HUMAN EXPLORATION OF THE SOLAR SYSTEM SYMPOSIUM (A5)
Human and Robotic Partnerships in Exploration - Joint session of the Human Spaceflight and Exploration Symposia (3-B3.6)

Author: Dr. Christopher S. Langley
MDA Corporation, Canada

Dr. Andrew Allen
MDA, Canada
Mr. Andrew Ogilvie
MDA Space Missions, Canada
Mr. Paul Fulford
MDA, Canada
Dr. Froduald Kabanza
Menya Solutions, Canada

SUPERVISED AUTONOMY AS AN OPERATIONS TOOL FOR DEEP SPACE ROBOTICS

Abstract

Human missions to deep space destinations such as Mars and Earth-Moon Lagrange point 2 (EML2) will require considerable infrastructure for safe exploration. To maximize the return of such a large exploration endeavour, the crew should spend a minimal amount of effort to maintain this infrastructure. Extravehicular robotics can be used to sustain deep space infrastructure when it is in a crewed or an uncrewed state, reconfigure infrastructure elements, assist crew in achieving mission objectives, and enable greater crew independence in an environment presenting stringent communications constraints with mission control on Earth.

The key questions to address when extending existing Low Earth Orbit robotic capabilities to deep space applications are:

- How can crewmembers operate the robotics in a safe, flexible, time-efficient way, independent of ground oversight?
- How can ground operators safely and effectively operate the robotics in the presence of time-delay, constrained bandwidth, and communication dropout conditions?

This paper discusses the prospective benefits of supervised autonomy for extravehicular robotics and how these key questions can be addressed. Planning tools will enable efficient task and trajectory planning at variable levels of autonomy by ground or crew operators, and technologies for automated execution of actions with accompanying telemetry monitoring will ensure safe and efficient deep space operations. Considerable cost savings can be realized over the lifetime of the infrastructure by reducing the level of effort required to plan and replan operations. Productivity and utilization of the infrastructure can be increased by speeding up the pace of planning and executing ground-controlled tasks.

For safety and mission assurance, lessons learned for Mobile Servicing System (MSS) ground control can be applied and extended to ensure that a command given to the robotic system is safe to execute without an operator monitoring its progress. For example, each step must result in a deterministic safe end state within a finite duration. In the near term, supervised autonomy can be matured by incremental technology demonstrations using the MSS, and could conceivably be incrementally adopted for ISS operations starting with ground control activities.

This paper will present the elements of the proposed supervised autonomy planning and execution architecture for Deep Space Robotics. It also will include a technology development roadmap for the system, starting from the current level (TRL 3), through ground experiments, to demonstration tests on the Mobile Servicing System on the International Space Station.