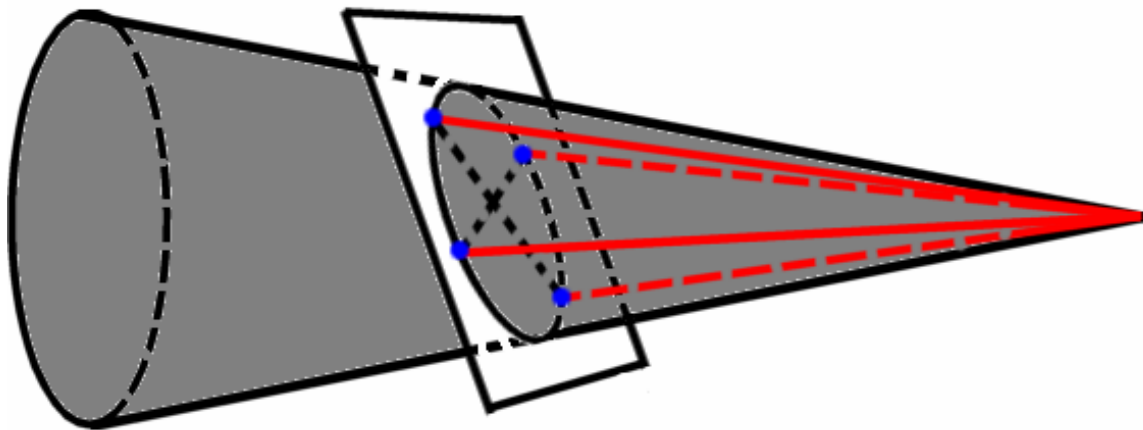


Figure 1. The intersection of the laser projection cone with the docking target plane is shown. The four points of incidence trace out a unique ellipse which can be determined numerically.

These points of incidence of the lasers on the docking target trace out the intersection of the cone upon which the diverging laser beams are aligned and the docking plane. Thus, the shape they trace out is a conic section: an ellipse. With four lasers, this ellipse can be determined numerically to a high degree of precision. The mathematical properties of this ellipse, together with the known vertex angle of the cone, allow for the calculation of the range and relative attitude of the two spacecraft.

This research investigates this configuration, and reports its benefits and limitations. The experimental apparatus and procedures are explained, data is summarized, and conclusions regarding the feasibility of such a configuration are drawn.