Enabling Advanced Automation in Spacecraft Operations with the Spacecraft Emergency Response System

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Abstract:

True autonomy is the Holy Grail of spacecraft mission operations. The goal of launching a satellite and letting it manage itself throughout its useful life is a worthy one. With true autonomy, the cost of mission operations would be reduced to a negligible amount. Under full autonomy, any problems (no matter the severity or type) that may arise with the spacecraft would be handled without any human intervention via some combination of smart sensors, on-board intelligence, and/or smart automated ground system.

Until the day that complete autonomy is practical and affordable to deploy, incremental steps of deploying ever-increasing levels of automation (computerization of once manual tasks) on the ground and on the spacecraft are gradually decreasing the cost of mission operations. For example, NASA's Goddard Space Flight Center (NASA-GSFC) has been flying spacecraft with low cost operations for several years. NASA-GSFC's SMEX (Small Explorer) and MIDEX (Middle Explorer) missions have effectively deployed significant amounts of automation to enable the missions to fly predominately in "light-out" mode. Under light-out operations the ground system is run without human intervention. Various tools perform many of the tasks previously performed by the human operators.

One of the major issues in reducing human staff in favor of automation is the perceived increased in risk of losing data, or even losing a spacecraft, because of anomalous conditions that may occur when there is no one in the control center. When things go wrong, missions deploying advanced automation need to be sure that anomalous conditions are detected and that key personal are notified in a timely manner so that on-call team members can react to those conditions.

To ensure the health and safety of its lights-out missions, NASA-GSFC's Advanced Automation and Autonomy branch (Code 588) developed the Spacecraft Emergency Response System (SERS). The SERS is a Web-based collaborative environment that enables secure distributed fault and resource management. The SERS incorporates the use of intelligent agents, threaded discussions, workflow, database connectivity, and links to a variety of communications devices (e.g., 2-way paging, PDA's, and Internet phones) via commercial gateways. When the SERS Detects a problem, it notifies on-call team members, who then can remotely take any necessary actions to resolve the anomalies.

The SERS goes well beyond a simple "911" system that sends out an error code to everyone with a pager. Instead, SERS' software agents send detailed data (i.e., notifications) to the most appropriate team members based on the type and severity of the anomaly and the skills of the on-call team members. The SERS also allows the team members to respond to the notifications from their wireless devices. This unique capability ensures rapid response since the team members no longer have to go to a PC or the control center for every anomalous event.

Most importantly, the SERS enables safe experimentation with various Techniques for increasing levels of automation, leading to robust autonomy. For the MIDEX missions at NASA GSFC, the SERS is used to provide 'human-in-the-loop' automation. During lights-out operations, as greater control is given to the MIDEX automated systems, the SERS can be configured to page remote personnel and keep them informed Regarding actions taking place in the control center. Remote off-duty operators can even be given the option of enabling or inhibiting a specific automated response in near real time via their two-way pagers.

The SERS facilitates insertion of new technology to increase automation, while maintaining the safety and security of mission resources. This paper will focus on SERS' overall functionality and how SERS has been designed to handle the monitoring and emergency response for missions with varying levels of automation. The paper will also convey some of the key lessons learned from SERS' deployment across of variety of missions, highlighting this incremental approach to achieving 'robust autonomy'.