Astrobee Operations on the ISS: GUI's Impact on the Operators' Cognitive Load

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Abstract

The Astrobee free-flying robots have completed their fifth successful year of operations housed in the Japanese Experimental Module (JEM) on the International Space Station (ISS). In this paper, we introduce two Graphical User Interfaces (GUI): the Ground Data System (GDS) and GDS Helper, used to operate and monitor in real-time the Astrobee free-flying robots onboard the ISS. We report on the impact these GUIs have on the operator's cognitive load. A review of the state-of-the-art GUI design for remotely teleoperated scenarios with minimal time delay is presented. The study's conclusion is used to determine the elements and recommendations to create an interface that minimizes its impact on the overall performance of an operator during an activity on the ISS.

GDS contains several tabs displaying different sets of controls for specific tasks e.g. Overview, Run Plan, Teleoperate, Guest Science; some also display video and a three-dimensional (3D) representation of the ISS and robot based on the Astrobee's telemetry. Most tabs enable a single operator-robot connection, however some of its tabs are capable to monitoring and controlling up to three Astrobees simultaneously. GDS Helper is a text-based interface created to facilitate commanding and monitoring of an Astrobee robot directly from an SSH terminal session. In full interactive mode it displays a maximum of 5 sections: general commanding, feedback/ack, telemetry, guest science commanding, and data, all in one view. In batch mode, it enables complex command scripting while retaining some interactive capabilities.

A comparative analysis between these GUIs is carried out at an analogous ISS environment at NASA Ames Research Center's Granite Lab and its results presented. While GDS is able to provide an operator with control and situational awareness via its video and 3D displays, its several tabs may confuse and delay the operator especially during time-sensitive maneuvers where the operator needs to switch between them. GDS helper does not provide tools to allow an operator to attain situational awareness, however it provides the operator with a single window design, enabling the understanding of the robot's state at a glance and controlling it solely through commands via keyboard input. The results of the experiments measure the cognitive load across several operators maneuvering Astrobee to accomplish tasks ranging from fully manual to supervised activities. A GUI combining a single data display along with video and a 3D display is expected to reduce the operator's cognitive load.