

# Spatial Auditory Displays for Enhancing Situational Awareness during Non-terrestrial and Remote Exploration

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*Abstract*—During Extra-Vehicular Activities (EVA), the EVA astronaut must maintain situational awareness (SA) of a number of spatially distributed "targets" such as other team members (human and robotic), the rover, the lander/habitat or other safe havens. These targets are often outside the astronaut's immediate field of view and visual resources are needed for other task demands. The authors have been developing real-time spatial auditory display systems and investigating their use in applications such as navigation in virtual environments, tele-robotic control, and caution and warning systems. Initial development efforts in ambient auditory displays for SA resulted in a demonstration of an "orientation beacon" display at NASA Ames specifically for EVA applications. This auditory display prototype created an ambient environment with non-intrusive "beacons" that enhance situational awareness without imposing undue

distraction or workload. Current work has focused on the development of a software test bed for experimental evaluation of a revised beacon display prototype, an audio-visual simulation of a spatial audio augmented-reality display for tele-robotic planetary exploration on Mars. Recently, a study was completed that compared performance with different types of displays for aiding orientation during exploration: an auditory orientation aid, a 2D visual orientation aid, and a combined auditory-visual orientation aid. Preliminary data have confirmed the hypothesis that the presence of spatial auditory cueing enhances performance compared to a 2D visual aid, particularly in terms of shorter average response times to orient toward and acquire a target outside the field of view. Future work will address the usability and efficiency of 3D audio in the context of multimodal displays for aiding orientation, navigation, and way finding during non-terrestrial exploration.