Introduction to *Lunar Pioneers*
A forthcoming science-fiction book by Phil Harris
Final Draft, 4/02/2009

PROLOGUE

Fiction can be a way of entering into the future. Many of tomorrow's possibilities discussed in past science fiction are today's realities. What humans imagine can, in time, be transformed into experience. ***Lunar Pioneers*** is such a book, for it is based on the authors' scientific research and professional publications.* For example, Dr. David Schrunk has been involved in implementing the "Planet Moon Project" which is summarized below as an introduction to our novel.

Lunar Development in the 21st Century

The spectacular advances of science, engineering, and the humanities in the 20th century established the basis for creating permanent human settlements in space in the 21st century. Since the Moon is our closest celestial neighbor and is in orbit around the Earth, it will logically be the next principal focus of human exploration and settlement. The Moon is an unparalleled platform for astronomy and other scientific investigations, and for technological development. It also has access to the virtually unlimited energy and material resources of space, which can be applied to the global exploration and expansion of the Moon. Excess solar-electric power that is generated on the Moon can potentially supply the Earth with all of its future needs for clean, low-cost energy. These opportunities, combined with the universal desire of humanity to explore and settle new lands, assure that the global transformation of the Moon into an inhabited sister planet of the Earth will become a reality in this century.

A major impediment to the exploration of space is the high cost of delivering cargoes from the surface of the Earth into space. For example, the cost of launching a payload into low earth orbit by the Space Shuttle is approximately $10,000 per pound, and that figure will be an order of magnitude higher for missions to the Moon. Thus it appears that even limited lunar projects will be prohibitively expensive, even with the design of an improved lunar transportation system. However, there are three emerging technologies that may delimit the cost of lunar industrial and scientific activities.

First, new generations of more cost-efficient, less complex launch vehicles will become available for space missions in the decades ahead. Second, advances in micro-device technology and the miniaturization of complex optoelectromechanical systems toward the nanotechnology regime will mean that increasingly smaller, yet more capable payloads can be delivered to the Moon. Third, and most important, methods will be developed for using lunar resources to manufacture everything that is needed on the Moon itself, rather than shipping goods from the Earth. This process of "in-situ resource utilization," or ISRU, will herald the most dramatic reduction in the cost of lunar projects. Finally, global economic instabilities, climate change, overpopulation, and excessive exploitation of Earth's resources, will motivate humanity to utilize more space resources and to benefit from offworld enterprise.

Industrial processes on our home planet use energy, raw materials, labor, and machines to manufacture sophisticated products such as computers, medical imaging devices, launch vehicles, and

---

- See *The Moon: Resources, Future Development, and Settlement* (2008) by David Schrunk, Burton Sharpe, Bonnie Cooper¸and Madhu Thangavelu….*Space Enterprise – Living and Working Offworld in the 21st Century* (2009) by Philip Robert Harris, Both books are published by Springer/Praxis (www.springer.com).

communication satellites. Within the next two decades, it will become possible to use lunar regolith (Moon dirt) as feedstock to manufacture equally sophisticated products in lunar factories. Few of the processes or tools for doing so yet exist in a mature form** - they will have to be developed from existing technologies as we go, essentially "bootstrapping" from small caches of Earth-manufactured machine tools, communications devices, and other portions of payloads yet to be defined. Once these technologies and innovations beyond Earth have been developed for lunar purposes, they will have ubiquitous applications in outer space on asteroids, planets, and moons throughout the solar system.

The Moon has a reliable source of energy in the form of sunlight, and the lunar regolith contains abundant supplies of iron, silicon, aluminum, [magnesium, titanium, calcium] and oxygen. The regolith also contains helium-3, an isotope that holds promise as the ideal fuel for future fusion reactors, and traces of other light elements such as carbon. In addition, the past *Clementine* and *Lunar Prospector* satellite missions detected and mapped increased hydrogen concentrations in the north and south polar regions, suggesting the presence of water-ice in these areas. Scientific data will be gleaned from these lunar materials and resources, and they will then become the feedstock for manufacturing processes and other lunar base activities.

Thus a significant reduction in the cost of space projects can be achieved by simply transporting the basic components of Earth's industrial base, such as mining and processing equipment, lathes, drills, ovens, robots, and electro-mechanical control devices, to the Moon. The *lunar* industrial base will then use solar energy and indigenous materials to manufacture the tools and products that are needed to begin the global transformation of the Moon into an inhabited planet. Through many iterations using a "learn as you go" approach, increasingly sophisticated tools and products will be manufactured on the Moon. By this means, the costs associated with transporting materials from the Earth to the Moon will be reduced drastically, and large-scale, economically viable space projects will become a reality. This process will also inaugurate the development of a twin-planet economy between Earth and its sister Moon.

Initially, the "labor" component of lunar industrial processes will be performed by teleoperated and autonomous robotic devices that have been delivered to the Moon. Teleoperation is the process by which remotely located devices are controlled using visual and haptic ? feedback systems. It is widely used on the Earth for diverse applications such as mining, undersea projects, and even certain surgical procedures (e.g., telemedicine). It is fortuitous that the Moon always has the same face directed to the Earth and that the round-trip time for communications between the Earth and the Moon is less than three seconds. Telemedicine is another application of such communications technologies, so that medical treatment and procedure that originate on Earth can be applied to lunar dwellers. These conditions will allow Earth-bound operators of lunar telerobotic devices to have a virtual presence on the Moon 24 hours per day, 365 days per year. Furthermore, robots will become vital in lunar health care systems. .

The site for the first unmanned base will likely be on the Earth-facing side of the south polar region of the Moon. There are several promising sites in the south polar region, such as the summit of Malapert Masif, that always have the Earth in view for continuous telecommunications, and that receive over 300 days of sunlight per year for the generation of solar electric power. A south polar base will have access to increased concentrations of hydrogen (possibly water-ice) that will be useful for industrial operations and eventual human habitation. The tall peaks and deep depressions of this region also offer the opportunity for the placement of long line-of-sight telecommunication links and power beaming facilities.

Many countries currently have rocket launch systems that can be modified to place payloads on the Moon. In one scenario for the establishment of a lunar base, one or more of these rocket systems will be used to transport solar panels, communication systems, scientific equipment, and other payloads from the Earth to the south polar region of the Moon. When these components are in place, tele-operated and autonomous rover vehicles will explore the lunar surface and transmit data back to Earth for analysis. Protocols for the preservation of unique features of the lunar environment will be observed, and scientific data will be obtained before local materials are utilized for experiments. When surveys and analyses have been completed, experiments in the production of bricks, wires, transistors, and glass products from lunar regolith materials will begin. These pioneering activities will be ongoing 24 hours per day, and there will be opportunities for direct participation by virtually anyone on Earth via the Internet.

Since abundant, reliable electrical power is the key to any large-scale development, priority will be given to the fabrication of solar cells from lunar materials. The generation of electric power on the Moon from the first lunar-made solar photovoltaic cell will be a milestone in space exploration because it will prove unequivocally that human enterprises can be self-supporting in space. From that beginning, lunar-made solar cells will be added to the electric power system of the lunar base. As electric power levels then grow, additional scientific and manufacturing equipment will be delivered from the Earth, and the lunar base will expand in all of its capacities.

Within a decade after the first unmanned base has been established, humans will return to the Moon on short-duration missions (60-90 days) to service and maintain complex machinery and to supervise operations. Initially they will live and work in lunar lander spacecraft evolved from present-era technology. During the build-up of the first lunar base, controlled ecological life support systems (CELSS) will undergo continued research and development on Earth and on the International Space Station. Work will also commence with the development of reusable rocket systems and orbiting stations in figure 8 orbit, so as to ferry more people between the Earth and the Moon. When a reliable lunar electric power system is in place and pressurized underground habitats (for protection from radiation, temperature extremes, micrometeorites, and lunar dust) have been constructed, regenerative life support systems and agricultural modules will be delivered to the lunar base. Humans will then return to the Moon for longer periods, and all aspects of lunar base activities will be expanded until the lunar industrialization and settlement is sufficiently mature, to enable further planning for human missions to Mars and its moons, as well as to other areas of interest in our solar system.

In this same time frame, the solar-electric power system will be expanded in east and west directions from the lunar base to create a circumferential electric grid. The advantage of a solar powered electric grid that is placed around the circumference of the Moon is that 50% of the solar panels will always be in sunlight, thus delivering continuous electric power to the grid. Energy in the grid can be transferred so that consumers - new arrivals - can simply “plug and play” into an extant electric power system.

The construction of the lunar power system will give rise to the need for an efficient surface logistic system that can deliver tools, building materials, and people between manufacturing facilities and construction sites without disturbing the cohesive abrasive dust of the lunar surface. To meet these needs, a railroad system will be developed either above or below the lunar surface. The "lunar railroad" would be an effective, efficient, and simple (mostly automated) logistic system on the Moon, and it would avoid most of the problems of lunar dust accumulation that plague "off-road" vehicles. Iron rails for the railroad could be made from lunar iron, for example, to construct a simple two-track rail line from the first base to other areas in the south polar region, including the geographic south pole. A "southern rail line" would greatly expand the ability to carry out exploratory missions and would facilitate the growth of all lunar projects. The challenge of building the circumferential rail system would be similar to the challenge of building the solar-powered electric grid, and both construction projects could thus be undertaken simultaneously. Since communication systems and pipelines for thermal management and the transport of fluids will be needed on the Moon, these infrastructure elements would also be constructed in parallel with the railroad and electric power networks.

As the railroad and other infrastructure elements grow and eventually become linked together, the first circumferential utility network, extensive geologic expeditions will be carried out in the south polar region. The lunar industrial base will produce products and scientific instruments, including optical and radio telescopes, that will initially be placed at the south pole and the far side of the Moon, respectively. The rail line and other utilities will be extended northward to the mare / equatorial regions of the Moon, and then to the north pole.

Power levels in the circumferential grid will rise to the multi-megawatt range as construction of the utility infrastructure continues, and experiments will be conducted with the first microwave beaming of electric power from the Moon to the Earth. With continued growth, it will become possible to supply the Earth with terawatt levels (one terawatt = one trillion watts) of clean, low-cost solar electric power. Lunar development will thus contribute to increased living standards on Earth and to the "greening" of Earth's biosphere through less need and usage of fossil and fission fuels. Revenues from the sale of electric power to Earth, Moon, and cis-lunar markets will support the expansion of the lunar power system and other utilities.

Hundreds of people will then be able to live permanently in each of several large underground habitats and a tourism industry that operates between the Earth and the Moon someday will be established. Given the wide and growing range of lunar activities, a broad cross section of humanity will participate in creative and economic pursuits on the Moon. Sculptors, artisans, athletes, and musicians will join entrepreneurs, technicians, and scientists in the unique conditions of the "Planet Moon" to create a rich, diverse, and desirable cultural environment for people to work, live, and even retire there. The Moon can become a human laboratory for meeting the challenges and hazards of off-world existence. This knowledge, learning, and experience can then be transferred to development of other celestial bodies, beginning with Mars and near-by asteroids. Going off-world enables humanity to fulfill our evolutionary potential through the creation of a new type of being – *spacekind*!

With proper planning and execution, the "Planet Moon Project" will reflect upon our highest aspirations, and provide significant benefits for the people of the Earth. It will emphasize international cooperation and draw upon the expertise of all interested parties, including governments, entrepreneurs, investor-supported commercial enterprises, and non-profit institutions, such as universities and foundations. As experience with lunar operations increases, the scientific and industrial capability of the Moon will approach parity with the Earth, perhaps within three to five decades after the founding of the first base. Widely separated, permanent human settlements will be established, and the only cargo that will need to be transported from the Earth will be humans - the scientists, technicians, tourists, and immigrants who will explore, develop, and eventually inhabit the Moon.

When humans permanently inhabit the Moon, they will explore the mountain ranges, mares, craters, and rilles of the Moon, and investigate lava tubes that have been sealed for billions of years. By then the Moon will be our principal platform for making astronomical observations. Thousands of lunar-made telescopes will be placed at regular intervals on the Moon so that objects of interest in the universe, including the Earth and the Sun, may be observed continuously under ideal viewing conditions. People will live and work in extensive underground spaces that have Earth-like living conditions, including luxuriant vegetation and large lakes of water (without poisonous snakes or mosquitoes!). A wide range of research projects will use the unique conditions of the Moon to advance knowledge in such areas as materials science, superconductivity, power beaming, and bioscience. Advances in existing technologies will accelerate the phased development of the Moon, and it may be expected that new, as-yet-unimagined innovations will greatly enhance our evolution into a spacefaring species. A magnetic levitation rail system will provide high-speed access to all areas of the Moon, and abundant supplies of solar electric power will be beamed from the Moon to the Earth and other locations in space by the lunar power system.

Before the end of the 21st century, thousands of spacecraft will be manufactured on the Moon and launched by electromagnetic "mass drivers" to all points of interest in the solar system, and robotic missions from the Moon to nearby stars will be underway. Communication, power, transportation, and life support systems that have been manufactured on the Moon will be launched to Mars and other locations in space in support of the exploration and human settlement of the solar system. Asteroids and "burned out" comets in Earth's orbital vicinity, especially those that pose a threat of collision with the Earth or the Moon, will be moved out of harm's way and mined for their hydrocarbons, water, metals, and other constituents. These resources will then be delivered to the Earth, Moon, or cis-lunar locations as needed. The binary Earth-Moon planetary system will thus draw upon and benefit from the vitually unlimited rsource assets of space. More important, lunar settlement will challenge us to transform ourselves, extending knowledge, disciplines, and cultures into new dimensions.

The terraforming of the Moon, largely subterranean, into an inhabited sister planet of the Earth is an achievable and highly beneficial objective that can be realized in the coming century. The first robotic missions will establish a permanent unmanned lunar base, short-duration human missions will follow, and, with continued experience and growth, permanent human settlements will be established. The "Planet Moon Project" will result in a substantial expansion of scientific knowledge, advance all engineering disciplines, and it will create a higher awareness and appreciation for the Planet Earth, her environment, and ecology. It will provide high quality job and business opportunities, improve living conditions on Earth, and lead to a greatly expanded program of solar system exploration. When the first lunar base is commissioned, the accumulated technological and cultural expertise of humanity will become linked to the virtually limitless energy and material resources of space. The spacefaring epoch of human existence will thus be firmly established and the entire solar system will be open to in-depth exploration and human settlement. This, then, is the realistic vision and context the authors endorse, and share with their readers in a story format.

The Origins of *"Lunar Pioneers"*

This novel began on a cruise ship back in 1982 when Dr. Harris imagined that the best way to inform his fellow citizens about our future space prospects would be through science-based fiction. This space psychologist still hopes that such works eventually will be translated into other mass media, such as television, movies, and even simulation games. As he researched material for his first novel, he was invited to seminars at the California Space Institute of the University of California-San Diego. Then in 1984, he was appointed a Faculty Fellow at a NASA Summer Study there focused on "Strategic Planning for a Lunar Base in 2010." It was an intensive nine-week learning experience, led by some of the best brains in the American space program. The program speakers included four *Apollo* astronauts, such as Buzz Aldrin, the second human to land on the Moon, and Harrison Schmitt, one of the last humans on the lunar surface. Phil's research centered on space management and space culture, topics on which he would further publish extensively. This learning experience provided one of your authors with a file cabinet of resource data which subsequently formed the basis for three professional books on space, as well has his original novel, *Launch Out.* One of the lecturers in the Cal Space lunar studies was Gene Roddenberry. creator of the *Star Trek* television series and films. He offered to review the LO manuscript when it was finished, but unfortunately died a week after receiving it in 1988.

Lunar Pioneers is a sequel to *Launch Out,* and is also a science-based novel about lunar industrialization and settlement. The original book was about human migrating offworld in the 21st century, and that story is continued in this present text about space enterprises. The first plot centered around two visionaries, Robert Delahunt, CEO of Pacific Interplanetary Enterprises in La Jolla, California, and KazuoYamamoto, founder of Nippon Interplanetary Services in Kyoto, Japan. Their synergistic business relationship leads to the formation of the Global Space Trust (GST), an international consortium of private space enterprise, working in collaboration with the world's space agencies. Its objective was to engage in a macroproject called LUNAR WORLD. As a start-up enterprise, this venture constructs the Krafft Ehricke Lunar Industrial Park, named after a great rocket scientist who wrote detailed plans about *Selenapolis*, the first city on the Moon inhabited by earthpeople dubbed, *Selenians* (after the mythological Greed goddess of the Moon, Selene). The GST goal was initially was achieved by sending robots to the lunar surface in 2009 to prepare for human missions in 2010. That year was chosen for the lunar launching of humans because it was the date NASA originally proposed for a permanent lunar return. Delays in achieving this goal resulted from loss of the Shuttles *Challenger* and *Columbia*, along with the deaths of fourteen brave astronauts, as well as the prolonged building of the International Space Station. In the 21st century, the United States national space policy, *Vision for Space Exploration,* calls for a permanent NASA lunar return by 2020, a plan that we have also incorporated in our current scenario.

Thus, ***Lunar Pioneers*** is set in A. D. 2050, and tells us what happened to those people launched to the Moon some forty years before. Some of the GST *technauts* have died, others have returned to Earth, and many of the characters are now senior citizens of LUNAR WORLD. With improvements in the lunar transportation system, there are now almost a 1000 humans living and working on the Moon. These include permanent residents, contractors, visitors, and tourists. In addition to the lunar industrial park, two residential communities are now well established known as *Euramer* and *Eastasia,* In the past four decades other facilities have been constructed, such as the Dr. Martha Rogers Wellness Center, the Konstantin Tsiolkovsky Science Center and Observatory, the Criswell Lunar Solar Power Plant, and other additional infrastructure. Existing United Nations space treaties confirm the principle that the Moon and other celestial bodies as the "common heritage of mankind." Therefore, no country may appropriate land and resources on our sister planet. To deal with that legality, we have proposed the formation of a Lunar Economic Development Authority (LEDA) charted by the UN to authorize and administer all lunar undertakings, whether by nations, institutions, or individuals.* Such a quasi-public entity is necessary to coordinate global efforts on the Moon, in advance of the formation of an interdependent lunar government.

We have also included in our tale some contemporary developments in space science and technology that may be created by 2050. Obviously, there will have to be extensive Earth support systems to assist these lunar explorers. Thus, we have retained from the first LO novel, the Unispace Academy in Hawaii which prepares spacefarers for their orbital missions. All such ground services and space transportation is coordinated through the Global Space Trust. We are convinced that the complexities, costs, and risks associated with offworld ventures, requires cooperation and collaboration by both the private and public sectors worldwide. Lunar development is too big a challenge for any one space agency or organization to undertake. We have also tried to make this a truly international undertaking, so North America, Europe, Asia. the Middle East and Africa are represented among our *Selenians!*

As previously indicated, the research in this book is based upon two professional volumes which we wrote – *The Moon – Resources, Future Development, and Settlement*; *Space Enterprise – Living and Working Offworld in the 21st Century.* However in our plot, a catalyst for lunar development is **The Moon Declaration of 2015,** subscribed to by leading nations at an international summit. That strategy was inspired by an International Lunar Conference led by publisher, Steve Durst, in 2003. It resulted in formation of *The Hawaii Moon Declaration* on which our document is modeled. The authors welcome reader feedback before another edition of ***Lunar Pioneers*** is published.

Philip R. Harris, Ph.D.` `
(www.drphilipharris.com)

David G. Schrunk
(www.qualityoflaws.com)

3941 – to online papers

- Based upon "Legal Strategies for a Lunar Economic Development Authority" by Declan J. O'Donnell and Philip R. Harris in *Annals of Air and Space Law* published by the Institute and Center for Air and Space Law, Mc Gill University, Montreal, Canada (Vol. XXI-II, pp. 121-130)…Also refer to the *Proceedings of the International Lunar Conference 2003* edited by Steve Durst, et al (San Diego, CA: UNIVELT, 2004); The Hawaii Moon Declaration is on page xxvi(,

.