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LUNAR HUMAN-ROBOT TEAMING REQUIREMENTS

Abstract

Multiple government organizations, such as the U.S. National Aeronautics and Space Administration, are currently planning efforts to return humans to the Moon. However, unlike the earlier Apollo missions, the Artemis missions will not be "flags and footprints" short-duration sorties but rather longer term missions of increasing duration, many returning to previously visited locations, such as the lunar south pole. To support this, NASA is developing a mission architecture requiring both the accumulation of supporting infrastructure and investigations into the utilization of in-situ resources located near the ultimately selected site(s). In response, many authors commonly produce studies attempting to show how potential lunar surface activities can be completed using an all-robotic workforce. In many cases, the all-robotic workforce is touted either close a business case by reducing the costs associated with human surface activities, reduce technical complexity, or reduce risk. To be sure, the elimination of a requirement for human "boots-on-the-ground" would itself eliminate a significant mission cost-driver from the economics of any business case, reduce the complexity of the overall surface architecture, and reduce the risk to human life; however, we believe this is not a realistic near-term assumption. While robots are appearing with greater frequency in highly controlled and well understood industrial environments such as factory assembly lines, they are not yet able to operate in environments about which we know so very little. In addition, their ability to make deft self-repair or repairs of other robots or machinery is unproven. Secondly, and in stark contrast, our understanding of the lunar environment is scant, especially when considering locations such as the lunar south pole which possess unique environmental characteristics and which have never been visited. Of the information we do have, the preponderance suggest enormous challenges are posed, not just by the general space environment, but also by the extreme hostility of the lunar regolith to mechanical components, to name just one. Thus, in a potential lunar south pole scenario, the environmental conditions the robot(s) will be exposed to include a critically high number of unknowns underlying already known challenges. This paper will examine the requirement for at least intermittent human surface intervention to do what humans do best: adapt and innovate to unexpected and challenging conditions. Much of this would involve rescuing, repairing and adapting the first generations of robots and vehicles once on the lunar surface where the actual field testing of the equipment will occur.