The Role of Robotic Missions in a Lunar Outpost Strategy. M. B. Duke, 1030 Sunset Canyon Dr. S., Dripping Springs, TX 78620.

A coherent strategy for a lunar program leading to a permanently inhabited lunar outpost should include a series of robotic missions for science, site selection and verification, and technology demonstration and early pilot plants for ISRU. These missions could be carried out at a rate of 1-2 per year for 5 years prior to the first human missions and could have the following benefits to the program:

1. Conduct high priority lunar science. This would answer major science questions and add important information to that from which a final site for a permanent outpost would be selected. Scientific progress made by the program would provide regular and visible accomplishments directly linked to the sustainability of the human program.
2. Develop and demonstrate technology, in particular, lunar resource extraction and utilization (ISRU) demonstrations that would enhance the performance of the early human program. Robotic missions that can be launched on Intermediate boosters are capable of emplacing pilot plant scale systems on the lunar surface that could provide a cache of consumables or propellants for the first human explorers.
3. Answer the question of whether there are recoverable resources near the lunar poles.

The robotic program can have the goal of gaining global access for the emplacement of a geophysical network of up to six stations. The interests of the human program should include polar, equatorial and intermediate sites, including the far side. Although some of these sites will not be visited by humans in the near term, many technology demonstrations do not need to be done at geologically unique sites and can be incorporated into any mission.

Costs of the robotic program can be minimized by designing a workhorse lander, capable of emplacing experiments, conducting demonstrations, deploying rovers and returning samples. Experience in designing the Moonrise (South Pole – Aitken Basin Sample Return) mission suggests that a single Intermediate launcher from Earth can emplace both a surface station and a sample return mission as separate landers. Landers should be designed such that they do not have tight margins that increase development costs and lead to discarding planned experiments when margins are exceeded in the design process. They should be able to carry a variety of packages and deploy them on the lunar surface.

Conducting a planned program of six launches allows recovery of experiments should a mission be lost or misdirected, lowering the overall risk of attaining results desired by the program. Conducting the program over a period of 5-6 years allows some feedback of information from earlier missions to later ones, and into the human program.

A scientific strategy suggested in the NRC report "The Scientific Context for the Exploration of the Moon"[1] illustrates a possible mission set: (1) one (or two) lunar polar landers to explore the physical and chemical conditions prevailing in and near permanent shadow; (2) emplace a global geophysical network; (3) conduct two sample return missions from the South Pole – Aitken Basin; (4) utilize the technology and infrastructure developed to target areas such as the Aristarchus Plateau or the youngest basalt flows. This could be combined with emplacement of a global communications and navigation system, demonstration of technology for regolith moving and ISRU systems, landing and ascent system validation; robotic deployment of power systems, and other technology demonstrations. All of this could be accomplished by 3-4 New Frontiers class missions, probably equivalent to the cost of one human mission to the lunar outpost.

Long-term power is a critical technology for lunar surface missions, both robotic and human. Providing power for long nights, up to 14 days except at the poles, is essential for survival during the lunar night. Either a new generation of rechargeable energy systems or radioisotope devices will be needed to optimize a global robotic program.

Reference: Space Studies Board (2007) *The Scientific Context for Exploration of the Moon*, National Academies Press.