NRL Developing Space 'Tow Truck' Technology For Satellite Operations

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The Naval Research Laboratory's Naval Center for Space Technology has achieved a key milestone toward the development of autonomous servicing of unaided spacecraft. Working with the Defense Advanced Research Projects Agency (DARPA), NRL has developed, tested and ground-demonstrated guidance and control algorithms to allow a robotic servicing vehicle to autonomously rendezvous and dock with customer satellites not pre-designed for docking.

This demonstration coupled three significant accomplishments into one milestone;

-- The necessary robotic control algorithms are proven to be capable of operating reliably within a realistic spaceflight-processing environment and are now flight traceable.

-- A simulation of a realistic geostationary communications satellite with no visual aids or docking aids was grappled reliably in realistic on-orbit lighting conditions.

-- The demonstration was completed under full autonomy with no human-in-the-loop assistance.

NRL and DARPA are developing the key technologies and reducing the technological risk to allow autonomous spacecraft rendezvous and docking to become a reliable reality. As part of the Front-end Robotics Enabling Near-term Demonstration (FREND) effort, the DARPA/NRL

team is advancing the state-of-the-art in spacecraft autonomous rendezvous and grappling, offering "tow-truck" service to nearly every satellite currently, or soon to be, in space.

This service offers potential for satellites to operate longer, to be salvaged if they are in an inoperable orbit, to be transferred to a new orbital position if they are unable to make that transit on their own, and has a capability for making certain orbital regimes safer by transferring derelict spacecraft or space debris into graveyard orbits.

Full-scale laboratory demonstrations have now been successfully completed, proving that reliable autonomous grapple of spacecraft hardware is feasible. The NRL team has accomplished autonomous grapples using a one-meter-long research grade robot arm, custom developed flight traceable control algorithms, research grade machine vision cameras, prototype grappling mechanisms, and flight traceable processors. These grapples have been of simulated spacecraft hardware, grappling at the launch vehicle interfaces (Marman ring, separation bolt hole) commonly flown to geosynchronous orbit, and with simulated in-space lighting conditions.

By accomplishing these technology demonstrations, the autonomous control algorithms advance from a spaceflight Technology Readiness Level (TRL) of 4 to a TRL of 5, by having been tested in a variety of relevant environments. The DARPA/NRL team will further improve the TRL by integrating flight-ready robotics, electronics and software with evolving algorithms for grapple demonstrations in the laboratory environment. Laboratory demonstrations with fully flight-ready components will be another major milestone toward the ultimate goal of reaching the highest TRL of 9, which is reserved for systems that have been proven through successful operations in space.

DARPA and NRL have contracted the expertise of Alliance

Spacesystems, LLC of Pasadena, CA, to design and build the robotics that would allow a servicing spacecraft to dock with satellites not originally designed for servicing. Alliance is best known for designing and building the robot arms that are successfully exploring Mars on both Mars Exploration Rovers, Spirit and Opportunity. Alliance is presently designing, fabricating and testing of the first two robot arms for the FREND program.

An engineering development unit (EDU) robotic arm is scheduled for delivery to NRL in August of 2007, with a second flight prototype unit (FPU) built to space flight requirements being delivered in July of 2008. Both arms will be built to meet the performance and test requirements set forth by NRL, which emphasize operability in both Earth's gravity for laboratory testing and the zero-gravity environment of space.

Once the FREND technology prototype is fully demonstrated over the next year, it will have reached a spaceflight TRL of 6 and will be ready for an on-orbit demonstration mission. DARPA is presently involved in a search to identify a spacecraft mission partner for the on-orbit demonstration phase of this technology. Any interested government; private or other entities should contact the DARPA Tactical Technology Office. Parties interested in the FREND spacecraft technology should contact NRL's Naval Center for Space Technology.

More information about the FREND project is available online at www.darpa.mil/tto/programs/frend.htm

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