MEX-LUNARHAB (MLH):
A LUNAR HABITAT ANALOGUE IN THE STATE OF JALISCO

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Introduction

The Lunar Mexico Habitat Analogue project, or Mex-LunarHab (MLH) as called the entire project (both analogue and real), is intended to support the establishment of a Moon Base at a first permanent site on the Moon, approximately at 0^o longitude and 85^o S latitude, the "Newton Base" on Malapert Mountain in the South Pole region of the Moon as proposed by the authors of one of the best book's ever 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].

The Lunar Mexico Habitat Analogue Project, is planned to be installed near Guadalajara, State of Jalisco. Also, it is considered to invite a group a specialist in design, planning and construction of spacel theme parks, as space camps, from Huntsville, Alabama. It is still premature to define a site for this complex (probably, for the already existing infrastructure to make it, one of the places proposed today is close to the Museum of the Child located in the northern area of the Municipality of Zapopan, Jalisco. Still, it will be necessary to analyze closeness and distance from the city, and subsequent motives.

Due to the lately confirmed support given by **Rep. Jorge López Portillo Basave** and due to the great interest demonstrated by the authorities of the State of Jalisco for this type of scientific projects, it is planned to install the Lunar Analogue Habitat of Mexico near the city of Guadalajara, where also it is thought to be establishing a Space Theme Park. It is thought to carry out this bi-project, Park/MLH in coordination with the following dependencies: **Secretariat of Public Education (SEP)-Jalisco**, the **National Council for the Culture and the Arts (Conaculta)**, **Secretariat of Social Development (SEDESOL)-Jalisco**. Here, we give special thanks to our partner in Guadalajara, **Víctor Figueroa**, who has been very active, in an efficient way, so this complex is established there.

Technical specifications given here about designing the MLH today are only approximations estimates. We are asking for collaboration to continue to make it real. This paper is also for supporting other's investigation, researching on this technical and scientific field. I have to remark, 1) the intention of this paper is to raise some very serious questions for everyone concerned about space habitats, and; 2) everyone one of us involved in making the MLH project real, have to work—this is not the work of one-man show.

For designing, building, constructing, developing and deploying the entire Mex-LunarHab Habitat Project, 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 now is to identify our commercial customers, as well as to execute project management and fundraising.

We know there is no place on Earth that is completely like the Moon, but we are to take some steps in order to accomplish our goals[4]. The entire MLH Project is 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 in Mexican space activities within Mexico, meanwhile generating economical, educational and natural environmental benefits to Guadalajara area and the State of Jalisco; and co-related MLH habitat experiments in Cerro del Pinacate (Black Beetle Hill), as well in the State of Chihuahua **(Appendix A)**, and across Mexico—**helping to enhance the people's standard of life**. Those issues to be met in both short-term and long-term goals. The intention of the MLH Analogue Station proposal also is: 1) to develop joint programs for supporting the return to the Moon under simulated scientific exploration. 2) To get actual scientific and technological research on different areas. 3) Harnessing both the robotic & human lunar exploration. 4) To improve a human permanent presence on Mars. 5) The formation of an Ibero-American space agency; in the long-term, an international space agency too[4].

WE STILL HAVE TO LEARN HOW TO REFINE SPACE HABITATS

The Need to Make Designs Under the Correct Scientific Method

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-1960s (the pace of John F. Kennedy) by now we *might have well been* on the way to *properly* building such habitats. Now, before we get into details on how to design and construct space habitats, I want to use aeronautical engineering as a good example of what we are going to be discussing here. 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 that of 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[5,6].

The B-1B *Lancer* bomber, a variable swept-wing like the F-111, has not been much operational despite additional funding and bold attempts over two decades. This ineffectual but modern bomber is being slowly relegated to the "bone-yard". It can only be used where other aircraft compensate for its lack of readiness. Another variable sweep-wing Grumman F-10 *Jaguar* was a unfortunate attempt to make a fighter. All Russian variable sweep-wing fighters, like Sukhoi Su-9, Su-20 and Mikoyan-Gurevich MiG-23, are mediocre. The Russian variable swept-wing bomber Tupolev Tu-160 *Blackjack* is actually worse than the B-1B in performance. These models of aircraft were not usually considered under the cost of "more maneuverable, longer range, and faster" (maybe faster, but lacking the other two), nor were considered under the mission effectiveness of "more maneuverable, longer range, and faster", which makes really sense. Only the Grumman F-14 *Tomcat* met with some seemingly operational success. It took about two decades to find a good use for the F-111. Regarding the latter, Bill Gunston presents a concise and interesting case study of the F-111 aircraft development. His explanation is, "If TAC had not insisted on low-level Mach number of 1.2, but instead chosen M 0.95 (which would have in no way harmed the ability of the aircraft to penetrate), millions of dollars would have been saved and the requirements would have been met with ease"[7].

Regarding the **Space Shuttle's** Orbiter, one important design consideration was whether to use straight-wing ("T-wing") or delta-wing configuration. The Air Force wanted a delta-wing design for strategic reconnaissance reasons. Delta Wings provide a large cross-range (the ability to move far to the right or left or where it entered the atmosphere during landing). The obvious problem is that delta-wings are much heavier and harder to maintain; but offer other benefits such as more stable landing gear, and more stability between transitions from supersonic to subsonic speeds. One of the major problems the aerospace designers have been facing is that after Kennedy was gone, the funds were reduced under President Richard M. Nixon's administration, then NASA tried to gain support for a "cost-effective" approach, rather than for a scientific and technological approach. As plainly shown, this strategy was a mistake made by "government bureaucrats who played the political game and sold the Shuttle as an inexpensive program, in the process sowing the seed of disaster."[8] Nevertheless, the Space Shuttle is one of the biggest engineering management challenges ever faced—**after the budget cuts, it is amazing it was done at all. However, under those "cost-effective" requirements the methodology of launching it became wrong and human *safety* was *sacrificed*.**

To Get Space Habitats Available for Us: What Do We Have From Now?

As expressed in my last paper "Designing the Mex-LunarHab (MLH)"[9], **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 certainly to learn how to apply the true scientific and engineering methods in building them and also stay away from the "cost effective" approach—it 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, **1959 Project Horizon-style** lunar outposts were considered to be established, which would enable 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. As one of those innovations, 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 for the Malapert Mountain**[10].

Through our national lunar analogue Mex-LunarHab Project, Mexico is to develop an **In Situ Resource Utilization (ISRU)** experiment, meaning a "living off the hand" project, such as a solar oven, a light UV telescope, or any other useful device, that would be a component for the first lunar base. ISRU is an strategy to reduce the initial mass that has to be launched from Earth and to have, for example, an *in situ* production of propellant (In-Situ Propellant Production – ISPP) or breathable gases, water, and other goods needed by a human crew. This is what it means to have a power system for solar power production, or Helium-3.

Likewise, I also want to use an efficient application of the correct method of organization for the utilization of lunar resources—which can properly uplift a strong lunar economy. To understand the latter, I recommend a review of the following lectures: "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)[11]. On the other hand, we have **Dr. Peter Eckart's** book ***The Lunar Base Handbook***, one of the most complete publications covering engineering, development, transportation, cost, economical and other aspects[12]. All of these cases are out of the scope of this paper.

Dr. Robert M. Zubrin and **The Mars Society** are currently working on designing and developing habitats for actually living and working on the Red Planet[13]. Any experience obtained from this kind of research and developments are going to be eventually very useful for our path to the stars.

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**[14]. 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"[15]. So it is no such thing as a *perfect* Moon analogue 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 analogue programs such as the NASAHMP". ("The NASA Haughton-Mars Project", pp. 44-47).

Kurt Micheels, once involved in designing the **NASAHMP**, in his "Lessons Learned: Design, Fabrication and Deployment of the First Mars Analog Habitat"[16] shows us a list of lessons for constructing, deploying, managing, and other matters, including logistic lessons—a very interesting document that should seriously be taken in account.

DESIGNING MODULES: CONFIGURATION

Habitat/Fuel Tank

As I sat down for the first time, to draw some sketches, so many ideas came to my mind. Perhaps, it was how **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, were: 1) to find the best practical way to safely put the Mex-LunarHab habitat space-ship on the Moon[17]; 2) optimizing spaces in any compartment. This was just the beginning. The first images led me to think about 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.

In order to fit a current rocket for reaching the Moon today, a rocket like the Titan V/Centaur as presented at this paper. This choice is made for a lunar habitat to be designed considering the smallest space available, considering also the lowest number of necessities required by human survival. In few words, this habitat, as depicted at this paper, is considered **to be made in a very hard way**; a cheapest way, without risking human lives. The MLH habitat, thus, must be a cylinder of 4 m diameter and 9 m length. In order to obtain the useful floorspace and volume of the cylinder, we compute the area of the cylinder:

$A = \pi r^2$

$A = 3.141 \bullet 2^2$

$A = 3.141 \bullet 4$

$A = 12.5m^2$

To obtain the cubic volume we multiply this Area by the cylinder's length:

$V = A \bullet L$

$V = 12.5m^2 \bullet 9m$

$V = 112m^3$

A. A Fuel Tank, a Rigid Structure

We choose the vertical option, the "silo" vertical deployment, because this configuration is consistent and does not offer wasted subspaces, congested headroom or awkward ceiling slopes. Access from floor to floor can be off-center, out of the way (the only centered access is the airlock at the top, using a moveable stairway). Any tall fixture can be positioned anywhere on any floor. When in vertical position is easier to implement bulkheads as floors to isolate rooms against pressure breaches.

This configuration also allows segregation of the engineering space (airlock to outside, air and water processing, power, storage, etc.), from technical space (workshop, communications, laboratories, computers, libraries, etc.), and from living space (dormitories, infirmary, spare time room, etc.). The psychological compatibility for this living configuration seems quite favourable, whereas the "submarine" horizontal deployment is stressful on long-term crew.

The heavy equipment would be on the upper floor (workshops, storage, tools, spare parts). Labs, communications, infirmary, and etc. would be in the middle floor (the second floor). The living quarters, library, amusement section, deeper in the third floor, for better radiation shielding.

The real MLH habitat would be installed vertically, either the airlock will lead into the outside, to the surface of the Moon, or connected to a underlying tunnel tied other habitats.

Therefore, a cylinder offers an 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 kept in vacuum during welding. Once the habitat/fuel tanks reach the lunar surface, it is necessary 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.

I have designed Architect engineer **Alfonso Perez Alvarad**o as the National (Mexico) Director of the Lunar Mexico Analogue Project (MLH). He will also be dealing with these all same issue.

DESIGNING CONCEPTS

Intention: Application of Correct Methodology

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 unreasonable that the first lunar crews should be dispatched to an inhospitable place as the Moon unless all essential pieces of equipment for survival are already 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 fusion nuclear base complex satisfying the needs of the initial crews. We must be aware that it will be difficult enough to transport the individual units to the selected site to be integrated, without incurring damages during a landing operation.

Using the cylinders, the whole habitat can contain a sleeping compartment, rest and work 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, one for decontamination and dust cleaning, and one for air decompression.

For human EVA activity outside the habitat, typically lasting several hours, food, drink and waste management facilities must be included. The correct methodology of the **Project Apollo's Lunar Excursion Module (LEM)** can be useful as a model[18]. 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. Further considerations are necessary when designing a spacesuit for lunar use.

B. Inflatable Structure

Inflatable modules, the so-called "Transhab" concept at NASA Johnson Space Center, which is just fine for habitats, 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. Yet, we are to discover, develop and produce new kinds of light resistant materials protecting humans from radiation and micrometeorite impacts.

We are to take care of degradation of materials in a lunar environment, in particular adhesives and plastics, and other kinds of material. In the **Lawrence-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 depressurized 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 been regarding inflatable structures, such as the one made by the late **Dr. Willy Sadeh**[19] and **Paul Blase**[20] from TransOrbital—still, we have some unknowns to deal with.

C. Crew Quarters and Other Facilities

The 4.27m 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 here is to avoid a 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. Its 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 rigid modules for living quarters as a composite structure about 25 mm thick. Discussion with the aerospace company (Lockheed Martin, Boeing, et al.) on how to construct the interior of the fuel tank/module has yet 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).

The MLH will have a central of information. But, the crew members will carry personalized computers. When in **Biosphere 2**, the **Space Biosphere Ventures (SBV)** began putting together the computerized elements of Biosphere 2 in 1985. Programmers under the management of Cybernetics engineer **Norberto Alvarez-Romo**[C], SBV's Director of Cybernetics Systems, "decided that a distributed network of personal computers, or one with no central brain, would work better because the design was less prone to the paralyzing 'crashes' that sometimes plague central computers. It is cheaper, as well."[21] Both Norberto Alvarez-Romo and cybernetics engineer **Fernando de la Pena Llaca**[D] would design some especial personal computers for the Project MLH. Software engineer **Krishnamurthy Manjunatha**[E] is the designer of the controllers.

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

1. The MLH (Analogue Lunar Habitat) will provide means to protect the crew from hot and cold weather 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 at sea level on Earth (approximately 60%) in order to reduce leak losses, reduce structural stress, and make it easier to change into space suits for work on the outside.

3. **Gail Leatherwood**, in his article about the Lunar Habitat Analogue of Mexico (Mex-LunarHab) in *Ad Astra*, regarding human behaviour in limited spaces, he wrote, "Then there is the issue of humans living together for long periods in even a semblance of harmony. Experiences starting with the earliest habitats in space have demonstrated again and again that as compatible

as people can be, private space is critical to mental health. It may be as simple as a curtain that can be drawn across a sleeping cubicle, but it is necessary".[22] Due to the psychological difficulty for people to live together in a small place for long period of time, we, in the MLH Simulator Station in Mexico, are going to design, develop and carry out actual psychological experiments for people. Experiments to be done about how to eventually be the most successfully possible for them, to live, work, and get fun along each other. On the Moon, the *real* MLH Program 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' lives. Studies of human acclimation to the lunar environment must involve both physiological[23] and psychological[24] testing.

• Sexual behaviour. We cannot avoid it. We are to face it. We are to face what the Biosphere 2 or any other simulator habitat, including *Mir* and the International Space Station have had to. As a MLH combined crew, men and women, the crew's private lives are private. As explained by **John Allen** at the book *Biosphere 2: The Human Experiment*, "Still, the hottest topics of interest for the news media, and a subject for amused conjecture for Biosphere 2 watchers, are the love lives of the crew once the doors have closed. Four men, four women. None of them married to one another. Scientific inquiry may be their primary objective here, but it is hard to imagine that eight healthy adults will put romance and sex on hold for the entire two years. **Curt Suplee** of the *Washington Post* put it thus: 'Will there be sex in the Biosphere? Of course, but who cares… those bidding for a berth in the Biosphere 2 are in it for the love of the idea, not the colleague down the hall.'" (John Allen, *Biosphere 2: The Human Experience*, p. 130).

• On psychological matters very important remarks following the Shuttle/Mir missions (as a working team too) are given in SEM Science & Technology Board of Advisors member **Marsha Freeman's** book *Challenges of Human Space Exploration*[25]. 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* (ibid., *Challenges of Human Space Exploration*). 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"[26]. Therefore, for a excellent international cooperation in space we are to take these subjects very seriously. China's space program is developing in a dynamic way; it engineered a great leap in space exploration by putting into orbit its first *taikonaut*, **Yang Liwei**. We are to look for international cooperation in space as **Steve Durst** (Space Age Publishing Co.), **Declan O'Donnell** (USIS), **Dr. Eligar Sadeh**[27], and others have been proposing for a long time.

• Cooperation in space is also becoming more and more important, and fundamentally necessary; a very good example is the existence of the International Space Station. Today, China is also looking for a potential space and lunar cooperation[28]. Apollo 17 moonwalker **Dr. Harrison Schmitt** at his book *Return to the Moon: Exploration, Enterprise, and Energy in the Human Settlement of Space*, he sees the return to the Moon only viable with private enterprise becoming integrally involved and justified only if U.S. and its partners are to stay[29].

4. Sanitation must be considered 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 family and, 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 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 time 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 alike.

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 makes it undoubtedly necessary to distribute and to delegate too many of the required skills to 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 increase. The roles of humans and robots working as geologists, miners, astronomers, astrophysicists, etc., must be carefully scheduled[30].

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 increase in contaminants, 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 extended low gravity exposure and other environmental conditions.

9. Microbial contamination, in particular, air contamination, in space facilities is not easy to avoid. Both chemical and microbial contaminants have the potential to accumulate in a habitat of limited volume[31]. We are to carefully consider the short-term and long-term health impact 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 medical equipment will include electrocardiogram (EKG) and heart rate monitors and exercise/diagnostic devices. SEM Science & Technology Board of Advisors member **Linda Plush** is in charge of this development.

<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 in our current situation to assembly any kind of work on the surface of another celestial body. EVA sorties will typically last for several hours, thus food, drink and waste management facilities must be included.

Argentinean engineer **Pablo De Leon**[F] and his team have been experimenting a spacesuit smaller than those in Earth orbit by NASA and **Russia's Federal Space Agency (Roscosmos)**, and more flexible than NASA's Apollo lunar spacesuits. One of the Mars prototype's most noticeable features is a bright blue covering, designed for thermal protection and to guard against dust, which can be removed. These spacesuits are going to be of very practical use by future planetary explorers on Mars, who will likely stage many extravehicular activities and have reuse and repair their own spacesuits[32].

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 device to be serviced. For designing a spacesuit for lunar operations, we are to take into account various important and considerations such as: communications, radiation and thermal protection, mobility, visibility, glove dexterity, micrometeorite protection, satisfactory circulation flow, quality of pressurized environment, and more.

Lunar Vehicles and Human Safety

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, SEM Science & Technology Board of Advisers member **Dr. David Schrunk**, and **Dr. Madhu Thangavelu**[33], as well **Brad R. Blair**, and others about this matter.

In Mexico, we have the human sources to get those teleoperated-robotic systems, the **National Autonomous University of Mexico's (UNAM) Aeronautical Space Engineering Society (SIAE)** designed a scout robot named *Quetzalcoatl* ("Feather Serpent") capable of making decisions on its own. This spider-like robot is about 30 cm^3 (which is part of a research project in the archaeological site Teotihuacan). SIAE Vice-President **Antonio Andrade**, designer of *Quetzalcoatl*, has said that *Spirit* inspired this robot to exist. We would welcome any support from UNAM, the **National Polytechnic Institute (IPN)**, the **Technical Institute of Monterrey (ITESM)**, **LaSalle University (ULSA)**, **University of Guadalajara (UDG)**, the **Autonomous University of Juarez City (UACJ)**, and many others Mexican educational institutions.

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 500g 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 24hr period during the lunar day in some habitats. EVA hours may be 20% for most 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

On the Moon, the MLH equipment must include: one *Apollo*-type moon rover (this is also a requirement for the Lunar Analogue Habitat); 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. Developing the Moon requires 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…"[34] (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, not too problematic 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 five-day supply of 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 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

Such as the making of the MLH needs to be studied and discussed, experimental science equipment still needs to be clarified. The MLH is intended to make contests among universities, institutes of technology in Mexico. Nanotechnology is also one of the most relevant science-technical activities to be performed. We are learning. Marsha Freeman, in her book *Challenges of Human Space Exploration*, regarding space stations's crew performance, 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 a more extended discussion.

All together, the lunar habitat, the scientific equipment, and etc., must be taken as a whole. Failures made in the past can help us to develop improved machines today. An example of it is, in response then to the Congress, a 1995 program led by the **Defense Advanced Research Projects Agency (DARPA)** was established to develop an advanced short take-off and vertical landing (ASTOVL) aircraft. It is now named Joint Strike Fighter (JSF). Today it could be wrong to conclude that the JSF would fail because the TFX did so. Another case is that, for instance, stealth technology has undergone five generations,[35] and we still have much more to learn about it—this same approach must be applied to space habitats.

THE QUESTIONS OF PRIVATE FUNDING AND GOVERNMENT FUNDING

Funded by a Public/Private Enterprise Partnership Formula?

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 technological development and research in a lunar program can replace much investment towards a Mars program, if planned wisely. But, as we know, 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"[36].

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 also that NASA historically focuses its 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. It does not only happen 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 very wide pathway induced inertia.

Human exploration of the Moon will thrust the human exploration of Mars. The latter is regarded as the only one element of exploration of the entire Solar System. Therefore, 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. Still, even when it does exist a U.S. national, presidential initiative to go to the Moon and to establish human settlements there, one of our 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? If we get a client and we do not know his/her needs: Certainly, we can not begin to solve a problem if the specific tasks to be done on the Moon are not already been established. Furthermore, it is certain the same thought about establishing a prototype installation to be on approval of concepts. We must find sponsors having anything to gain, after they gave us their money which will make us able to build the hardware needed to stay on the Moon. These customers have to have a financial advantage from the Moon's products and services before anyone is going to set up cabins there.

The private sector alone cannot accomplish the development of the Moon. As a proven fact, it could not make it in 30 years. After the Apollo Program was cancelled, the private sector itself became involutive, many of those branches of industry which were essential to the lunar program itself are gone. Sure, operational costs are undoubtedly hard to judge, as they depend greatly on the success engineers have in developing systems that need relatively little continuing oversight. Experience with the Space Shuttle[37] and with early design version of the **Space Station *Freedom***[38] suggest that operations costs grew in part because increases in estimated costs and decreases in appropriate funds. It caused project planners to cutback on spending for subsystems and facilities that would have controlled long-term operations costs by simplifying and automating operational tasks.

There is another lesson. 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 of uncertainty associated with the new developments. Trying to explain why rockets advancement was a slow task, Goddard said then that "chemical propulsion was new research difficulty and completely hard to design and to build a new special engine–of–common use"[39]. Certainly, this is applied to any entirely new technology.

For Funding the Mex-LunarHab (MLH) Project, Which Way to Go?

As a privately funded project, we do not still know how the Lunar Mexico Habitat Analogue Project may exactly be funded. But, as we go, the execution of project management and fundrising the MLH Project and other legalities could be quite instructive to the Colorado-based **Lunar Economic Development Authority (LEDA)**, the **United Societies in Space (USIS)**, and the **Space Orbital Development Authority (SODA)**; the **Space Frontier Foundation (SFF)**; **National Space Society (NSS)**; the Guadalajara-based **Mexican Space Society (SEM)**; and some other organization joining this project.

For fundrising the entire Lunar Mexico Habitat Analogue Project, we will go through corporate sponsorships (foreign aerospace private sector, national manufacturers, and etc.), government grants (state, county, and federal), tourist attractions, postcards and other publishable goods, in the State of Jalisco and throughout Mexico as well as foreign nations. The universities would be bringing some of their research and research money to the project.

Regarding fundrising the *real* MLH habitat, we should have to pass through a similar process as done for the Analogue Project. The exception is, this effort will be done through getting much bigger funds. As anybody else in higher aerospace businesses, this project must be done through a joint international effort**—we all are together!** If we all want to effectively achieve substantial results in space, we are to see space exploration and colonization of space as an international cooperation effort as a whole.

Anyway, for the MLH's introduction into lunar operations, whatever turns out, the next entire lunar effort will be slightly easier than the first time when 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 been done before the effort should only be about 50% to 60% of the previous Apollo Program ($25B), adjusted for inflation ($150B). Through our experience gained in developing and making operative the Analogue Habitat in Jalisco, we will undoubtedly become able to develop and make operative the Mex-LunarHab (MLH) real.

The effort of the private sector has been realized in a great way by the flight of the aerospace plane SpaceShipOne (SS1). On June 21, 2004 the test-pilot Mike Melvill became the first civil in piloting into space an operational private ownership vehicle. The designer of SS1, Burt Rutan, said: "Today's flight marks a critical intersection in aerospace history … Our success proves out of any question that the crewed space flight does not need of expenses mammoths of the government"[40].

To illustrate my standpoint here, even though the *real* 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 $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, then-**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"[41]. He also made 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"[42]. The *Clementine* mission to the Moon is an impressive indication of how efficient modern advanced telerobotic systems can be compared with traditional space probes. *Clementine* sent more pictures from the Moon than all previous lunar spacecraft combined despite being much smaller and cheaper—real out of the actual "cost effective" approach. Although *Clementine* was originally developed for military purposes, being part of the **U.S. Air Force's Strategic Defense Initiative (SDI)**, it plainly demonstrated what can be done if we only get the opportunity to do so. A very good example of a small private company working with the government is SpaceDev, which is helping to create the world's First Private Sector Astronaut—**Jim Benson** did a very good job![43]

We still need of the private businesses/government formula to be working together to form that so needed partnership. Up to this point, as that partnership is not around the corner, we are to keep going private.

THE SITES TO STAY FOR BOTH THE SIMULATOR AND REAL HABITATS

The Lunar Mexico Habitat Analogue Site: Somewhere at 20º 20' 10'' N Latitude and 100º 10' 10'' W Longitude on Earth

Near Guadalajara

As the Lunar Mexico Habitat Analogue Project (Simulation Station) is now being planned to be placed near Guadalajara, Jalisco, this simulation station will be set up on a plain land, still to be carefully chosen, which will permit us 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).

Benefits for the People

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 close to Earth's.

The benefits for that region (and also other for the nation) will be as follows: In closed environments on the Moon, we will need to create some ecosystems similar to those of the Earth. Therefore, those mentioned benefits here would be,

- An increased optimization in agricultural development to generate immediate benefits to the local agriculture; an adaptation programmed for cultivating vegetables, using technology for open greenhouses will be investigated.
- Reforesting eroded areas near the MLH site. By using techniques for deserts to stop for keeping growing up and to stop deforestation.
- Developing new technologies or improving those already existing ones.
- A larger improved education for the younger population. The MLH Project would become a national symbol for any boy and girl, to be motivated to learn science, physics, biology, mathematics, chemistry, and so on. Many children are coming to the schools underprepared, unmotivated, and lacking self-confidence—the MLH educational programs would give them a very precise idea for developing their skills to study engineering or science careers. As for children and teenagers involved in drugs and gangs, they would become able to find a definite,

real purpose for their education. We are to dramatically improve our educational systems, basing them upon a true-science standview approach.

- An increased tourist activity. (Appendix A).

We have another well-done visionary organizational-method explained in 1997 by the president of the **Moon Miners' Manifesto** organization, **Peter Kokh**. He very accurately said then, "… if we are talking about an **initial** expedition to Mars only, doing the Moon first is a detour. BUT, if we would **open Mars as a frontier** for settlement, we must already be developing the lunar frontier… Let the government(s) choose to go to Mars. Let space activists who see their role only as government gadflies concentrate in Mars too. But first, set the game rules aright, so that international private enterprise can open the Moon. If we don't have both, in this fashion, in this order, we'll only win another tragicomic 'flags and footprints' dead end."[45] (bold types are Kokh's)

As **George T. Whitesides**, Executive Director of NSS, on October 19, 2005 said "we are going back to the Moon and on to Mars with a plan that the nation can afford".

By no means, 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. In the MLH simulator 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[46]. 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.

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 several 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 only possible by using aeroponic technology, since there is no soil on the Moon and some work is needed to change lunar 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 been 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 the MLH 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 (although tasting it is not so quite good).

The MLH Project plans to bring in **Dave A. Dunlop's Lunar National Agricultural Experiment Corporation (LUNAX)** concept. LUNAX was brought to the public in August 1990. It is a very good project, which can develop science experiments *in situ* to address some of the interdisciplinary problems involving space-based agriculture such as energy supply and consumption, use of "local" resources in the lunar and Martian environment for soils. As much as the adaptive response of various plants to different environmental conditions. (Appendix B)

Those developments (and more) mentioned above are intended to reach some goals as proposed by the Ehricke's Extraterrestrial Imperative. Such as Ehricke's 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.

Dr. Schmitt clearly emphasizes the need to exploit resources *in situ*, for instance, of helium-3. In my opinion, I think he is quite right. In Chapter 7, he explains considerable detail on lunar settlement for the purpose of mining, processing and refining ^{3}He, better known as helium-3 (He-3), which will be useful for nuclear fusion power. Following Dr. Schmitt's early research and proposals on He-3, I had appointed out this element as a first choice to power a moonbase and send it to the Earth[47]. (Harrison H. Schmitt, *Return to the Moon*). Industrializing our natural satellite is the first and major priority.

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. 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. We can take a great advantage of the ESA's SMART-1 lunar probe directed by **Dr. Bernard Foing**. Very good pictures about lunar sites were taken by this probe. SMART-1 made a good job![48]

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. 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, 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. The MLH crew and computers would analyze some of the data. 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".[49] There, through human-made activity on the Moon, detailed scientific investigations were covered up.

In 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. The first lunar base ever designed was introduced at the Project Horizon Report. This Report stated that "…for a number of technical reasons, such as temperature and rocket energy requirements, they (outpost sites) 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…".[50] (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 (Singular word is *mare*, they are the dark spots on the Moon. *Maria* means "seas" in Latin; the lunar maria have their name due to their Earth's ocean-like appearance in contrast to the lighter spots on the Moon) 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. They will be necessary for the initial mining, extracting all kind of raw materials; processing, and manufacturing (solar cells, construction materials, computer chips, electric cables, ceramics, etc.). We will need transportation tasks made for the circumferential utilities grid construction project. A lunar railroad 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…"[51] (also David Schrunk, et al., *The Moon*, pp. 93-99).

Obviously, during its operation a Lunar Base will frequently be confronted with the problem of defective equipment due to wear, tare, and random failures. Therefore, spare parts must be available at the base for quick replacements. As the capabilities of the lunar crew and facilities grow, defective parts can be repaired at a central workshop, and even produced using lunar resources later. Five different categories of lunar base equipment that need parts must be considered:

- Structural parts (under dynamic loads).
- Mechanical parts (under dynamic loads and exposed to friction).
- Electrical parts (wires, cables, batteries, instruments, electric equipment, etc.).
- Electronic parts (computer controls, telemetry, television, photo cells, etc.).
- Medical equipment parts (telemedicine, typical medical equipment, electrocardiogram (EKG), heart rate monitors, exercise diagnostic devices, etc.).

The demand for spare parts for the habitat must be determined on the basis of expected failure rates, before a management concept can be developed. However, maintenance and repair will certainly be one of the most important activities, both inside the hab and EVAs, and they must be taken into much consideration. In the MLH Simulation Station, we are to develop models simulating this operation which must be appropriate to solve this problem. We still have to make a detailed study regarding this issue.

For sure, the operation of the International Space Station (ISS) during this current decade will lead to improved assumptions for optimizing an initial moonbase. Some of the recommended lectures for increasing our knowledge about building a moonbase are the following books: Paul Spudis's *The Once and Future Moon*[52], and **Peter Eckart** & **Buzz Aldrin's** *The Lunar Base Handbook*[12]. Regarding the latter, Dr. Peter Eckart collected writings of many prominent engineers and scientists who has designed advanced concepts for returning to the Moon and the establishment of a permanent lunar base. A very good technical book meanwhile providing a general interview and equipment, good engineering concepts; Apollo astronauts Dr. Buzz Aldrin and Jack Schmidt describe very detailed aspects of lunar exploration.

Also, very interestingly, in Dr. Schmitt's *Return to the Moon*'s Chapter 11, "Investors: the best Approach", is a business plan for attracting investors through the economic rewards of not just the sell of He-3, but also the countless spinoff technologies and services as a result of lunar settlement. Related to investors, respect the MLH operational activities, I have made emphasis on preventing to fail to address the requirements of a paying customer. That "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." And, that we are now to be aware that along the way we will solve particularly technical and logistical problems and yet fail to meet a customer's needs[53].

Part of the future group of the **Mexican Astronaut Corps (CAM)** will be able to train in the facilities of the Simulator (Lunar Analogue Habitat) MLH based on the specifications of the international space experts, as some are briefly described briefly here[53]. The fundamental training activities will be delineated more specially the same way as we are going to work the plan for the CAM. We will have a center of theoretical instruction for astronauts in Mexico, in the **AQS Centro de Entrenamiento Aeronáutico, S. C.** [53]54 in Toluca, State of Mexico, which is had planned to be collaborating very closely with the **Mexican Council of Space Sciences and Bioastronautics (COMEXCEBA)**, as well as with the **National AeroSpace Training and Research (NASTAR)**[53] center, with the **Yuri A. Gagarin Russian State Science Research Cosmonaut Training Centre**[53], and others.

The Astronaut Corps will have to be conducted and assisted by aerospace medical doctors from the **Center for Aviation Medicine**[53] and the **Mexican Air Force (FAM)** [53], as well as advised by aerospace medical doctors from the **Ibero-American Association of Aerospace Medicine (AIMA)**[53]. The Center for Aviation Medicine, under more specializing training to keep astronauts in form to go to the outer space, not only will have one of the highest qualifications in the world for this regard, but it already possesses a Chamber of Altitude or Hipobaric Chamber that it is possible to use for medical checking of the astronauts. Our nation already account with experts in aerospace medicine in FAM.

One of the Mexican Astronauts's major functions will be take a positions as ambassadors of science and technology for the Secretariat that sponsors them, and it will be of explaining and presenting the missions and its intentions and the educational technology to the public in general. There will be an important way to create conscience of these Nation's progressive initiatives and on how these investments faced towards the future, they will bring benefits to the people and their economic progress. Perhaps the biggest meaning of a Mexican Astronaut Corps is the impact inside the country itself on the system of national education and in giving an attention approach for the public attention in on as the space technology can be used for benefit of the national economy, to protect the natural resources of the nation, and to give form to the technology of the nations.

For a Scientific and Economic Gain

During the **Apollo 12** mission the crew was successful in setting up seismometers on the Moon, then the crew jettisoned the Lunar Module (LM) ascent stage causing it to crash onto the Moon on November 20, 1969. It created a force equivalent to one ton of TNT explosion. The LM’s impact, about 64 km (40 miles) from the Apollo 12 landing site, created an artificial moonquake with startling characteristics: The Moon resounded like a *bell* for nearly an hour and the shock waves built up to a peak in eight minutes, which surprised the scientists at NASA. This event was very publicly known. And we all know that nothing comparable happens when objects strike Earth. It does bring to collation a forced situation, that the Moon might be hollow. Out of all speculations, in order to finally get *real* scientific results, humans are to go back to the Moon and stay there. To prove this theory that the Moon might indeed be hollow, NASA needed a larger seismic explosion to provoke an appropriate energy wave to travel the entire diameter of our silver neighbor and back to the seismometers, which an explosion equivalent to at least 30 ton of TNT, is needed.

There are some particles brought back from the landing site selected for Apollo 17, the Taurus-Littrow Valley on the eastern rim of Mare Serenitatis. They are from the most widely known and highly publicized samples of the Apollo 17 mission, which were from the "orange soil" found by Harrison Schmitt at Shorty Crater during the ExtraVehicular Activity (EVA) 2[52] (R). The orange particles are mixed with black grains of other material, and are about the same size as the particles that compose silt on Earth. Chemical analysis of the orange soil material revealed it is similar to samples from the Apollo 11 landing area site, Sea of Tranquility, which is several hundred miles to the southwest. Like Apollo 11 samples, Apollo 17 samples are also rich in titanium, 8%, and iron oxide, 22%. Unlike the Apollo 11 samples this orange soil is also unexplainably rich in zinc. The orange soil is probably of volcanic origin and not the product of meteorite impact. The question is, could volcanic action have existed on the Moon? It remains unproven if the Moon ever had volcanoes in the ancient past.

Likewise, the maria is composed primarily illeminite, a mineral containing large amounts of titanium, the same metal used to fabricate the skin of the SR-71 *Blackbird* and the hulls of deep-diving nuclear submarines. The elements uranium 236 and neptunium 237, which not found in Nature on Earth, were discovered in lunar rocks, as were rustproof iron particles. Moreover, Moon rocks were magnetized, which is apparently odd because there is no magnetic field on the Moon itself; neither could not have originated from an encounter with the Earth, which could have ripped the Moon apart. Another weird thing is that some of the Moon's craters originated internally, yet there is no indication that the Moon was ever hot enough to produce volcanic eruptions.

There are some very interesting studies regarding Moonquakes and magnetic "anomalies" explaining strange things, which are taking place on our space neighbor. One of those has been presented by **Yosio Nakamura**, titled "New Discovery into Distribution and Mechanism of Deep Moonquakes with Recently Identified Seismic Events"[52] (R), and certainly is very worthy to be taken seriously. An abstract of Nakamura's "Deep Moonquakes: Remaining Problems" can be found at Google[52] (R). Likewise, although a science-fiction novel, Dr. Alan Binder's *Moonquake* is also worthy to also be taken seriously, which is described as "Science Faction"[52] (R).

There is another strange thing, our natural satellite is the only one in the Solar System with a stationary, circular orbit which is almost perfectly circular. The Moon's center of gravity is approximately 1,800 meters (6,000 feet) closer to the Earth than its geometric center, which should cause wobbling, but it does not. The resultant bulge is located on the far side of the Moon, opposite the side facing our planet. And, a "coincidence" can be also found: The Moon is just the right distance, coupled with just the right diameter, to almost in our epoch completely cover the Sun during an eclipse. An annular eclipse is when the Moon is at its furthest point in orbit. It will not cover the Sun completely that is when a thin ring of solar light emerging from the outside rim of the Moon can be seen.

Robert Jastrow, once director of the Vanguard Project at the Naval Research Laboratory, making of *Vanguard 1* the second artificial satellite successfully placed in Earth orbit by the United States on March 17, 1958 (*Vanguard 1* is the oldest artificial satellite still in space, as *Vanguard's* predecessors, *Sputnik 1*, *Sputnik 2*, and *Explorer 1*, have fallen to the Earth; it was the first artifact using solar energy in space), accurately said that: "The Moon, as I wrote in a magazine article, was the Rosetta Stone of the solar system... So the Moon was uniquely valuable; we all knew that." [52] (R)

Launching the *real* MLH Using Current Technology

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 originally made rocket lack a powerful enough upper stage. On the other hand, the U.S. Air Force's **Titan IV/Centaur G** could be used almost perfectly, but is probably too expensive at between $250M and $300M per launch.

We have powerful and not so powerful rockets, such like Russia's **Proton**; France's **Ariane 5**; China's **CZ-5**; U.S.A. **Rocketplane/Kistler K-1**; Japan's **H-IIA** launch vehicle; and, Brasil's **VLS** sounding Rocket—still, we need to develop a common space vehicle. During the Propulsion for Space Transportation of the XXI Century conference held in Versailles, some discussions and recommendations were raised from the **Societe Nationale d'Etude de Construction de Moteurs d'Aviation (SNECMA)**, **FiatAvio** and **Astrium** which for the next 10 years were on designing engine systems and parts from reusability and reliability. SNECMA's main goal for the Ariane 5 is to decrease the cost by 30% of this expendable launcher (the **Vulcain 3** engine design approach is conceived to reach this goal)[54]. How to implement the transition to a reusable engine is the main question to be answered[55]. **Pratt & Whitney** and **General Electric** still have to solve the making of aerospace engines for easy access to space. American and European aerospace companies, such as **Northrop-Grumman**, **Messerschmitt-Bolkow-Blohm (GMBH)**, and others, are some to provide us of reliable, utilizable aerospace vehicles.

The space industry capabilities of India are the first stage of both the **Geostationary Satellite Launch Vehicle (GSLV)** and the **Polar Satellite Launch Vehicle (PSLV)**. They make of India the fourth most powerful solid fueled engine in the world, coming after the boosters of the U.S. Space Shuttle, Titan IV and **Ariane 5**.

During the last several years, the Chinese space engineers have been advancing in rocketry, on lunar landing control systems as those to track desired height and velocity profiles respectively for lunar gravity-turn descent[56]; as well as those for calculating launch window time for a lunar probe. One of those presentations of a typical orbit of lunar probe includes Earth-Orbit segment, lunar satellite orbit segment and Moon landing orbit segment, are presented by **Xia Xiao-Ning**, **Zeng Guo-Qiang**, **Zhu Wen-Yao**[57]. There is a very interesting Chinese paper which reveals a lot of technical details on the Chinese plans for lunar exploration. Orbiters, landers, and sample returners are very well described (but throughout the paper, the meaning of the acronym remain unexplained), which includes some details (and a tentative drawing) of a 4 tons sample return probe to be launched around 2010 by the smaller member of the **CZ-5** group of rockets. That paper includes a preliminary technical concept and tentative idea about the lunar exploration on the basis of analyzing the current technology base of China[58]. Right here, assuming the existence of a lunar base in its early stage, the logistic system supporting such a base, at large, is a combination of a **Heavy Lift Launch Vehicle (HLLV)**, a lunar launch-and-landing vehicle, an operations station in lunar orbit, at least. The average life cycle specific transportation cost of this system for cargo between Earth and Moon has been estimated to be $2,026/kg, the average life cycle roundtrip cost of lunar personnel had been estimated to be $3.60 million.

As a reference for the MLH, 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 12.2m length. Perhaps, one 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 be decreased by 50%.

Perhaps, in a not so far future, one day, a more powerful vehicle than the cancelled NASA **Constellation Program's Orion**[59,60] may carry the MLH Lunar Habitat to the Moon. Or, perhaps a common international transit vehicle is developed to carry also payloads between the Earth and the Moon, then every nation will be able to use a common carrier to add their own specific components to the future lunar base. Mexico would be able to put much easier a lunar habitat and equipment on the Moon. Meanwhile, as proposed here, 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. Continuing with the proposal of the fuel tank/habitat idea, we would start with 2 rigid cylinders, 1 inflatable cylinder, and 1 sphere. This idea 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 (or, to eventually be linked to other nations's habitats). This configuration must nearly be alike the MLH simulator to be installed near Guadalajara.

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 has ever played building a model using "bricks", like Legos.

CONCLUSION

Economic development requires the introduction of revolutionary new technologies, to increase the productivity of work and the standard of living of the population. The most critical prerequisite, is the *creation* of a stratum of scientific and engineering manpower that can convert breakthroughs in science into new technologies for broadscale application. The project Lunar Habitat Analogue of Mexico: Mex-LunarHab (MLH,) is potentially able now to lead Mexico into that direction.

The Project MLH was introduced to the public during the Procedures of the Conference of United Societies in Space and Affiliate Authorities, Trust, and Associates, on August 4, 2003 in Denver Colorado[60]. The following international public presentation was during the International Lunar Conference 2003 (ILC-2003), on November 17, 2003, in Waikoloa, Isla Hawai'i[61]. It is premature to try to make today a final design of the real habitat, *including* the simulator. At present, the design of the Simulator that will be established near Guadalajara has still to be done step by step; we are going to learn much more about as doing an efficient *real* habitat. Now we cannot make a design of the real habitat, first because we still do not have a client definite and do not know his requirements: Certainly we cannot begin solving a problem when it has not even been exhibited, or when in the present there are no still specific works that are done on the Moon. The same thought is applicable even for the installation of a prototype "to concepts-proof". We have to find sponsors who have something to gain for giving his money which will make us advance more quickly to construct the hardware necessary to settle on the Moon. For the hardware of the MLH, we have to set to work the general ideas, at once to do a presentation and then to attract customers.

I always dreamed that one of the first things that it was going to happen was the establishment of a Moon Base. And, it has *not* still happened! But, it 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. Yet, this is a challenge for us and we should be optimistic.

We can, and will, design several of lunar habitats. Almost all of 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, science 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 technical and logistical problems and yet fail to meet a customer's needs.

Therefore, as the creator, collaborator and coordinator 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, into reality. In the future, many countries will be able to participate in the exploration and formation of settlements on the Moon, Mars, and beyond. In this process, more and more nations will join today's spacefarers, in the great project of space exploration.

Without any doubt, the Project Horizon played a very important role for the decision 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, exemplary and significant role for the decision to go back to the Moon soon. This time to stay.

Notes

[A] Architect engineer Pedro Alfono Perez Alvarado, a prominent SEM Member, currently lives in Chihuahua capital city. He works for a very important construction company.

[B] Cybernetics engineer Noberto Alvarez-Romo is the current Director of the Planetarium in Guadalajara; and a prominent SEM Member.

[C] Cybernetics engineer Fernando de la Pena Llaca, www.tulancingo.com.mx/delapena/aexa/htm

[D] Software engineer Krishnamurthy Manjunatha works on embedded controllers for LSI Logic in Atlanta; he is an expertise in designing software for embedded and mainstream applications. He is also a member to The Mars Foundation – Project Teams, www.marsfoundation.org/about/bin.html

[E] Space engineer Pablo de Leon is an expert in designing and developing space suits; he works for the University of North Dakota, www.human.space.edu

[F] For any person or entrepreneurial initiative wishing to ,
please contact Dave A. Dunlop at dunlop720@yahoo.com Mr. Dunlop is Director of the Development for the Moon Society.

Refrences

[1] David Schrunk, Burton Sharpe, Bonnie Cooper and Madhu Thangavelu, *The Moon: Resources, Future Development, and Colonization*, Praxis Publishing/John Wiley & Sons, New York, 1999, pp. 26, 91, 121.

[2] Declan J. O"Donnell and Philip R. Harris, *A Lunar Economic Development Authority*, Gordon and Breach Science Publishers, Printed in India, 1998; Philip R. Harris & Declan O'Donnell, "Facilitating a New Space Market through a Lunar Economic Development Authority", *Space Governance*, Vol. 4, No. 2, July 1997, pp. 122-130.

[3] Marsha Freeman, "Krafft Ehricke's Extraterrestrial Imperative", *Space Governance*, Vol. 2, No. 2, December 1995, pp. 20-23, 31.

[4] Peter Kokh and David A. Dunlop, "What a Lunar Analog Research Station Should Attempt to Demonstrate", *Moon Miners' Manifesto & The Moon Society Journal*, No. 195, May 2006, pp. 5-8.

[5] Jesus Raygoza B., "Mex-LunarHab", *Space Governance Journal*, Double Volume,: No. 7, No. 8, 2000 & 2001/2002, pp. 94-99.

[6] Robert J. Art, *The TFX Decision: McNamara and the Military*, Little Brown, Boston, 1968, pp. 15-24, 26.

[7] Robert F. Coularn, *Illusions of Choice: The F-111 and the Problems of Weapons Acquisition Reform*, Princeton University Press, Princeton, 1977, pp. 3-4.

[8] Bill Gunston, *Attack Aircraft of the West,* Ian Allen Ltd., London, 1974, pp. 173-175.

[9] Roger D. Launius, "Toward an Understanding of the Space Shuttle: A Historiographical Essay", *Air Power History*, Winter 1992, pp. 6, 17.

[10] Burton L. Sharpe and David Schrunk, "Malapert Mountain Revisited", www/angelfire.com/space/usiss

[11] Brad Blair, Javier Diaz, Michael Duke, et al. "Space Resource Economic Analysis Toolkit: The Case for Commercial Lunar Ice Mining", Final Report to the NASA Exploration Team, Center for Commercial Applications of Combustion in Space (CCACS), Colorado School of Mines, Golden, CO, December 20, 2002.

[12] Peter Eckart, with contributions by Buzz Aldrin, Arthur C. Clarke, Harrison H. Schmitt, John Young, and many others, *The Lunar Base Handbook: An Introduction to Lunar Base Design, Development, and Operations*, McGraw-Hill Primis Custom Publishing, New York, 1999.

[13] Robert M. Zubrin, with Richard Wagner, *The Case for Mars: The Plan to Settle the Red Planet and Why We Must*, Simon & Schuster, New York, 1996, chapters 8-10.

[14] Michael B. Duke, "Workshop on Analog Sites and Facilities for Human Exploration of the Moon and Mars", Center for Commercial Applications of Combustion in Space (CCACS), Colorado School of Mines, Golden, CO, May 21-23, 2003.

[15] Pascal Lee, "The NASA Haughton–Mars Project: Lessons for Moon and Mars Exploration from Devon Island, High Arctic", in Michael B. Duke, *Workshop on Analog Sites and Facilities for the Human Exploration of the Moon and Mars*, Center for Commercial Applications of Combustion in Space, Colorado School of Mines, Golden, CO, May 21-23, 2003, pp. 44-47.

[16] Kurt Micheels "Lessons Learned: Design, Fabrication and Deployment of the First Mars Analog Habitat", Workshop on Analog Sites and Facilities for the Human Exploration of the Moon and Mars, Green Center, Colorado School of Mines, Golden, CO, May 21-23, 2003, pp. 44-47.

[17] Alexei A. Leonov, "The Apollo-Soyuz Project: A Practical Step toward Implementation of a Soviet-American Approach to Space Rescue", in Margaret B. Edwards (ed.), Proceedings of the 1989 Conference on Space Rescue, held by the Association of Space Explorers, Fifth Planetary Congress, Riyadh, Saudi Arabia, November 13, 1989, p. 34.

[18] Thomas J. Kelley, *Moon Lander: How We Developed the Apollo Lunar Module*, Smithsonian Institution Press, Washington, D.C., 2001.

[19] Willy Z. Sadeh, et al., "Computer Simulation of an Inflatable Structure for Lunar/Martian Base", IAF-95-Q.1.09, 46th International Astronautical Congress, Oslo, October 2-6, 1995.

[20] Paul Blase, Inflatable Lunar Habitat, TransOrbital, Inc., 6430 The Parkway, Alexandria, VA, 22310 pblase@transorbital.net

[21] John Allen, *Biosphere 2: The Human Experiment*, a Synergetic Press, Inc., Penguin Books, New York, 1991, p. 120.

[22] Gail B. Leatherwood, "Chapter Projects", *Ad Astra*, Vol. 16, No. 4, Winter, 2005, p. 41.

[23] Tony S. Keller, et al., "Bone Loss and Human Adaptation to Lunar Gravity", in The 2nd Conference on Lunar Bases and Space Activities of the 21st Century, NASA Conference Publication 3166, Vol. 1, April 1988, pp. 569-576.

[24] Nick Kanas, "Psychosocial Issues Affecting Crews During Long-Duration International Space

Missions", *Acta Astronáutica*, Vol. 42, No. 1-8, pp. 339-361, 1998.

[25] Marsha Freeman, *Challenges of Human Space Exploration*, Springer/Praxis Publications, Chichester, United Kingdom, 2000.

[26] Nick Kanas, Vyacheslav Salnitsky, Ellen M. Grund, et al., "Psychological Issues in Space: Results from Shuttle/Mir", *Gravitational and Space Biology Bulletin*, Vol. 14, No. 2, June 2001.

[27] Eligar Sadeh, James P. Lester, and Willi Sadeh, "Models of International Cooperation for Space Exploration: From Apollo-Soyuz to International Space Station", IAF-95-IAAA.3.1.03, presented at 46th International Astronautical Congress, Oslo, Noway, October 2-6, 1995.

[28] "China Cooperation Talks with America", *Space Enterprise Daily*, Year 6, No. 185, 20 September, 2006.

[29] Harrison H. Schmitt, foreword by Neil Armstrong, "Fusion: Helium-3 Power Economics" and "Investors: The Best Approach", *Return to the Moon: Exploration, Enterprise, and Energy in the Human Settlement of Space*, Copernicus Books, Springer Science/Business Media, New York, 2006.

[30] Paul D. Spudis, et al., "The Roles of Humans and Robots as Field Geologists on the Moon", in The 2nd Conference on Lunar Bases and Space Activities of the 21st Century, NASA Conference Publications 3166, Vol. 1, April 1988, pp. 307-313.

[31] George W. Morgenthaler, "Contaminant Risks Assessment in Space Habitation Environments", 46th International Astronautical Federation (IAF) Congress, paper IAF-95-IAA.3.1.04, Oslo, October 2-6, 1995, p. 26.

[32] Pablo de Leon, //spacesuitlab.blogspot.com/, www.space.edu/FacultyStaff/Pablo2.asp

[33] Madhu Thangavelu, "The Nomad Explorer Vehicle for Global Lunar Development", *Proceedings of the 1992 International Astronautical Federation (IAF) Meeting*, Washington, D. C., 1992.

[34] David Schrunk, Madhu Thangavelu, Bonnie Cooper, and Burton Sharpe, "Physical Transportation on the Moon: The Lunar Railroad", *Space Governance*, Vol. 5, No. 2, July 1998, pp. 162, 165, 187.

[35] Tsgt Phil Rhodes, "Stealth: What is it, Really?", *Airman*, Vol. 35, No. 9, September 1991, p. 23.

[36] Rodney A. Brooks and Anita M. Flynn, "Fast, Cheap and Out of Control", *Journal of the British Interplanetary Society*, 1989, Vol. 42, pp. 468-485.

[37] U.S. Congress, Office of Technology Assessment, *Reducing Launch Operations Costs: New Technologies and Practices*, OTA-TM-ISC-28, Government Printing Office, Washington, D.C., September 1988.

[38] William F. Fisher and Charles R. Price, *Space Station Freedom External Maintenance Task Team, Final Report*, NASA Johnson Space Center, Houston, July 1990.

[39] David H. DeVorkian, *Science with a Vengance: How the Military Created the U.S. Space Sciences After World War II*, Springer-Verlag, Berlin, 1992, p. 10.

[40] John Kross, "X Prize Ends in Desert Drama", *Ad Astra*, Winter 2005, pp. 14-17.

[41] Lt. Col. Pedro Rustan, *Aviation Week & Space Technology*, March 7, 1994, p. 21.

[42] Lt. Col. Pedro Rustan, *Space News*, April 25 – May 1, 1994, p. 1.

[43] SpaceDev, Jim Benson, www.spacedev.com/newsite/templates/subpage3.php?pid=164

[44] Peter H. Diamandis, "Algae Dependent Closed Life-Support Systems for Long Duration Space Habitation", *Space Manufacturing 5*, American Institute of Aeronautics and Astronautics (AIAA), October 1985, pp. 107-115.

[45] Peter E. Glaser, "Energy for Lunar Resources Exploration", *Proceedings of Lunar Materials Technology Symposium*, NASA Space Engineering Research Center, Arthur D. Little, Inc., 1992.

[46] Bernard Foing, SMART-1, www.esa.int/SPECIALS/SMART-1/SEMT00Z7QQE_0.html

[47] Brad R. Blair, "The Commercial Development of Lunar Mineral Resources", *Earth Space Review*, Vol. 10, No. 1, 2000, p. 82.

[48] Project Horizon Report, "A U.S. Army Study for the Establishment of a Lunar Military Outpost", 4 Vols., U. S. Army Ordnance Missile Command, Redstone Arsenal, Alabama, June 8, 1959.

[49] David Schrunk, Madhu Thangavelu, Bonnie Cooper, and Burton Sharpe, "Physical Transportation on the Moon: The Lunar Railroad", *Space Governance*, Vol. 5, No. 2, July 1998, pp. 162, 165, 187.

[50] Marc M. Cohen, "Selected Precepts in Lunar Architecture", 53rd International Astronautical Congress – 2002, Houston, TX, 10-19 October, 2002.

[51] Paul D. Spudis, *The Once and Future Moon*, Smithsonian Institution University Press, Washington, D.C., 1996.
[52] Jesus Raygoza B., "Designing the Mex-LunarHab (MLH): Application of Correct Methodology", in Steve M. Durst, C. T. Bohannan, C. G. Thomason, M. R. Cerney, and L. Yuen, eds., *Science and Technology Series*, Vol. 108, AAS 03-704, American Astronautical Society, San Diego, CA, 2004, pp. 43-56.
[53] ______________, "Razón Fundamental para un Programa de Desarrollo Espacial Mexicano", Recomendaciones para el nuevo Gobierno Presidencial del Presidente Felipe Calderón H. y la Legislatura LX del Congreso Mexicano, primera presentación: Secretaría de Gobernación (SEGOB), 3 de Mayo, 2007, México, D.F., pp. 2, 6, 8-10, 13, 61-63.
[54] AQS Centro de Entrenamiento en Aeronáutica, S. C., www.e-aqs.com
[55] NASTAR, www.nastar.center.com
[56] The Yuri Gagarin Russian State Science Research Cosmonauts Training Centre www.gctc.ru/eng/index.html
[57] Centro Nacional de Medicina de Aviación, www.dgpmpt.sct.gob.mx/index.php?id=448
[58] Fuerza Aérea Mexicana (FAM), www.es.wikipedia.org/wiki/Fuerza_Aérea_Mexicana
[59] Asociación Iberoamericana de Medicina Aeroespacial (AIMA), www.ites.google.com/site/aima1976org/home/
[60] Apollo 17 – Orange Soil, Views of the Solar System, www.solarviews.com/cap/moon/moondust.htm
[61] Yosio Nakamura, "New Discovery into Distribution and Mechanism of Deep Moonquakes with Recently Identified Seismic Events", Institute for Geophysics, University of Texas at Austin, Austin, TX, 1 April, 2004 to 31 March, 2005. *www.ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.../20050169201_2005170525.pdf*
[62] ______________, "Deep Moonquakes: Remaining Problems", www.adsabs.harvard.edu/abs/2004AGUFM.P23A0224N
[63] Alan Binder, *Moonquake*, Apogee Books, Burlington, Canada, 2006.
[64] Robert Jastrow, "A Conversation with Dr. Robert Jastrow", George C. Marshall Institute - Science for Better Public Policy, Arlington, VA, www.marshall.org/article.php?id=30
[65] "Propulsion for Space Transportation of the XXI Century", Versailles, May 13-17, 2002.
[66] Hermann H. Koelle, "Role of Launch Vehicles on Moon-Mars Exploration Program", *Journal of Aerospace Engineering*, Vol. 11, No. 4, October 1998, pp. 119-123.
[67] Wang Dayi, Li Tiesshou, Yam Hui, Ma Xingrui, "Guidance Control for Lunar Gravity-Turn Descent", *Chinese Space Science and Technology*, Vol. 20, No. 5, 2000, pp. 17-23.
[68] Xi Xia-Ning, Zeng Guo-Qiang, Zhu Wen-Yao, "Window Selection for the Lunar Probe Launched from the Earth", *Acta Astronomica Sinica*, Vol. 41, No. 4, 2000, pp. 361-372.
[69] Li Dong, Chen Minkang, Guo Linli, Zhu Dongge, "A Tentative Idea about Lunar Exploration", *Missiles* and Space Vehicles, No. 5, 2002, pp. 20-28.
[70] NASA Constellation Program, Orion, www.nasa.gov/mission_pages/constellation/main/index.html
[71] Robert Z. Perlman, "Project Orion to Follow Apollo to the Moon", *Space.com*, July 20, 2006, www.space.com/news/060720_cev_orion.html
[72] Jesus Raygoza B., "Mex-LunarHab", submitted during the Proceedings of the 2003 Conference of the United Societies in Space (USIS) and Affiliate Authorities, Trusts, and Associates, Denver, August 4, 2003.
[73] __________, "Designing the Mex-LunarHab (MLH): Application of Correct Methodology", International Lunar Exploration Working Group 5 (ILEWG 5), International Lunar Conference 2003 (ILC-2003), Waikoloa Marriott Beach Hotel, Kohala Coast, Hawai'i Island, November 17, 2003.

APPENDIX A

Geographical Places

[1] Zapopan - Guadalajara, Jalisco, México,
www.guiarte.com/.../satelite_poblacion_zapopan.html
www.it.app.jalisco.gob.mx/organismo/territorial.html
www.mapserver.inegi.org.mx/.../hypertext.cfm?s...c...

[2] Cerro del Pinacate, Sonora, México,
www.explorandomexico.com.mx/about-mexico/6/164/
www.mexicodesconocido.com.mx/.../4306-El-Pinacate-y-Gran-Desierto-de-Altar:-lugar-de-dunas-y-lava-(Sonora)
www.ugm.org.mx/pdf/geos07-1/sesiones_regulares/VUL.pdf

[3] Cd. Juárez, Chihuahua, México,
www.mapserver.inegi.org.mx/geografia/espanol/.../HID_SUP.PDF?s...

APPENDIX B

In memory of my parents: **Carlos Raygoza Enciso** (1918-1992) who was a farmer at heart; raising potatoes, wheat, and etc. (he also was an agricultural products merchant, potatoes, mainly). And of my mother **Elvira Berrelleza Peña** (1928-1972) who was his support in the family.

Pioneering Space Farming

Since we received notice that there are huge deposits of frozen water on the Moon, we are now sure future lunar bases could certainly be supported by an artificial, closed system, like Earth's biosphere, as reviewed above, with all the necessary plant and animal species: enough for food, and for air recycling. Settled on the Moon, humans could head to colonize Mars, more easily and more cheaply. To achieving this task, space greenhouses will be needed. Vegetable crops, and even wheat, whose grains the astronauts will use to mill flour and to cook fresh bread as on the Earth, will be grown there. An example of future agriculture on the Moon can be found at Dr. **Philip R. Harris's *Lunar Pioneers***, with **Dr. David G. Schrunk**, the first text of this novel[1].

For investigating and developing plant growth under microgravity, in order to include plants in future biological life support systems for long-term manned space missions, **some of the first greenhouses have been developed and produced in Bulgaria**. A Bulgarian-Russian project, the SVET greenhouse automated plant growth facility was developed in the 1980s, and was launched in the *Mir* Orbital Station on June 10, 1990. To monitor additional environmental and psychological parameters, a United States-developed **Gas Exchange Measurement System (GEMS)** was added to this equipment. Dr. Tania Ivanova, as head of the **Space Biotechnology Department** at the **Space Research Institute of the Bulgarian Academy of Sciences** in Sofia, Bulgaria, was in charge of these many long duration plant space experiments, which were carried out in the SVET-GEMS complex at the end of the 20th century.

The SVET space greenhouse had become 1,000 cm^2 growing area storing mature plants up to 40 cm, with fluorescent lamps and windows; the front window is transparent for seed sowing, observation, and sample taking by the crew. An original Bulgarian technology there is a special module, which is a root module divided into two equal sections and is filled with the substrate balkanine (a nutrient charged clinoptilolite zeolite) which is a natural zeolite (they are microporous, aluminosilicate minerals commonly used as commercial adsorbents) that is enriched with mineral salts in order to sustain several consecutive crop cycles. This module is changeable, mounted on rails like a drawer. The substrate moisture being controlled at a desirable level by sensors, a water pump, valvles, and the necessary oxygen is supplied to the root area.

Because Russia did not have then enough funds to use all of the capacity of its orbital laboratory, unfortunately, in the SVET Space Greenhouse came to a standstill for almost five years, and various important programs were simple given up. Including, it become a critical situation: questioning whether the *Mir* Orbital Station itself could then be given up as well. But, NASA's interest in this long-standing, habitable Space goal saved, at the moment, *Mir*. The United States, after being force to loose the first real orbital laboratory in history, *Skylab 1* in the 1970s (being exhibited, *Skylab 2* remains in the Smithsonian Museum in Washington, D. C.), they did not have their own space station, in which to conduct long-term experiments. And after NASA got reduced the budget for space research and for the then-*Freedom* Space Station, the U.S. scientists directed their efforts to the Russian capabilities. It was as a Russian-Bulgarian agreement was signed in Moscow in April 1994 to carry out long-term experiments within the framework of the *Mir*-NASA program in the SVET Space Greenhouse during 1995-1997. With the participation of U.S. astronauts onboard *Mir*, through repeated flights and capabilities of the Space Shuttle and the Russian cargo missions, SVET conducted experiments called "Greenhouse 1", "Greenhouse 2", and so on[2]. In "Greenhouse 2a" and "Greenhouse 2b", "super dwarf" wheat experiments were conducted[3].

In the SVET-2-GEMS complex, the "Greenhouse 2b" was repeated by the same investigators[4,5,6] that "Greenhouse 2a"s,which was made in two stages of 123 days and 43 days, showning male sterility in the wheat plants. A mustard plant species *Brassica rapa* with a very short life cycle was used in the next seed-to-seed experiment, "Greenhouse 3", in 1997, where its main investigator was **Mary Musgrave**[7], from Louisiana State University. And, **the first successful seed-to-seed full plant cycle in space was completed in 1997, in spite of passing through one of the most serious accidents in space ever happened!** On June 25 of that same year, a collision of the Progress supply spacecraft with *Mir* caused a loss of power to the SVET-2 Space Greenhouse, which subsequently provoked a lowering of the temperatures and changing of the atmospheric pressure and composition on *Mir*. By supplying the experiments with power from the main core module of *Mir* to SVET-2 by a cord, U.S. astronaut **Michael Foale** saved the experiments. After that "exciting adventure", the challenge of the scientists was to grow wheat seeds. U.S. scientist **Bruce Bugbee**, from Utah State University, proposed using another wheat variety called Apogee, because it is resistant to high ethylene concentrations, which was proved in ground studies to be a big problem measured as 1 to 2 ppm in *Mir's* cabin atmosphere.

The "Greenhouse 4 and 5" experiments were carried out by Russian cosmonauts in the **Russian Scientific Program**, mostly by **Sergei Avdeev**. In the "Greenhouse 4" experiment, 12 Apogee plants produced a total of 508 seeds. In the "Greenhouse 5" experiment, 10 of the space-produced seeds were planted, and one of them gave a second generation space seeds. During these last two experiments, **all the seeds were developed in a normal fashion. Then, they were planted on Earth, germinated, and produced healthy green plants[8].**

The successful *Brassica rapa* and Apogee wheat experiments proved that the lack of gravity was not an obstacle for normal plant development in space. Therefore, since these kind of wheat can make it in space, human supply of grains is beginning to be a reality in future human settlements on the Moon and Mars. The first plant growth facility to support commercial plants experiments, already launched onboard the International Space Station (ISS) in 2001, was made by **Advanced Astroculture (ADVASC)** and is developed at the **Wisconsin Center for Space Automation and Robotics**[9]. **The Russian Institute for Biomedical Problems** and the **Utah State University** developed the **LADA** plant growth facility, with the same infrastructure, and based on the same functional principles as the SVET, for the Russian Service Module onboard the ISS. LADA has two growth chambers with a smaller volume, one quarter the size of SVET[10,11,12].

In Green Bay, Wisconsin, **Dave Dunlop's** Lunar National Agricultural Experiment corporation (LUNAX) concept can develop science experiments *in situ* to address some of the interdisciplinary problems involving space-based agriculture such as energy supply and consumption, use of "local" resources in the lunar and Martian environment for soils.

It is very interesting to note that, the astronauts like to make experiments very much, and they are very prepared and pleased in taking care of the growing plants. During the series of experiments on *Mir*, it was prescribed in the instructions to watch over the plants one every five days—yet, the astronauts were visiting the greenhouse at least five times a day to care of the growing plants. When writer **Marsha Freeman** interviewed astronaut Michael Foale if he could consider taking plants on missions just to take care of them, and not as subjects for experiments, Foale answered that, "Yes, very much so. I think, just like we have house plants for no reason but for their being there… they are pretty, or that they are a reminder of Earth…"[13]

Providing crews and lunar and Martian settlers with food and nutrition is still a central problem at present. The experience obtained as a result of the international research and experiments in the SVET Space Greenhouse facility in Bulgaria, the support of commercial plants experiments in the Advanced Agroculture, and other more recent centers, is making for humans to make "space" bread becoming a reality. But there is still much to be done before habitable bases on the Moon are operational.

As for the Mex-LunarHab agricultural experiments, Mexico own various very high-level capabilities. Cd. Obregón, in the State of Sonora, is home of the famous **Center for Agricultural Researches of the Northwestern (CIANO)** and the **International Center for Improvement of Corn and Wheat (CIMMYT)**[14] offering highly professional services on agricultural and forest investigation to farmers, industrialists, educational institutions and Government, which operates in 81 experimental fields, and its investigations come out even the human nutrition. This complex naturally becomes as one of our most relevant research centers for Space Agriculture in Mexico, and a collaborator with the project Lunar Habitat Analogue of Mexico as well. In CIANO, the great researcher in agronomy **Dr. Norman Ernest Borlaug**, known as the "father of the Green Revolution"[15,16] (a scientifically successful revolution; failed by inept political economic policies), and Nobel Peace Prize winner in 1970, used to work there. During his 20 years in Mexico, Dr. Borlaug and his colleagues perfected a dwarf wheat variety that could produce large amounts of grain, resist diseases, and resist lodging (the bending and breaking of the stalk that often occurs in high-yielding grains). Under Dr. Borlaug's guidance, this new wheat was planted with great success, not only in Mexico, but also in India and Pakistan. In subsequent years, the wheat was planted in nations in Central and South America, the Near and Middle East, and Africa.

For experimentation and irrigation in the MLH greenhouse plant growth facility, we will use the called Siloes of Water, which have already received some awards. The company **Xnet-Solaris**[6] (R), established in Mexico, D. F., which it will provide energy to the electrical equipment and to make experiments in the MLH about new solar energy high-technology applications, making use of developing more efficient photovoltaic cells than the current ones, since they will be planned to be used on the lunar surface, it will also make experiments using its "solid water" on the vegetable crops of the MLH. After consulting with universities, offices of government and institutions specialized on the subject of water, verifying that the "solid rain" is a viable project, the Fundación Miguel Alemán granted to the author with the "IX Annual Award of Ecology and Environment 2002". For our experiments about the matter of space agriculture, this product will be of much utility to us since, among other capacities, we will use it because: a) It is a dust polymer; b) Is not soluble in water; c) It does absorb up to 500 times its weight in water; d) it is possible to store even for 5 months inside sacks, which facilitates to be used on the Moon, and in the Earth, it is a suitable and sufficient time to wait for the raining season (it saves up to 90% of water for irrigation); e) Its installation cost is low; and, f) It is easy to get kept in any receptacle or sacks, and being guaranteed for 6 years. Also, it has a useful life of up to 10 years. In our planet, it is possible to initiate the sowing without waiting for the raining season; during his growth, the plants do not suffer of water stress for lack of rain; and the areas of cultivation increase their productivity. Earlier it was taking a shower every third day, 150 times per year, today an average of 12 times is taken for making a shower one or two times per month, that is to say, an average of 12 times per year.

References

[1] Dr. Philip R. Harris, with Dr. David G. Schrunk, "Lunar Pioneers", Section: Moon Fiction, Moon Fiction - Out of the Cradle, Ken's Lunar Library, 2010, Chapter 8, pp. 231-234. www.outofthecradle.net/categories/.../moon-fiction/

[2] Tania Ivanova,Yuri A. Bekovich, A. L. Machinkiy, and G. I. Meleshko, "The First 'Space' Vegetables Have Been Grown in the 'SVET' Greenhouse Using Controlled Environment Conditions", *Acta Astronautica*, 1993, Vol. 29, No. 8, pp. 639-644.

[3] F. B. Salisbury, "Growing Super Dwarf Wheat in Space Station Mir", Life Support and Biosphere Science, 1997, Vol. 4, pp. 155-166.

[4] Tania Ivanova, Svetlana Sapunova, Plamen Kostov, and Ivan Dandolov, "First Successful Space Seed-to-Seed Plant Growth Experiment in the SVET-2 Space Green House in 1997", Space Research Institute, Bulgarian Academy of Science, Sofia, Bulgaria, 1997, www.space.bas.bg/astro/Aerosp16/tania1.pdf

[5] ___________, Plamen Kostov, Svetlana Sapunova, Ivan Dandolov, F. B. Salisbury, G. E. Bingham, et al., "Six Month Space Greenhouse Experiments: A Step to Creation of Future Biological Life Support Systems", *Acta Astronautica*, 1998, Vol. 42, No. 1-8, pp. 11-23. www.docs.lib.purdue.edu/cgi/viewcontent.cgi?article

[6] ___________, Snejana Docheva, Iliana Ilieva, Plamen Kostov, Svetlana Sapunova, Rumyana Dikova, and Ivan Dandolov,"Experiment Investigating the Influence of Oxygen Deficiency on Plants Grown in Microgravity", Space, Ecology, Nanotechnology, Safety 2006 (SENS 2006), Varna, Bulgaria, 14-16 June 2006, www.linkinghub.elsevier.com/retrieve/pii/S0273117702007445

[7] Mary E. Musgrave, Anxiu Kuang, et al., "Gravity Independence of Seed-to-seed Cycling in *Brassica rapa*", Planta, 2000, Vol. 210, pp. 400-406.

[8] M. A. Levinskikh, V. N. Sychov, et al., "Growth and the Development of Plants in a Row of Generations under the Conditions of Space Flight (Experiment Greenhouse-5)", *Aviakosmich i. Ekolog Medical,* 2001, Vol. 35, No. 4, pp. 45-49.

[9] W. Zhou and P. Falk, "State-of-the-Art Plant Growth Chamber for Conducting Commercial Plant Research in Microgravity", *Space Technology and Applications International Forum-2000*, 2000, CP504, pp. 374-375.

[10] G. Bingham, I. G. Podolsky, M. A. Levinskikh, and V. N. Sychev, "LADA, a New Joint Russian-U.S. Plant Greenhouse: Continuing the 'SVET' Science and Technology Development Traditions on ISS", *Grav. and Space Bio. Bul.* , 2001, Vol. 15, No. 1.

[11] Shuttle-Mir History/Science/Fundamental Biology/, Greenhouse, Greenhouse: Integrated Plant Experiments on Mir, Shuttle-Mir Missions: Mir 19, Mir 20, NASA-2, NASA-3, Science – Fundamental Biology, www.spaceflight.nasa.gov/history/.../fb/sc-fb-svet.htm

[12] NASA, "Growth and Development of Higher Plants through Multiple Generations (Rastenia)", International Space Station, May 18, 2010, www.nasa.gov/mission_pages/.../Rastenia.html

[13] Marsha Freeman, "Growing Food in Space", *Challenges of Human Space Exploration*, Springer/Praxis Publishing, Chichester, United Kingdom, 2000, pp. 57-79.

[14] Obson, "Wheat Breeding at CIMMYT: Commemorating 50 Years", Cd. Obregon, Sonora: The

Technology City of the Northwest, April 11, 2010, www.obson.wordpress.com/category/economia/

[15] Obson, "Dr. Norman E. Borlaug y el Inicio de la Revolucion Verde", Cd. Obregon, Sonora: The Technology City of the Northwest, www.obson.wordpress.com/.../dr-norman-e-borlaug-y-el-inicio-de-la-revolucion-verde-ciano/

[16] "Remembering the Father of the Green Revolution", *Market to Market*, Iowa Public Television, January 1, 2010, www.iptv.org/.../mtom_20100101_3518_clip

[17] Xnet-Solaris, Tel. 52 (55) 5905 - 4385, www.xnet-solaris.com

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