DESIGNING THE MEX-LUNARHAB (MLH)
APPLICATION OF CORRECT METHODOLOGY

Jesus Raygoza B.

Abstract

The Lunar Mexico Habitat Analogue project, or Mex-LunarHab (MLH), is intended to support the establishment of a Moon Base at a first permanent site on the Moon, approximately 85^{o} S latitude, the "Newton Base" on Malapert Mountain in the South Pole region of the Moon as proposed by the authors of the best book published on lunar industrial development: *The Moon: Resources, Future Development, and Colonization*[1]. The Mex-LunarHab is also dealing with other aspects of incremental lunar programs, with geopolitical and economic considerations, such as the Lunar Economic Development Authority's (LEDA) Moon program[2] and Krafft Ehricke's Extraterrestrial Imperative[3].

For our Lunar Mexico Habitat Analogue Project (the MLH Analogue Station), it is planned to use the Cerro del Pajarito's (Bird's Mountain) geographical position and geological conditions for scientific research and working activities as those needed to be accomplished on a harsh place for man as the lunar surface, as I proposed to mines engineer Brad R. Blair, President of LEDA, and to Declan J. O'Donnell, Esq., President/Founder of the United Societies in Space (USIS) and founder and a Member of the LEDA Board of Directors.

Technical specifications shown at this paper, specifications on designing the MLH today are only approximations, estimates. We are asking for collaboration to continue to make it real.

For designing, building, constructing, developing and deploying both the Lunar Mexico Habitat Analogue Project and the real Mex-LunarHab habitat, this paper also deals with *method*, scientific method and method of organization. Also, in order to start developing this project, one of our very early steps is now to identify our commercial customers, as well as executing the project management and fundrising.

We know there is no place on Earth that is completely like the Moon, but we are to do some steps in order to get goals accomplished. The MLH Project is one part of a set of other relevant space-related projects in Mexico. Our proposal and intention for making the analogue lunar station operative is to generate interest for Mexican space activities within Mexico. The MLH Analogue Station proposal also intends to be developing joint programs for supporting a very much needed return to the Moon under simulated scientific exploration; actual scientific and technological research in several different areas; harnessing the robotic lunar exploration, as well as human exploration; and, generating programs to stimulate planetary missions in Low-Earth-Orbit (LEO) and to Mars; and also to generate excellent international cooperative techniques; in a short term, to encourage the so-long needed establishment of the Mexican Space Agency; likewise, the formation of an Ibero-American space agency; and, in a long-term, an international space agency too[4].

We Still Have to Learn How to Refine Space Habitats

We do not know how to properly build a lunar habitat for even a half-dozen people. The National Aeronautics and Space Administration (NASA) has been conducting systems studies for the definition of habitats housing many men, and there is literature of studies for smaller lunar bases. Indeed, had the U. S. space program continued at the pace of the mid-to-late 1960s (the pace of John F. Kennedy) then by now we *might well be* on the way to *properly* building such habitats.

Of course, there were studies for the large aircraft as well as for the fast ones. History makes clear this point, as those made for the F-111 *Aardvark* or the C-5 *Galaxy*, and no doubt the studies showed that they would be wonderful aircraft. Still, events proved otherwise. What happened? Even when the original engineering design could certainly be correct, the methodology for carrying out the final design was wrong. In the F-111 case, only the F-111F actually fulfilled the original Tactical Fighter Experimental (TFX) program. This was less the fault of General Dynamics than the civilian planners in the Pentagon whose "cost effective" tendencies ironically produced the major aeronautical fiasco of the 1960s, and a costly one at that.

Building self-sustaining habitats on the Moon is to a very large degree a much newer and more uncertain enterprise than designing a new aircraft. This does not mean we have to learn much by "trial and error" how to do habitats. Instead, we are to certainly learn how to apply the true scientific and engineering methods in building them. And also stay away from the "cost effective" approach— that has failed us in the past.

A study is not properly a habitat. But, we can make a proper study of a habitat by applying the correct scientific method. After the *Apollo* lunar missions small lunar outpost, Project Horizon-style lunar outposts were considered to be established, it was going to be a gradually increasing the stay time and the number of people on the Moon. As history shows us even on Earth, small outposts are quite risky.

The design of the Mex-LunarHab displays some technical innovations. Among those innovations is, it may remain uncovered on the lunar surface (it is an innovation applied to remain proprietary for now). Defining the hardware is easy to do and the engineer within us wants to sit down and immediately build hardware. But, I am interested in focusing such talent and enthusiasm onto a succession of smaller steps which will eventually realize the installation of outposts of humankind on the Moon, like those proposed at the Malapert Mountain [5].

Likewise, I also want to use an efficient application of the correct method of organization for the utilization of lunar resources— those which can properly uplift a strong lunar economy. To understand the latter, I recommend to make a review of some lectures as the following ones: "Mining and Processing Systems" (B. Blair, J. Diaz, M. Duke, et al, "Space Resource Economic Analysis's Toolkit: The Case for Commercial Lunar Ice Mining", pp. 21-22) and SRD Appendix 2, Case 1, Architecture 2, "Development and Cost Model" (ibid., pp. 50-56)[6]. These cases are out of the scope of this paper.

A typical explanation on how to deal with building and deploying lunar habitats is found at the Workshop on Analog Sites and Facilities for the Human Exploration of the Moon and Mars conducted by Dr. Michael B. Duke[7]. For instance, Pascal Lee from the Mars Institute, SETI Institute, and the NASA Ames Research Center has written that "as there is no place on Earth that is completely like Mars, it is important to note that there is no such thing as a *perfect* Mars analog"[7], such as there is no such thing as a perfect Moon analog on Earth at all. Regarding a space habitat, Lee has also described some examples of lessons for the safety of a crew, and his "results and many others will be firmed up and further refined through continued research on analog programs such as the NASAHMP"[8].

Designing Modules Configuration

A. **Habitat/Fuel Tank**

I myself as I sat down by the first time, and I started to be drawing some sketches, so many ideas came to my mind. Perhaps, it was as Dr. Wernher von Braun once said: "Basic research is what I am doing when I don't know what I am doing". Some of those first ideas I got to deal with, they were: 1) To find the best practical way to safely put the Mex-LunarHab habitat space-ship on the Moon; 2) optimizing spaces in any compartment. This was just the beginning. The first images led me to think in ultimately drawing cylinders and spheres. A cylinder is simpler to fabricate than a sphere. And a sphere is probably much easier to deploy. A short example may serve to demonstrate the respective useful achievements.

A. 1. A Fuel Tank, a Rigid Structure

A cylinder offers and optimum launch shape and good pressure retention envelope for rigid modules. Cylinders would likely be machined from slabs of titanium, much as Lockheed Martin builds *Titan* and *Atlas V* airframes. As we know, titanium is very hard to weld but may yield to vacuum processes on the Moon if the working surfaces can be keep during welding. Once the habitat/fuel tanks reach the lunar surface, it will be required to clean them up and integrate internal equipment systems for operations. The MLH is also envisioned to use inflatable structures that are transported in collapsed state.

A. 2. Inflatable Structure

Inflatable modules are likely to require labor-intensive integration of internal equipment systems at the site. In case we decide to build a multi-level module configuration, because the upright multi-level stacks will be very difficult to transport over rough lunar terrain or to cover with regolith for radiation protection.

We are to take care of degradation of materials in a lunar environment, very in particular adhesives and plastics, and about some other kind of material. In the Lawrance-Livermore National Laboratory (LLNL) an expandable lunar habitat was designed; it was compiled of separate subassemblies including the bladder, restraint, and thermal and micrometeoroid cover— a coated fabric bladder, made from silicon coated Vectran, was chosen for its simplicity, cold temperature deployment properties, and robust nature. It was a very interesting design. But, one problem to be solved was to maintain structural geometry once the habitat was despressurized for ingress/egress. One option developed to address this was to rigidize the structural restraint portion of the habitat, a technique used frequently in several places. The rigidization is complete, the structure acts as a rigid composite structure.

We are to face temperature changes, and some other aspects of technological unknowns. Several detailed computer simulation studies have made regarding inflatable structures, as the one made by late Dr. Willy Sadeh[9] and Paul Blase[10] from TransOrbital— still, we have some unknowns to deal with.

A. 3. Crew Quarters and Other Facilities

The 4.27 m diameter modules of the International Space Station (ISS) present the smallest practical cross sections that will effectively accommodate minimum height requirements for people. Some studies indicate that larger modules only begin to offer significant functional advantages when the diameter reaches approximately 6.7 m. At this point the cylinders can be divided into two floor levels. What is intended to avoid here is claustrophobic feeling; to get windows to look at the outside, the landscape.

The U. S. *Skylab* workshop is a very valid historical example of the technology that was available about 30 years ago, and the orbital workshop module, derived from the third stage of the *Saturn V* launch vehicle, had a diameter of 6.7 m, a length of 14.6 m and a mass of 35,380 kg. The entire system was comprised of an airlock, a docking adaptor, the modified device unit of the launch vehicle, and a telescope.

Living quarters are designed as rigid structures. For the MLH habitat, if using fuel tanks as habitats, as proposed, we still are to deal with the fuel tank's builder on how we are going to meet the required needs. We could obtain walls of living rigid modules as a composite structure about 25mm thick. Discussion with the aerospace company (Lockheed Martin, or Boeing, et al.) on how to construct the interior of the fuel tank/module still have to come.

Crew quarters must facilitate provisions for human comfort: for comfortably sleeping, personal stowage, communications system, computer work compartment, a recreation facility, and just in case, one more as needed. For personal hygiene: provisions for shower, body cleansing and grooming; toilets, waste management collection and treatment systems, laundry equipment to wash clothing/towels. Other rooms: kitchen, dinning-cafeteria/wardroom (adequate seating for the whole crew during eating and other group assemblies), exercise room (with equipment to minimize physical de-conditioning under reduced gravity conditions), library, infirmary room (equipment and supplies for health monitoring, diagnostics, and routine and emergency treatment), storage room (for food preservation/storage, etc).

B. **The Launching**

With current rocket technology, the carrier rockets configuration chosen today could be Russia's *Proton* with a United States's *Centaur G* upper stage. Today's any originally made rocket currently lack a powerful enough upper stage. On the other hand, the U. S. Air Force's *Titan IV/Centaur G* could be used almost as the perfect one, but is probably too expensive at between $250M and $300M per launch.

The Lockheed Martin *Centaur G*'s basic specifications are: Diameter: 4.3 m. Gross mass: 23,880 kg. Thrust (vac.): 14,970 kgf. Isp: 444 seconds. Propellants: LOX/LH_2. Engines: 2 RL-10A-3A.

The MLH rigid cylinders might be 4 m diameter, 9 m length, in order to fit the *Titan IV/Centaur*'s Envelope. Envelope maximum cylindrical diameter is 4.57 m, and its cylindrical section is 12.2 m length.

Perhaps, an MLH/Fuel Tank would feature a single Pratt & Whitney RL-10 engine, already used on the *Centaur* upper stage. If the U. S. highly reliable RL-10 engine were used on the MLH/Fuel Tank, the mass in low Moon orbit would decreased by 50%.

Any cylinder finding its way to the Moon will probably expend its early life as fuel or oxidizer tank. That is how it pays its trip to the Moon. Assemble 4, 5 or 6 tanks of comparable diameters and length into a square or polygon with airlock couplings at each joint. During its very early stage, for instance, the MLH would be formed by 2 metallic cylinders (rigid, the fuel tanks), and 1 inflatable. Once the tanks are placed and coupled then a sphere is placed in the center of the cylinder ring (if 4 or more cylinders), bolted to the tanks and inflated. Once the sphere is fully deployed epoxy is injected into cavities in the fabric where it hardens. Then the whole thing is partially covered with the excavated regolith. Starting with 2 rigid cylinders, 1 inflatable cylinder, and 1 sphere, is for planning to use 2 rockets (hence those 2 metallic cylinders; and carrying the sphere and the rest of basic equipment and crew); these are the minimum number of modules for this habitat to efficiently be operative. This configuration must be exactly the same for the MLH simulator to be installed on the Cerro del Pajarito (the Little Bird's Mountain) near Ciudad Juarez, in the State of Chihuahua.

The fuel tanks can be fabricated with the airlock joint on one end and a receiver on the other, or each airlock can separately be carried and assembled when on the lunar surface. Anyway, this asymmetry has both advantages and disadvantages. There is a functional elegance which can be appreciated by anyone who is ever played building a model using "bricks", as those like Legos.

Designing Concepts

The concepts will be managed depending on the following aspects:

1. Optimization of spaces in each compartment
2. Size reduction
3. Risk reduction for the astronaut's life and the habitat's integrity

It is not logic that the first lunar crews will be dispatched to an inhospitable place as the Moon unless all essential pieces of equipment for survival are in place on the Moon surface in operable condition. Prefabricated units will be the basis for lunar facilities, preliminary integrated on the lunar surface into a nuclear base complex satisfying the needs of the initial crews. We are to be aware that it will be difficult enough to transport the individual units to the selected site to be integrated, without receiving damages during a landing operation.

Using the cylinders, the whole habitat will be capable to contain a sleeping compartment, resting and working out areas, a toilet and a bathroom. In some other compartments will be located the infirmary and telemedicine compartments; laboratories of mining, geology, astronomy, astrophysics, and biology; a chamber for extravehicular activities (EVAs), containing two airlocks for decontamination and dust cleaning, and other one for air decompression.

For human EVA activity outside the habitat, it will typically last for several hours food, drink and waste management facilities must be included. The use of pure oxygen in space suits during EVAs is acceptable. The requirements to design space suits arise from the considerations of human factors, operations, safety, environmental conditions, and interfaces with the pressurized facility and the object to be serviced. Regarding important considerations to deserve attention when designing a spacesuit for lunar use still have to be under deep consideration.

<u>Space Suits</u>

Human labour on the Moon will be very expensive, especially if work has to be performed in spacesuits, it is why assembly work on the Moon must be minimized. It is a very difficult task on our current situation to assembly any kind of work on the surface of another celestial body. EVA sorties will typically last for several hours food, drink and waste management facilities must be included.

As we know, the requirements to design spacesuits are born from the consideration of *human* factors, safety, operations, environmental conditions, and interfaces with the pressurized facility and the artifact to be serviced. For designing a spacesuit for lunar operations, we are to take into account various considerations which are important and deserve attention, among them are: communications, radiation and thermal protection, mobility, visibility, glove dexterity, micrometeorite protection, satisfactory circulation flow, quality of pressurized environment, and some more detailed considerations.

<u>Physical and Psychological Protection for the Crew Inside the Habitat</u>

1. The MLH will provide means to protect the crew from radiation and other health/safety hazards within

the habitat. We are to design systems to provide easy servicing access for routine and emergency maintenance.

2. The atmosphere inside the habitat should be close to the Earth's atmosphere. The pressure level would be less than used at sea level (approximately 60%) in order to leak losses, reduce structural stress, and make it easier to change into space suits for work on the outside.

3. The MLH will also provide crew support and safety measures to extend crew duty cycles to practical limits, minimizing personnel rotation requirements and costs; but, without going so low to the "cost effectiveness" viewpoint risking the astronauts's lifes. Studies of human acclimation to the lunar environment must involve both physiological[11] and psychological[12] testing. On psychology matters very important remarks are described at the psychological results from Shuttle/Mir missions (as a working team too) as those given in Marsha Freeman's book *Challenges of Human Space Exploration*[13]— chronologically, Mrs. Freeman covers the scientific results from the U. S. *Skylab*, followed by the Soviet stations *Salyut* and *Mir*, the U. S. Shuttle Program *Mir* cooperation, and the then still-to-be-launched International Space Station— this laboratory with 3 times the habitable volume and 5 times the power of *Mir*[13]. In particular, suggested attention on the Appendix 3, "Psychological Support of American Astronauts on Mir". Another excellent lecture is the one by Nick Kanas, et al., "Psychological Issues in Space: Results from Shuttle/Mir"[14].

4. Sanitation must be considered to be kept along with those measures designed to maintain an uncontaminated environment.

5. Personal Hygiene is considered to be in the list of maintenance of cleanliness of the body itself and clothing. These two need to be considered more extensively when building the habitat.

6. Each crew member will have his/her computer, his/her communication channel to the family, friends, contacts for personal matters, and also keeping his/her personal files. Provisions must be made for the constructive and creative use of leisure of the lunar astronaut. People living and working in the habitat may stay on the Moon of 6 to 12 months. Leisure is not only being amused, or being entertained, but it is an opportunity for learning. Still, we can not expect an individual to focus all his leisure to self-development, in particular with very limited outdoor activities— the main interest would appear to be movies, television set, music, reading, handicraft, arts, card playing, chess, and the like.

7. It will be very important to match crew skills with the duties required for the operations and maintenance of the habitat itself. A small number of crew members forces to distribute and to delegate too many of the required skills on the individuals inside the habitat as well outside. In the early establishment of lunar habitats and Moon base, the work-rest cycles will be closer to 60 hours per week— a 40 hour week will be unlikely for a lunar crew. The cycles will gradually be decreasing as the automatic equipment and the crew number increases. The roles of humans and robots working as geologists, miners, astronomers, astrophysicists, etc., should have to carefully be scheduled[15].

8. The Temperature Control System for the MLH should be designed to maintain the temperature inside the modules between 18^{o} – 22^{o} C and to maintain the dew point temperature between 4^{o} – 16^{o} C.
The atmospheres of the crew compartments will be modified by the inevitable increasing of contaminants, which sources are by-products of crew members, impurities in life support materials, chemical interactions, bacterial flora, and outgassing of compartment materials. Non-invasive techniques should be emphasized to analyse metabolic, immunological, hormonal and anatomic reactions to extend low gravity exposure and other environmental conditions.

9. Microbial contamination in space facilities is not simple to be avoided; very in particular, air contamination. Both chemical and microbial contaminants have the potential to accumulate in a habitat of limited volume[16]. We are to carefully take care of the effects in short-term and long-term health effects and to avoid those factors that will affect the performance and productivity of the astronauts. We are to develop standards to specify allowable contamination levels.

10. Typical equipment will include electrocardiogram (EKG) and heart rate monitors and exercise/diagnostic devices.

<u>Lunar Vehicles and Human Safety</u>

We are to incorporate automated, teleoperated and robotic systems where possible to minimize crew labor requirements and work hazards. We still have to discuss many details with, for instance, Dr. Madhu Thangavelu[17] and others about this matter.

During lunar activities crew members will be exposed to ionization radiation which is a hazard to health and performance. Radiation includes solar particles, gamma and X-rays, neutrons, protons and electrons, as well alpha particles.

During the 1970s, the annual dose for astronauts over 30 years of age was set up at 38 rem and the lifetime limit at 200 rem. The annual radiation dose within the upper meter of the lunar surface is approximately 30 rem during solar minimum; but can go up as high as 1,000 rem during a solar flair period occurring every 11 years. Currently shielding estimates to minimize these effects are in the order of about 500 g of lunar regolith, depending on the design concept. Structural materials and equipment used also for this purpose, might reduce this requirement. For instance, up to this point, as the MLH is being designed, it could remain uncovered— it is an innovation applied to remain proprietary for now. It is now estimated that astronauts on the Moon work about 10 hours in a 24 hr period during the lunar day in some habitats. EVA hours may be 20% for must but not all of the crew. When eventually establishing habitats and a base on the Moon, on the basis of the available experience, the permissible radiation dose would have to be established by the responsible agencies.

The MLH Heavy Equipment

The MLH equipment must include: one *Apollo*-type moon rover; one nuclear power plant brought with the rest of the equipment; a robotic soil excavator/hauler; and any other needed devise. A lunar liquid oxygen plant, a mobile laboratory rover, and some other significant infrastructure required to be set up on the Moon is assumed to be at the lunar base site. For developing the Moon is required a great amount of transportation of the crew members, hardware, materials, emergency medical equipment, propellants and the like. This is a powerful reason for most of the vehicles to have a pressurized environment.

A lunar railroad will be the primary means of long-distance transportation of raw materials on the Moon, which will be crossing our natural satellite from the south pole to the north pole. "The challenge of building circumferential lunar rail system is virtually the same challenge as building the electric grid, and both construction projects can be undertaken simultaneously…"[18] (as well in David Schrunk, et al,., *The Moon*, pp, 93-99).

Emergency Life Support Equipment

It is also assumed here that the entire minimum number of the MLH modules only can carry limited supplies of food and water (< ~200 kg). Considering that a lunar outpost is already operational, it may recycle all water, air, and waste products, growing most of the food inside a closed life support system, no big problem is considered for the people living in the MLH habitat. However, in cases where the recycling facility service is interrupted, an emergency life support system must take over. A four-day supply oxygen and water is available as well as storage room for all wastes.

The outer space-related environmental parameters of high radiation flux, low weight, and superior reliability limits many typical aerospace materials to a short list reducing high performance alloys, nanocomposites and thin-layer metal laminates (Al-Ag, Al-Cu) with typical dimensions less than the Frank-Reed-type (packing flaws of "weak" points crystalographically) dislocation source.

Experimental Science Equipment

Experimental science equipment still needs to be clarified. Marsha Freeman, in her book *Challenges of Human Space Exploration*, regarding space stations's crew performance, Mrs. Freeman describes almost every experiment. She lists the names of the experiments involved, even those done by high-school students. And she gives a very good description of mission planning, crew performance, and so on; this is the kind of subject waiting for discussion.

The Questions of Private Funding and Government Funding

Cost is a major objection to a long-range human lunar program. We know that Mars human expeditions are several times more expensive and involve serious and unacceptable risks to crew survival. As we are behind schedule for exploring, living and working on both the Moon and Mars, investment in technology development and research in a lunar program can replace much investment towards a Mars program, if planned wisely. Ironically, in the United States an objection to go back to the Moon, raised by the followers of the "cost effective" doctrine, is that a lunar program of exploration would be an obstacle to the exploration of Mars. On the "cost effective" issue, the genius behind those wonderful machines exploring Mars such as the *Sojourner*, Rodney Brooks has something to say regarding it at "Fast, Cheap, and Out of Control"[19].

Therefore, under the "cost effective" viewpoint, already formed interests inside NASA and its client aerospace contractors would pursue ever more complex projects related to lunar infrastructure, with no intention to embark on new explorations; and its is true that NASA historically focus attention on a major thrust only when the current program is expiring, which means that future planning is tactical rather than strategic. So far, true expectations of future human space expeditions are alive only in school children and in science-fiction novels, movies, and television series. And, not only in the United States but the rest of the space involved nations, the objection assumes that exploring the Moon "will also undermine our nations", that "no one will have the energy to keep going to the planets beyond". Yet, on the contrary, real human history shows us that embarking into new lands generates creativity and debunk old ways of thinking in the generation that is raised on its threshold. In fact, nowhere in history, the Apollo Program opened a very wide pathway induced inertia.

Human exploration of the Moon will thrust the human exploration of Mars, which the latter as regarded as only one element of exploration of the entire Solar System, the establishment of a permanent human presence on our "Seventh Continent", as Krafft Ehricke used to call the Moon, is not a hobby or an impediment, but rather part of our historical process.

Therefore, in our unfavorable present situation, in order to get things done, one of the very early steps is to identify our commercial customers. Who is it that requires either the presence of humans on the Moon or a product which can only be produced there? These customers have to have a financial advantage from the Moon's products and services before anyone is going to set up cabins there.

A lesson to be learned. In 1931, the U. S. rocket pioneer Robert H. Goddard once recalled his advisers from the Carnegie Institution and the David Guggenheim Foundation that investing in unknown scientific territory, testing theories through experimental processes, often is a difficult process, frustrating sometimes, and taking a long time. Most of the time, the results do not show up very fast. Problems arise because uncertainty associated with the new developments. Trying to explain why rockets advancement was a slow task, Goddard said that then "chemical propulsion was new research difficulty and completely hard to design and to build a new special engine of common use"[20]. Certainly, this is applied to any new entire technology.

For Funding The Mex-LunarHab Project, Which Way to Go?

As a privately funded project, we do not still know how it may exactly be funded. But, as we go, the execution of project management and fundrising The Mex-LunarHab Project (MLH) and other legalities could be quite instructive to the Lunar Economic Development Authority (LEDA), the United Societies in Space (USIS), the Space Orbital Development Authority (SODA), the Mexican Space Society (SEM), and some other organization joining this project.

USIS Bonds when subscribed, could be one source of infrastructural money (that is money to rise other money). For the Lunar Mexico Habitat Analogue project, we will go through corporate sponsorships, government grants, tourist attractions, postcards and other publishable goods, etc., in the State of Chihuahua and the Federal Mexican Government. As also the universities would be bringing some of their research and research money to the project.

Nevertheless, whatever turns out, the next entire lunar effort will be slightly easier than the first time that the United States did it. Since we now have the International Space Station we can figure out how to make it to the Moon without using Saturn Vs to launch the whole package. We will still need to send an orbiter and a lander at escape velocity to the Moon. Since it has done before the effort should only be about 50% to 60% of the previous Apollo Program ($25B), adjusted for inflation ($150B).

To illustrate my standpoint here, even though MLH is a far more complicated apparatus to be built than the *Clementine 1* lunar probe, we can use the latter as an example. *Clementine 1* was primarily a Department of Defense (DoD) project, and NASA had minimal involvement. *Clementine 1* was designed, built, and launched in almost two years by a small team of 25 technicians, and it came under is $55 million budget. The Ballistic Missile Defense Organization (BMDO) of the Strategic Defense Initiative (SDI) had been in charge of the entire project. The same project manager, Lieutenant Colonel Pedro Rustan once said: "The spacecraft has been designed, built, tested, and controlled in space by a team of 55 people. We do not need a lot of fancy scientists PhDs to build a spacecraft"[21]. He also said another statement which is certainly true regarding *Clementine 1*: "The most important lesson, Rustan said, is that the government is better equipped than private industry to build demonstration spacecraft"[22].

The Lunar Mexico Habitat Analogue Project Site: At 30º 27' 40" Latitude, 107º 55' 15" Longitude on the Earth

The Lunar Mexico Habitat Analogue Project (Simulation Station) would be placed on the Cerro del Pajarito Mountain (The Little Bird's Mountain). The MLH Simulation Station will be set up on a plain land, to still be carefully chosen, which will permit to make all kind of tests with rovers (pressurized scouting vehicles) or human simulation expeditions (including, a sandbox for tourist attraction, for people to use remote-control robots).

The immediate benefits for the people living in that area will intrinsically be related to a bigger improvement in their economical, educational and natural environment situation. In closed environments on the Moon, we will need to create some ecosystems as closer to Earth's. Therefore, 1. An increased optimization in agricultural development to generate immediate benefits to the local agriculture; an adaptation programmed for cultivating potatoes, using technology for open greenhouses will be investigated. 2. Reforesting eroded areas near the MLH site. This place is close to the archaeological site of Paquime which has been designed as national park by UNESCO as a humankind's patrimony. By using techniques for deserts to stop for keeping growing up. 3. Developing new technologies or improving those already existing ones. 4. A better and larger improved education for the younger population. And, 5. An increased tourist activity.

Human settlements on the Moon will require real substantial advances in control mechanisms and monitors to stay operating for a long-term control and maintenance of recycling air, water, agricultural, and waste management systems, a very advanced life support (ALS) systems. The MLH is intended to be conducting closed habitat tests for long period of times on its Earth site. Evidently, in order to get reliable life-support systems, we are to operate indefinitely a required substantial engineering[23]. We have already learned some important advances in both space biology and medicine by experiments made in the *Mir* station (Marsha Freeman, *Challenges of Human Space Exploration*, "The Lessons Learned from Mir") that we can utilize for our next lunar exploration stage in the future. This book presents the scientific results from *Skylab* in plan, animal and human psychology, as well space physics and astronomy, materials, and precisely, very accurate analyzes some issues involving habitat designs, workloads, the effects of isolation and crew-ground relations.

A big challenge for the design of ALS will be the establishment of agricultural facilities on the Moon. So far, the growth of plants from seeds and their agricultural experiments have already been conducted in the microgravity environment of space stations, but no food crop cycle has been accomplished in space. One of the MLH major projects is to develop an extensive program of agricultural and forest experiments (the growth of food crops in the lunar regolith, a handful of regolith transformed into soil, could be one of the activities in biology done in the Mexican habitat).

In cases of long staying in space, humans need to have as close to the same conditions as possible as on Earth, in order not to suffer irreversible physical damage. For proper functioning the body requires traditional foods (not freeze-dried, or in the form of pills), in order to carry out such regular functions as intestinal peristalsis and the supply of maximum possible vital energy to the cells. This can only be obtained by raising fresh vegetables, and this is possible only with the utilization of aeroponic technology, since there is no soil in space and some work is needed to change Moon dust into Earth-like soil (not so much change will be needed on Mars surface). Thus, if we want to colonize space by allowing a long stay for some human beings, the only solution is aeroponics. Aeroponic techniques are a spin off from the space program. NASA begun studying them to solve problems of feeding people employed in space exploration and colonization.

Although hydroponics has long developed for areas with little cultivable land or short growing seasons, aeroponics is potentially a superior growing method all around (and cheaper), for several reasons. Hydroponics requires a substratum which is often expensive, and its function is more difficult than aeroponics one. In aeroponics, plants are inserted into support structures with their roots suspended in the air. The roots are regularly sprayed with a nutrient solution which is recycled through a closed-circuit hydraulic system, in order to minimize water and chemical dispersion. In MLH is intended to use, to experiment and to develop aeroponics. In this habitat, potatoes, onions, carrots, lettuce, etc., would not only be growing in a highly controlled growing situation, advanced experiments will also be carried out. Aeroponic products tend to be richer in nutrients, homogeneous in size, and to ripen more quickly.

Those developments (and more) mentioned above are intended to reach some goals as proposed by the Ehricke's Extraterrestrial Imperative such as his biographer Marsha Freeman has written: "He developed his concepts of the Extraterrestrial Imperative, based on the three laws of astronautics he had promulgated to guide the space program, in the 1950s: The Extraterrestrial Imperative is based on Ehricke's distinction between multiplication and growth. Multiplication is a phenomenon that abounds in nature; growth is unique to man, he proposed." (Marsha Freeman, "Krafft Ehricke's Extraterrestrial Imperative", p. 21).

A Possible Future Site for the MLH Real Habitat: At 0^{o} Longitude, 86^{o} S Latitude on the Moon

A permanently human lunar outpost will be an important element of a space transportation and operations infrastructure to start supporting exploration of the Solar System. Such human task can greatly advance scientific knowledge and progress towards realizing self-sufficiency as well as possible industrialization of near-Earth space. A logical site for one of the first bases will be at the highest latitude of the Moon that can provide a continuous post telecommunications link with the Earth, such as the Southern Pole. We can get near-continuous sunlight available at the north and south polar regions of the Moon, with the possibility of finding concentrations of water-ice, hydrogen that are needed for industrial processes and for life support systems, and they are suitable locations for the construction of the first utilities grid. Useful products can include plants grown, oxygen for breathing and propellant, ^{3}He, better known as helium-3 (He-3), for nuclear fusion power, and a variety of materials for construction. Obviously, for lunar power generation, nuclear reactors have previously been considered a first choice compared to solar photovoltaics, since most places on the Moon receive 14 days of sunlight followed for 14 days of darkness. But, the south polar region has geographical points of higher elevation that provides the placement of provisional solar power and communications equipment for the first lunar base[24]. The north polar region is also applicable.

As the site for the first permanent lunar base, the preferred beginning point is on the Earth-facing side of the Moon at 0^{o} longitude, 86^{o} S latitude (85^{o} S or N is also the highest latitude that permits continuous line-of-sight teleoperation of robots from Earth). That site is, the "Newton Base", in the Malapert Mountain in the south polar region, as Drs. Madhu Thangavelu, David Schrunk, Bonnie Cooper and Burton Sharpe have pointed out (*The Moon*, pp. 26, 91, 101). "Newton Base" is near the crater Newton, hence the name. That is a probable site for the Mex-LunarHab to become part of that future lunar base.

The *Clementine* probe imagining experiment showed that such permanently shadowed areas exist in the bottom of deep craters near the Moon's south pole. The fully NASA-funded *Lunar Prospector* results showed a much larger areas having water at the north pole. Anyway, much of the area around the south pole is within the south pole-Aitken Basin, a crater 2,500 km in diameter and 12 km deep as it lowest point, and many smaller craters exist on the floor of this basin, which, are never exposed to sunlight, and within them the temperature would never rise above 173^{o} C (100K). Thus, in that stable temperature, deep inside the regolith, approximately between 1 m and 3 m deep, somewhere in the Malapert Mountain, if buried the MLH would be installed some day.

Geology and geoscience research will entail surface extra-vehicular activity (EVA) missions; typical equipment includes portable seismometers, radiation detectors, fluorospectrophotometers, and core drilling/sampling devices. Some data would be analyzed by the MLH crew and computers. Soil and rock samples would be sent periodically to Earth.

A second site, unmanned, is on even higher ground at about 30^{o} W longitude, 83^{o} S latitude (approximately 100 km north and west of Newton Base). But its geographical position the Newton Base site may receive more than 340 days of sunlight per year for solar power generation. On the other hand, lunar resource investigations might take advantage of *Apollo* landing sites where geological conditions and soil composition are quite well understood, such as engineer in mines Brad Blair has pointed out that "at the present, only six locations on the lunar surface qualify as candidates for the design of a mining and extraction system: The landing sites of the Apollo missions"[25]. There, through human-made activity on the Moon, detailed scientific investigations were covered up.

At the late 1950s, it was believed the Moon had no water, and for establishing an earlier lunar outpost sites were considered to be closer to the equator rather than the poles, as the landing sites of the *Apollo* missions. At the Project Horizon Report, the first lunar base ever designed, was stated that "…for a number of technical reasons, such as temperature and rocket energy requirements, the are bounded by plus/minus 20^o latitude/longitude of the optical center of the Moon sees favourable… three particular sites have been chosen which appear to meet the more detailed requirements of landing space…"[26] (Project Horizon Report, Vol. I, Chapter II, p. 8).

Therefore, manned *Apollo* surveys indicate that lunar regolith contains as much as 40% oxygen in some locations. Maria ("seas") sites are known to also posses large quantities of silicon, titanium, magnesium, aluminum and other materials. Hydrogen should be extracted as well. Teleoperated robots will be delivered from Earth to the Moon will be needed for the initial mining extracting all kind of raw materials; processing, manufacturing (solar cells, construction materials, computer chips, electric cables, ceramics, etc.); and transportation tasks of the circumferential utilities grid construction project as the lunar railroad which will be the primary means of long-distance of raw materials crossing the Moon from the south pole to the north pole, as proposed by the authors of *The Moon*: "The challenge of building a circumferential lunar rail system is virtually the same challenge as building the electric grid, and both construction projects can be undertaken simultaneously…"[27] (also David Schrunk, et al., *The Moon*, pp. 93-99).

Conclusion

The Mex-LunarHab (MLH) Project was introduced into the public during the Proceedings of the 2002 A. D. Conference of the United Societies in Space and Affiliate Authorities, Trusts, and Associates, August 4, 2002 in Denver Colorado[4]. MLH is still in its infancy and will have to be developed in full later. Trying to make a final habitat design just now is premature. We can not make a final design now because we do not have a customer and we do not know his requirements: we can not certainly begin to solve a problem when it has not even been posed or specific tasks to presently be done on the Moon. The same thinking is true even of a prototypical proof-of-concept installation. We must find sponsors who have something to gain from giving their money which will unleash us to build the necessary hardware to stay on the Moon. For the MLH hardware, we are to work out the general ideas, next we make a presentation and then we get customers.

Certainly, it is a pity: when I was a child (the time of Yuri Gagarin, Alan Sheppard, John Glenn, et al.), and later on, when I had already began making some dissertations in physics (when Neil Armstrong and Buzz Aldrin walked on the Moon), and even when I had also already foresaw it was going to be very hard to happen the real exploration and colonization of space, I always dreamed that one of the first things that was going to happen was the establishment of a Moon Base. And still, it has not happened! But, it is just has to happen, because otherwise, the rate at which we are acquiring *real substantial* scientific and technological progress and *real knowledge* is slowed down.

Thus, we can, and will, design several of lunar habitats. Almost of all them will be useless because they fail, one way or another, to address the requirements of a paying customer. We must take care not to destroy, scrap or excessively cannibalize any experimental habitat structures. They are very useful for the tourism business, whether they are kept on-site in a tourist area or whether they may be moved to the tourist attractions. Also, they are very useful for space education; to educate the younger population about how to live in space, on other celestial bodies— (if we finally make these things, we would have left a great inheritance to the future generations). But, we are now to be aware that along the way we will solve particularly though technical and logistical problems and yet fail to meet a customer's needs.

Therefore, as the creator, collaborator and coordinator being now involved in the early design of such Moon habitat, my position is to find a proper way to get the MLH project done; to start to convert the dream of "Newton Base" in the Malapert Mountain, a reality.

Without no doubt, the Project Horizon played a very important role for the decision being made for going to the Moon during the 1960s. Probably, without that study there could have been no Apollo Program. Today, a project designing a lunar base in the Malapert Mountain ("Newton Base"), and the MLH habitat included, may play a historic and exemplary significant role for the decision to go back to the Moon soon. This time to stay.

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Jesus Raygoza B., in January 1968 (at 17 year-old), he outlined a theory for tentatively diminishing the "sonic boom", drag and heating in supersonic and hypersonic flight; in December 1973, by the first time, he submitted his concepts to the U. S. Air Force. A private pilot in 1975-1977. In 1983, his "Cone Surfer" concept, a derivation from his 1968 theory, was a device to be adapted to a hypersonic aircraft for diminishing the sonic boom, and reducing drag and heat transfer. He is the creator and the general director of The Mex-LunarHab Project (a real habitat) and The Lunar Mexico Habitat Analogue Project (a simulation habitat); as well as one of the Directors for The Mex-AreoHab (MAH) Project (a Mars simulation habitat). He is also engaged in pursuing for a permanent establishment in Mexico of a national space agency; two space launch ranges, one in Jalisco State, and another one in Quintana Roo State; and the Buzz Aldrin Libraries Project. He is the Founder/President of the Mexican Space Society (SEM); an International Director of the Lunar Economic Development Authority, Inc. (LEDA); a Regent and Secretary of the United Societies in Space, Inc. (USIS); a Member of the Board of Directors of the Space Orbital Development Authority, Inc. (SODA); a Member of the Institute for Advanced Sciences (ICA), National Space Society (NSS), and the American Institute of Aeronautics and Astronautics (AIAA).

October 2003