DESIGN AND FABRICATION OF AN AUTONOMOUS RENDEZVOUS AND DOCKING SENSOR USING OFF-THE-SHELF HARDWARE

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Statement of technical details of the capability being described

NASA Marshall Space Flight Center (MSFC) has developed and tested an engineering model of an automated rendezvous and docking sensor system composed of a video camera ringed with laser diodes at two wavelengths and a standard remote manipulator system target that has been modified with retro-reflective tape and 830 and 780 nm optical filters. TRW has provided additional engineering analysis, design, and manufacturing support, resulting in a robust, low cost, automated rendezvous and docking sensor design. We have addressed the issue of space qualification using off-the-shelf hardware components. We have also addressed the performance problems of increased signal to noise ratio, increased range, increased frame rate, graceful degradation through component redundancy, and improved range calibration.

Next year, we will build a breadboard of this sensor. The phenomenology of the background scene of a target vehicle as viewed against earth and space backgrounds under various lighting conditions will be simulated using the TRW Dynamic Scene Generator Facility (DSGF). Solar illumination angles of the target vehicle and candidate docking target ranging from eclipse to full sun will be explored. The sensor will be transportable for testing at the MSFC Flight Robotics Laboratory (EB24) using the Dynamic Overhead Telerobotic Simulator (DOTS).

History of the origins and evolution of the capability

As stated earlier, the TRW design evolved from an existing NASA design developed at MSFC EB24. This design was modified to further improve performance and to support manufacture, verification, and space qualification.

TRW has a long history in the design and fabrication of space qualified sensors, guidance, acquisition, and tracking systems for military and non-military applications as the following table indicates.

Program	Item	Comments
OMV	Rendezvous & berthing sensor & operations	Proposal
GEODSS	Visible cameras & space object tracking hardware & software	Part of nation tracking network
VUE	Commercial visible CCD, tracking hardware & software	Space qualified & flown
DSP	IR detection & tracking sensor hardware & software	Long lived space system part of national defense network
Brilliant Pebbles	Tracking & homing sensor, optics hardware, firmware & software	Prototype built
IRAD	Space qualification of visible CCD camera	In progress
IRAD	Sensor performance simulation facility	Existing hardware & software for evaluation of active & passive sensors
IRAD	Sensor test facility	Existing hardware & software for evaluation of active & passive sensors
IRAD	Millimeter wave aircraft landing sensor	Hardware, software, & simulation completed
IRAD	6DOF simulation software & hardware upgrade & requirements definition	Existing full scale mock up docking simulation

During the OMV program TRW developed operations and sensor concepts for rendezvous and docking of space vehicles. We have built prototype hardware for Brilliant Pebbles program consisting of a miniaturized processor and sensor for use on a space based interceptor. Similar hardware and software will be used for the rendezvous docking system. On VUE, we were able to design, build, and fly a space based visible sensor for tracking space objects in 18 months by using a maximum amount of off the shelf commercial and military hardware. Several of our current IRAD efforts have direct applications to rendezvous and docking sensors.

The level of maturity of the capability

We have a specification list of minimum requirements for the automated rendezvous and docking system. We have developed an analytical model of the sensor design to verify that the system performance will meet the docking system requirements. We have a parts list for all elements of the automated rendezvous and docking sensor system. We have an optical bench on which to assemble the breadboard. Other simulation and analysis tools as well as available laboratory hardware include visible CCD cameras and a laser ranging system. The Sensor Test Facility includes a dynamic scene generator in which the effects of jitter, drift, and sensor motion on overall sensor performance can be measured and tested.

Test experience and/or experimental results

TRW has experience conducting autodocking simulations using DOTS to: 1) integrate and calibrate new algorithms, 2) characterize the autodocking components, 3) validate autodocking requirements, 4) demonstrate sensor driven autonomous docking, 5) expand the docking sensor's operational envelope, 6) test new coordinated six degree of freedom algorithms, and 7) exercise the extended translational range of the simulation facility.

Tools and methods were developed to integrate TRW's 6 degree of freedom orbit dynamics simulator with the DOTS and the engineering model of the sensor in order to perform closed loop docking runs with real sensor data. We expect to use the DOTS facility to evaluate the TRW rendezvous and docking sensor performance. Test and verification requirements were derived from similar optical sensor qualification and test requirements and build heavily on our VUE experience and our experience with the TRW Sensor Test Facility. On the VUE program, we space qualified a commercial CCD focal plane array. Producibility assessment for the automated rendezvous and docking sensor proceeds from our survey of existing space qualified sensors and our experience in space qualification of similar systems and payloads with similar components. In September of 1991, TRW successfully completed space qualification of a commercial off-the-shelf (Pulnix) CCD camera system.

Source/sponsorship and current funding estimates

This effort is being pursued on Internal Research and Development funds.