ISRU WILL MAKE THE DIFFERENCE BETWEEN GOING BACK TO THE MOON TO VISIT AND GOING BACK TO THE MOON TO STAY. B.L. Cooper[1] and D. G. Schrunk[2], [1]Oceaneering Space Systems (16665 Space Center Blvd., Houston TX bcooper@oceaneering.com) for first author, [2]Quality of Laws Institute (docscilaw@aol.com).

"Living off the land" is the principle of in-situ resource utilization (ISRU). Throughout history, settlers of new lands brought their essential tools and equipment with them, but otherwise relied upon in-situ resources for their survival and growth. The migration of humanity to the Moon will be no different than previous migrations; the first humans on the Moon will bring their tools and survival equipment with them, but they will use indigenous resources for further development.

The tools and technologies that must be developed for ISRU are applicable to other purposes. Transportation of raw materials on the lunar surface teaches us how to operate in the harsh environment of space, whether the goal of the operation is ISRU, exploration, or scientific research. If ISRU were not being contemplated, most of the tools and techniques involved would be needed anyway. Trenching and drilling techniques are required for landing site preparation (burying utility cables, drilling post holes for masts). Haulers are needed for building berms to shield habitat modules from the dust stirred up by ascending or descending vehicles. Perhaps most importantly, ISRU engineers are already developing seals for pressure vessels in a dusty environment. When it becomes possible to construct sealed and pressurized underground chambers on the Moon, optimum conditions can be created for every manufacturing, agricultural, scientific, and human habitation purpose (Figure 1). Whether our destination is the Moon, Mars, or points beyond, we are likely to encounter dust, and it will present challenges for seals and airlocks.

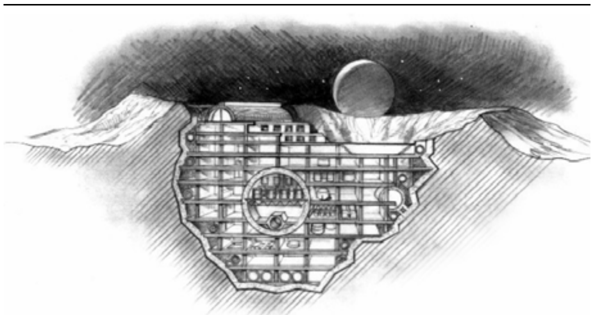

Figure 1. ISRU development includes seals that can be used both for pressure vessels and air locks. ISRU Excavation and construction enable the advanced lunar base. Illustration by Paul DiMare, from [9]; used with permission.

Radiation shelter is another important use of ISRU, because regolith is a pre-existing, low-technology way to mitigate the hazards to humans of Solar Energetic Particle Events. The capability to do excavation and construction on the Moon is Mars-forward, because longer stay times at Mars require the preparation of radiation shelters in advance of human arrival.

Another use for regolith is for berms to protect habitats and surface structures from the blast of dust generated by ascent and descent of lunar landing vehicles. Machines controlled from Earth will help to establish the process of "living off the land" by using available solar power. If they have a continuously available communications path to the Earth for receiving instructions and returning data, they can be supervised from Earth, reducing the need for either machine autonomy or supervision by the crew, whose time will be oversubscribed. The harsh conditions of the lunar environment will present challenges for the establishment and operation of machines and equipment. Technology developments needed to operate equipment on the Moon will be useful on Earth as well, for improving reliability of excavation systems both in humid and arid regions.

Studies conducted over the past 40 years [1-8] have shown that ISRU is an investment in our future—both for settlement of the Moon and for exploration of Mars and ever more distant locations. With various initial assumptions, almost all of the trade studies concluded that oxygen production would be economically beneficial for lunar base development. Large quantities of propellant will be required for an expanded human presence in space, and most of the mass and volume of this propellant is due to the oxidant (usually oxygen) that is required for the chemical reaction. Oxygen comprises approximately 42% of the material on the surfaces of the terrestrial planets, and finding a way to extract oxygen from regolith is likely to be one of the earliest forms of ISRU.

The Moon has all of the elements that are found on the Earth, including an abundance of iron, oxygen, aluminum, titanium, and silicon. Iron, titanium, and aluminum will be used for structures; aluminum can also be used for electrical cable and rocket propellant; and silicon will be used for solar cells, computer chips, and telecommunication (fiber-optic) cable. When the mining and manufacturing equipment for ISRU are in place on the Moon, a permanent utilities infrastructure can be constructed and global human settlement will then be possible (Figure 2).

Figure 2. When the mining and manufacturing equipment for ISRU are in place on the Moon, a permanent utilities infrastructure can be constructed and global human settlement will then be possible. Illustration by Paul DiMare, from [9]; used with permission.

The key to living permanently on the Moon is having the ability to produce everything that is needed from local materials. ISRU technologies developed for the Moon will eventually give us a “sister planet” and provide the benefits of settling new territories that are seen throughout history. ISRU will also, either directly or indirectly, enable human settlement of Mars.

When we are able to live permanently on the Moon, the human species will be protected against extinction by a catastrophic event on the Earth, such as a nuclear or biological war or the collision of a large asteroid. ISRU will make the difference between going back to the moon to visit and going back to the moon to stay.

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