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Trajectory Control Sensor Engineering Model Detailed Test Objective

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The concept employed in an existing Trajectory Control Sensor (TCS) breadboard is being developed into an engineering model to be considered for flight on the Shuttle as a Detailed Test Objective (DTO). The sensor design addresses the needs of Shuttle/SSF docking/berthing by providing relative range and range rate to 1500 meters as well as the perceived needs of AR&C by relative attitude measurement over the last 100 meters. Range measurement is determined using a four-tone ranging technique. The doppler shift on the highest frequency tone will be used to provide direct measurement of range rate. Bearing rate and attitude rates will be determined through back differencing of bearing and attitude, respectively. The target consists of an isosceles triangle configuration of three optical retroreflectors, roughly one meter and one-half meter in size. After target acquisition, the sensor continually updates the positions of the three retros at a rate of about one hertz. The engineering model is expected to weigh about 25 pounds, consume 25-30 watts, and have an envelope of about 1.25 cubic feet.

Concerns addressed during the presentation: Are there any concerns with differentiating attitude and bearing to get attitude and bearing rates? Since the docking scenario has low data bandwidth, back differencing is a sufficient approximation of a perfect differentiator for this application. Could range data be obtained if there were no retroreflectors on the target vehicle? Possibly, but only at close range. It would be dependent on target characteristics.

S8-18

Thruster Configurations for Maneuvering Heavy Payloads

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The Cargo Transfer Vehicle (CTV) will be required to perform six degree of freedom (6 DOF) maneuvers while carrying a wide range of payloads varying from 100,000 lbm to no payload. The current baseline design configuration for the CTV uses a forward propulsion module (FPM) mounted in front of the payload with the CTV behind the payload so that the center of gravity (CG) of the combined stack is centered between the thruster sets. This allows for efficient rotations and translations of heavy payloads in all directions; however, the FPM is a costly item, so it is desirable to find design solutions that do not require the FPM. This presentation provides an overview of the analysis of the FPM requirements for the CTV.

In this study, only the reaction control system (RCS) thruster configurations are considered for 6 DOF maneuvers of various CTV cargo configurations. An important output of this study are the viable alternative thruster configurations that eliminate the need for the FPM. Initial results were derived using analytical techniques and simulation analysis tools. Results from the preliminary analysis were validated using our 6 DOF simulation.

Using current baseline thruster locations on a main CTV without the FPM, operations are possible with 75 lbf thruster and 19% fuel efficiency (a 400 lbm fuel penalty) for lateral maneuvers of 100,000 lbm cargo within the final 1000 ft approach. The CTV without its cargo or strongback requires low torque (7.5 lbf thrust), but available 25 lbf thrusters yield 3.4 degrees per square second of rotation acceleration, which implies frequent and fuel-inefficient thruster activity and excessive angular acceleration. An alternative 36-thruster configuration with offset 25 lbf thrusters can achieve 24% efficiency and handle both fully loaded and core CTV operations.

Concerns that were addressed during the presentation: Is there a time penalty? No operational time delay is incurred with lower accelerations used. Is radial center of gravity offset a problem? Not unless it is significantly outside the CTV diameter.

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Optical Correlators for Automated Rendezvous and Capture

by Richard D. Juday, NASA JSC

The paper begins with a description of optical correlation. In this process, the propagation physics of coherent light are used to process images and extract information. The processed image is operated on as an area, rather than as a collection of points. An essentially instantaneous convolution is performed on that image to provide the sensory data. In this process, an image is sensed and encoded onto a coherent wavefront, and the propagation is arranged to create a bright spot of the image to match a model of the desired object. The brightness of the spot provides an indication of the degree of resemblance of the viewed image to the mode, and the location of the bright spot provides pointing information.

The process can be utilized for AR&C to achieve the capability to identify objects among known reference types, estimate the object's location and orientation and interact with the control system. System characteristics (speed, robustness, accuracy, small form factors) are adequate to meet most requirements. The correlator exploits the fact that Bosons and Fermions pass through each other. Since the image source is input as an electronic data set, conventional imagers can be used. In systems where the image is input directly, the correlating element must be at the sensing location.

Active programs in the development of this technology are already in place within NASA (JSC, JPL, ARC), the military, industry and academia. These programs have developed systems that are essentially ready to be flown in space. The two major elements may be characterized as algorithms/architectures and modulators. Numerous correlator architectures and the associated algorithms already exist and are available in original or modified form. Modulators, while in existence, are not as technologically advanced as the algorithms and architectures. Numerous small business proposals are under consideration to further this technology.

The Johnson Space Center is involved in all aspects of the AR&D activity, including the software and hardware developments. Algorithms such as "Backscratch," estimation filters, pattern recognition, and correlator architectures either are under development or are under influence of JSC personnel. Digital image processors and Spatial Light Modulators are examples of hardware currently being developed under JSC cognizance. According to the author, JSC is at the forefront of Fourier optics pattern recognition.

Some work has been done to estimate the funding required to qualify the hardware to a space environment and to build a flight system. One benefit which may accrue to the program is the ability to piggyback the flight qualification on an ongoing DARPA program. The DARPA correlator will be ready for ground testing in the Fall of 1993. It is estimated that space qualifiable hardware could be available a year later.

At this time, technological challenges are in the areas of developing Spatial Light Modulators to control light, continuing to develop software of filters and noise rejection capability, and improving sensitivity to scale and rotation. Emphasis should be placed on development of the modulators, since the algorithm and architecture development is ahead at this time.

Concerns/questions that arose at the end of the presentation: Existing DARPA program will take hardware through qualification and field testing at levels similar to and often exceeding space