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EVALUATING THE UTILITY OF ROBOTIC PRECURSOR, ASSISTANT, AND POSTCURSOR PARTNERSHIPS IN SUPPORT OF HUMAN LUNAR EXPLORATION

Abstract

During the half a century that has passed since the Apollo missions, there has been a revolution in robotics. Human and robotic partnerships in exploration are currently being explored, but significant questions remain as to the utility and benefit(s) of such partnerships. Three main potential partnership phases are envisaged: 1) robotic precursor activities, whereby a rover is sent to the site of future human surface operations some time (weeks to months) in advance; 2) robotic assistant activities during human surface operations; and 3) robotic postcursor activities, where the rover continues operations after the astronauts leave the field site.

Here, we present the results of an evaluation of the relative effectiveness and utility of robotic precursor, assistant, and postcursor partnership based on an analogue mission carried out over two successive years at the Mistastin Lake impact structure, Canada. The Mistastin structure was chosen due to its exceptional attributes as a lunar analogue site: it is relatively well-preserved – with a series of impact melt rocks, breccias, and ejecta deposits – well exposed in the tundra of northern Labrador, and formed in a target rich in anorthosite, the dominant rock type of the lunar highlands.

In year 1, we carried out detailed landing site selection evaluation activities using satellite data equivalent to what is available for the Moon. This was followed by the simulated robotic precursor mission. In year 2, two separate week-long human sortie missions were conducted at two separate sites, with the rover acting as an assistant. In advance of the human missions, a series of EVA traverse planning workshops were held that used and integrated the satellite and robotic precursor data from the previous year. This was followed by 4 days of postcursor robotic operations. For all phases, a mission control team with no prior knowledge of the field site – except what they could gain from satellite images – was based at the University of Western Ontario, London, Ontario, 1,900 km away from the field site.

The results of our analogue mission activities clearly demonstrate the utility of robotic precursor and postcursor activities. The major value of the robotic precursor mission was surface geology visualization and data at superior resolution, and from viewpoints not achievable from orbit. This data provided enhanced situational awareness of the landing site that enabled better EVA planning and the derivation of hypotheses that could be tested and evaluated in the field by the astronauts. The postcursor activities enabled the hypothesis testing to continue following the departure of the astronauts, both through the collection of further data from locations visited by the astronauts, plus by extending the rover's travel network to new sites.

In terms of the robotic assistant, we found that while the assistance of the astronaut greatly enhances the performance of the robotic exploration, it comes at a cost of astronaut EVA time. However, the key question for assessing value obtained from a mission is the performance of the mission as a whole, considering the value delivered by the human and robotic assets together. In this respect, having a robotic assistant onsite enabled the extension of operations time available through parallel work outside of EVA time and in off-loading particular tasks from the astronauts.