NASA Telerobotics Technology Highlights

C. R. Weisbin, JPL and D. Lavery, NASA

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1. Introduction

The goal of the NASA Telerobotics Program, part of the overall research program of the office of Advanced Concepts and Technology, is to develop the technology in space-borne systems which enables new space tasks in Earth-orbiting satellite and platform servicing; robotic tending of science payloads and instruments; and planetary surface exploration, scientific sampling, and in-situ analysis. Our objective is that by 2004, 50% of the IVA-required operations on orbit and on planetary surfaces may be conducted via remote operation.

The technologies developed for space have important dual uses for commercial areas such as medical robotics, agriculture, and subsea welding; this synergy is being actively encouraged. Moreover, mutually reciprocal collaboration with international partners (e.g. Japan and Russia) has received increasing attention.

The purpose of ibis invited paper is to overview some of the ongoing program activities which are described briefly below.

II. On-Orbit Servicing

Target applications for programs such as Space Station Freedom (SSF), Mission to Planet Earth, and the Space Transportation System (STS) include such tasks as ground based control and repair of free-flying satellites and external space platforms.

The Space Systems Laboratory (SSL) at the University of Maryland has focused primarily on space telerobotic operations, with emphasis on neutral buoyancy simulations of integrated EVA/telerobotic work sites, The Ranger vehicle (two 7-DOF manipulators, 7-DOF grappling arm, and a 6-DOF camera positioning manipulator) is being developed and tested in neutral buoyancy with subsequent incorporation of the technology into a low-cost expendable launch vehicle flight experiment for free-flying space servicing validation.

The Johnson Space Center (JSC) and Martin-Marietta, Denver, have proposed a new initiative entitled Dexterous Orbiter Servicing System which utilizes the flight manipulator delivered as part of the Flight Telerobotic Servicer (FTS) 'J'ethnology Capture Program, 'I 'his provides dexterous manipulation capability for the Orbiter payload bay for activities such as EVA worksite setup, payload operations, and Orbiter repair operations.

The Jet Propulsion Laboratory (J1'1.) has developed automated inspection capability which allows identification of anomalies relative to a given reference, and alerts the operator to possible flaws for verification and action. Examples include the inspection of truss struts for micrometeoroid damage and visible cracks on thermal radiator surfaces, This technology has been successfully tested by JSC in their Automated Robotic Maintenance of Space Station (ARMSS)

laboratory, used to emulate the Canadian manipulator system being designed for SSF.

III. Science Payload Robotics

The Science Payload Robotics element of the program matures technologies for robotics which will be used inside astronaut-occupied environments (i.e. inside pressurized living space) to maintain and service science payloads. Target systems include SSF, Spacel ab and Spacel lab. Illustrative experiments include protein crystal growth experiments, vapor crystal grow h experiments, and plant growth and harvesting.

The Intravehicular Automation and Robotics (IVAR) laboratory at the Langley Research Center (I aRC) and the Laboratory Tending Telerobot Project at]1'1. are being used to develop and demonstrate the technology needed to minimize onboard human part icipat ion and permit experimental ion d uring periods when astronauts may not be present (i.e. during the man-tended phase of SSF).

IV. Exploration Robotics

This element of the program supports the development of robotics to satisfy the planned requirements for exploration of the surfaces of the Moon and Mars. During such missions, robots will explore potential landing sites and areas of scientific interest, place science instruments, and gather samples for analysis and possible return to Earth.

The JPL Rover Technology Program is intended to greatly expand the current MESUR/Pathfinder microrover performance (see Sec. VI below) in the areas of

goal identification, increased vehicle mobility, intelligent terrain navigation, and in-situ sample acquisition and handling.

in preparation for potential lunar missions, Carnegie Mellon University (CMU) has embarked on the design and fielding of legged vehicles for terrestrial geoscience missions at Mt. Erebus (Antarctica) and Mt. Spurr (Alaska) in extremely harsh volcanic environments.

V. Terrestrial Applications

This element of the program addresses NASA terrestrial needs while providing a means for the demonstration of space targeted developed technology in realistic operational settings. These include a Ground Emergency Response Vehicle, developed by JPL, enabling HAZMAT Team personnel remote access to sites where hazardous materials have been spilled or released. The robotic demonstration includes technological advances such as robotic unlocking and opening of doors, climbing stairs, and maneuvering in tight spaces. The Satellite Test Assistant project at JPL is developing a mobile, multi-axis, multi-camera telerobotic inspection system deployed inside the thermal /vacuum satellite test chambers.

A last and important example is the Robotic Tile Inspection System being developed by the Kennedy Space Center (KSC), supported by LaRC, CMU, the Stanford Research institute, and Rockwell International. The task will demonstrate the ability of a semi-autonomous robotic vehicle to inspect surfaces of STS thermal protection tiles for chips and dents, automatically log inspection information into the tile data bases, and re-waterproof lower surface tiles, as well as provide a reconfigurable system that could perform cavity and gap

digitization, non-contact bond verification, and surface contour measurement. These processes are extremely labor intensive under the current manual approach.

VI. Related Flight Projects

in FY '94, MESUR/Pathfinder received a new start as a flight project sponsored by the Office of Space Science. A significant element of that project is the MESUR/ Pathfinder Rover Flight Experiment (MFEX), sponsored by OACT, which will validate technology developed in the Telerobotics Program through the operation of a rover vehicle on Mars.

NASA's Hubble Space Telescope (I 1ST) has been designed and built for periodic on-orbit servicing. The Goddard Space Flight Center (GSFC) is focused toward the control of a manipulator arm (called the Servicing Aid Tool) for worksite preparation, ORU exchange and post EVA closeouts for a planned 11ST 1997 servicing mission,

REFERENCES

1. 1). Lavery and C. R. Weisbin, "Telerobotics Program Plan", January 1993; next release is scheduled for January 1994.

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