**ASSESSING THE RESOURCE POTENTIAL OF THE MOON: THE CASE FOR A DECADAL-SCALE ROBOTIC LUNAR EXPLORATION PROGRAM.** R.S. Wegeng[1], A. Abbud-Madrid[2], and D. Boucher[3], [1]Battelle Memorial Institution (PO Box 999, Richland, WA 99352; robert.wegeng@pnl.gov), [2]Colorado School of Mines (aabbudma@mines.edu), [3]Northern Centre for Advanced Technology (dboucher@norcat.org).

**Introduction:** Many problems must be overcome for human civilization to thrive throughout and beyond the 21st Century. Among them are the seemingly unrelated problems of economic access to space; the continuing depletion of Earth's material resources in order to maintain national and international economies; and conflicts among culturally different nations, sometimes of different political ideologies.

At least a portion of these problems may be resolved through the application of resources from the Earth's nearest neighbor, the Moon.

**Potential Lunar Resources and their Applications:** The confirmation that volatiles, especially water, are present in cold traps in the Moon's polar regions have recently generated intensifed discussions on how lunar resources might serve cis-Lunar space operations and NASA's ambitions for the exploration of Mars. For example, if propellant depots are established in Earth orbit, they may be supplied more economically from the Moon than from the Earth and may become the first products of economical value from the Moon.

Other volatiles that are believed to have migrated into lunar cold traps include methane and other hydrocarbons, oxides of carbon, and ammonia – basically the constituents of comets – providing the elements needed in order to grow food on the Moon. In short, the cold traps may be chemical repositories that enable human lunar settlements, providing both consumables for the settlements and exportable products.

The economics of settlements may be further enhanced through their use of some of the major elements of the Moon, for example, aluminum, iron and titanium for structures and silicon for solar cells, thereby reducing what must be brought from the Earth to the Moon. In turn, the presence of lunar mining settlements may lower barriers associated with other possible uses of lunar resources, such as materials and/or components for space solar power satellites which would perhaps justify the construction of electromagnetic launch systems on the lunar surface. Inexpensive launch capabilities might additionally enable favorable economics for transporting high value elements to the Earth, for example platinum-grade metals from the meteoritic component of regolith or other elements from the maria or highlands of the Moon that might be used in terrestrial energy and/or electronics components (e.g., tellurium for cadmium-telluride solar cells).

While this sequence is notional and incomplete, it is nevertheless illustrative of the kind of evolving, growing economic scenarios, invoking positive feedback loops, that will be necessary in order to colonize bodies other than the Earth.

**A New Kind of Exploration Program:** In order to evaluate whether lunar resources can enable more affordable space activities or provide solutions for terrestrial problems, a campaign of lunar surface missions, perhaps a decade in length, are needed to accomplish the following objectives:

- Identify the locations, forms, and concentrations of lunar resources (i.e., *resource prospecting*),
- Evaluate various methods of extracting and processing lunar resources *(i.e., technology development and demonstrations*), and
- Determine the institutional conditions that would enable the productive use of lunar resources (i.e., *economics evaluations*).

Because the Moon is in close proximity to the Earth, a lunar exploration program designed to accomplish these objectives does not require a human lunar presence. The program, in fact, can be conducted in the context of a new space exploration paradigm – *participatory exploration* – where students and other members of the public, including people of multiple nations, are highly engaged in the cooperative and collaborative exploration of the Moon.

**Conclusions:** During the next decade, the Moon can be the setting for the accomplishment of a new kind of exploration program, one that has the triple goals of 1) assessing the resource potential of the Moon, 2) substantially supporting national education objectives and 3) broadly engaging international partners in peaceful space exploration activities.

The effort may lead to the use of lunar resources to reduce the mass of what must otherwise be launched from the Earth, making operations in cis-Lunar space more affordable; to support the human exploration of Mars and other destinations beyond Earth's orbit; and to provide affordable, sustainable energy systems for the Earth and/or solutions to other materials-related terrestrial problems. In the end, a determination that lunar resources are economically useful and important to society may constitute the strongest possible rationale for the return of humans to the Moon.