Concepts for the Evolution of the Mobile Servicing System

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Abstract
The Mobile Servicing System (MSS) performs critical assembly and maintenance tasks on the Space Station. This paper discusses the following specific enhancements the MSS baseline configuration:

1) Enhancements to the MSS Failure Management;
2) Remote Control of the MSS from the Ground;
3) Vision-based control of MSS manipulators;
4) High-dexterity MSS tools.

Introduction
The Mobile Servicing System (MSS) is part of the International Space Station (ISS) where it provides the robotic capabilities needed for on-orbit assembly, external maintenance, payload servicing, berthing and deployment of visiting spacecraft and many other functions.

As the first flight elements of the MSS have been launched and installed on the ISS, and the fabrication of the last element nears completion, it is time to develop concepts for the evolution of the MSS during its lifetime.

Summary
The diversity of the tasks to be performed and the need to reach worksites all over the Space Station drive the design of the MSS towards a mobile system with multiple manipulators. The large Space Station Remote Manipulator System (SSRMS) is designed to perform the capture, manipulation and berthing operations for large payloads. MSS functions requiring dexterous capabilities are satisfied by the smaller, dual-arm Special Purpose Dexterous Manipulator (SPDM). The elements of the MSS are connected through a common computer and video network, and are controlled from one of two Robotic Work Stations (RWS) in the pressurized environment of the Station.

This paper discusses four specific proposals for upgrades to the MSS baseline configuration which will:

1) enhance the performance, efficiency and robustness of the MSS in its current role, and
2) enhance the capabilities of the MSS such that it can perform additional tasks and further relieve crew from Extra-Vehicular Activity (EVA).

The proposed enhancements to the MSS Failure Management and Safing Architecture would complement the current architecture, which is based on having two completely independent redundant strings for all critical functions, by allowing operation of remaining functionality in each string in the presence of persistent failures, thus significantly reducing the risk of “crippling” a manipulator like the SSRMS by failures affecting both functional strings.

Remote control of the MSS from the Ground would obviously reduce the reliance on the ISS Crew to perform all robotic operations. In particular, the dexterous robotics operations performed with the dual-arm SPDM, such as the change-out of Orbit Replaceable Units (ORUs) for ISS maintenance, are very complex and time-consuming and are prime candidates for ground-controlled robotic operations. The basic technology for remote teleoperation is established and the MSS architecture has been designed to allow upgrade to a ground-control capability. Safety is a key consideration for the implementation of such a capability.

Vision-based control of the MSS manipulators, in a limited manner, can be implemented fairly easily using the Automatic Vision Unit (AVU) which is already part of the MSS. The AVU performs photogrammetric image processing in real-time to aid human operators. Its outputs can be used for automatic robot control.

The concept of a high-dexterity MSS tool is essentially to develop a “Robotic Hand” which can act as an extension to the SPDM and provides dexterity rivalling of an astronaut’s gloved hand with the objective to reduce EVA requirements. Even though a number of Robotic Hands have been developed, significant challenges remain with regard to the qualification of such a tool and its integration into the MSS system architecture.

Conclusion
Each one of the proposed enhancements adds useful capabilities to the MSS and should be evaluated for implementation on its own merits.