

Space Robotics at the University of Maryland Space Systems Laboratory

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This poster presentation summarizes the research background, technology contributions, and operational experience of the Space Systems Laboratory (SSL) at the University of Maryland. Founded in 1976 to focus on critical technologies for space assembly and advanced operations, the Space Systems Laboratory has been performing active research in space robotics since 1980. This work has focused on the design, development, and extensive testing of a series of fully functional space robotic systems, optimized for a realistic Earth analogue testing environment (neutral buoyancy) and tested against high-fidelity spacecraft mockups whenever possible. The Beam Assembly Teleoperator (BAT) was designed to assemble the same space structure developed and flown by the SSL on STS 61-B in 1985. In addition to successful assemblies of the EASE structure, BAT was also used for investigation of robotic servicing of the Hubble Space Telescope (HST) dating from the late 1980's, as well as the first simulations of direct EVA human/robot collaborations in both structural assembly and satellite servicing applications.

The Ranger system was developed by the SSL in versions for both free-flight and shuttle-based flight demonstrations of dexterous robotics. Designed to be capable of any activity performed by an astronaut in a space suit, Ranger repeatedly performed pure robotic and human/robotic collaborative servicing of HST and other space systems throughout the 1990's up to the present day. The Ranger hardware, although fully capable of operations both in the laboratory and underwater, was specifically designed for space flight, and successfully passed through the NASA Payload Safety Review Program (PSRP) for flight and mission operations on the space shuttle. After the loss of Columbia, no further flight opportunities were available for payload bay experiments, but Ranger was tasked by NASA Goddard to provide independent validation and verification in its neutral buoyancy capacity for the Hubble Robotic Servicing and Deorbit Mission (HRSDM). Temporarily modified by the SSL to replicate the kinematics of SPDM, Ranger performed critical tasks from the HST SM-4 servicing mission up through the termination of the NASA HRSDM program.

Ranger dexterous manipulator technology has progressed significantly since the design phase of that program. With support from DARPA, the SSL developed and prototyped advanced actuator technologies which maintain the human-equivalent capability of the Ranger arms at 1/10 the mass. A new prototype 2DOF elbow module demonstrated that near-human servicing capabilities can be provided with total manipulator masses below 10 kg, including interchangeable end effectors to accommodate standard human interfaces. SSL technologies in mechanical, electronic, and software modularity have been consolidated in the Proteus architecture, based on a series of standard actuator, sensor, and support modules which can self-reconfigure on-orbit to produce custom robotic configurations ideally suited to each different servicing task. Proteus core technologies have already been adapted by the SSL into an exoskeletal robot for severe shoulder rehabilitation, and SAMURAI, a 6000-m rated deep submergence manipulator for use in sampling from autonomous undersea vehicles.

The University of Maryland also has the Neutral Buoyancy Research Facility and a world-class robotics development laboratory, designed from the outset to meet NASA flight certification standards. Current relevant SSL development activities include a flight-rated 50-kg microsatellite with a dexterous manipulator, and miniature manipulators for use on Cubesats, along with advancements in vision-based autonomy and mitigation of teleoperation time delay.