Apr 30th, 1:00 PM

Paper Session II-C - Leo to Luna: Gathering New Information for the Establishment of a Permanent Presence in Space

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LEO to Luna
Lessons (to be) Learned

by
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What, exactly, can we learn from currently anticipated missions to low earth orbit (LEO) that can be successfully extrapolated with regard to a permanent human presence on (in) the moon?

There are days when it seems appropriate to wonder if it is still acceptable to say “return to the moon” out loud. Nonetheless, there is a quiet movement toward a return to Lunar missions within the aerospace industry. Slowly, often without funding, regardless of public or sometimes even corporate support, engineers and technicians are diligently concentrating on the work which will make those missions possible. One example which comes to mind is the redesign of pressure suits — which takes into consideration the need to function in 1/6 in the presence of Lunar dust and shards of regolith. They are even referred to, when no one is listening, as “moon suits”.

The courage and commitment of those engineers and technicians should be applauded. But until they and their efforts can be openly recognized and incorporated into a funded program, we must existing missions to gain information that can be extrapolated to strengthen the potential for successful Lunar exploration and settlement when the time finally comes.

Lunar mission planners can learn a lot from LEO activities — if the problems are posed in an appropriate way, and if the data gathered are analyzed so that they lead to the information needed. The following topics are all likely candidates to contribute to such information.

International Legal Infrastructure

International agreements do not happen easily or overnight. It is far too easy to assume that legal issues have been resolved, given the multi-national missions aboard Mir, the many shared missions aboard the STS, and the development of shared technology such as Spacehab. As we develop a larger space station, however, there are many questions which remain much discussed but unanswered. Organizations such as the International Colloquium on the Law of Outer Space and the United Nations Committee on the Peaceful Uses of Outer Space have been discussing these issues for decades. Missions to LEO will provide the chance to sort out those details and to develop regulations that can be extrapolated to Luna — and beyond, such as:

Intellectual Property, Copyright, and Patent Laws — Who will own the products developed on LEO? The company which built the facility? The scientist who spends a lifetime working on a specific problem on earth but finds a solution on LEO? The pharmacy, software company, or materials manufacturer which paid for an experiment, but paid nothing for the infrastructure which

enabled that experiment to be performed? Experiments aboard the STS show significant promise for drugs to combat Altzheimer's, AIDS, and cancer in general. Who will own those drugs if/when they are developed? We tend to assume that there is already a large body of scientists who are involved in similar working relationships, and that changing the venue does not change the legal issues. But assumptions are almost never sufficient. Intellectual property, copyright, and patent laws are among the most contested — and most frequently ignored — international legal issues on planet. There is little reason to assume they will be less controversial on LEO and they will certainly gain significance as we begin to utilize Lunar facilities.

Resource Laws and Territorial Treaties — Old-timers in the space program remember the extreme controversy over the so-called Moon Treaty. There was a raging fury in this country during which citizens accosted much of Washington and NASA, determined that the United States would not, under any circumstances, sign the Moon Treaty. There were those who argued, loudly if not always with legal standing, that the moon already "belongs to us". There were arguments that all laws which applied on the moon, from resource capture and utilization to issues of citizenry and landholding would be — could only be — the laws of the United States.

There is a related issue, and that has to do with access aboard the space station and, eventually, Lunar facilities. Will foreign nationals be permitted open access to all areas of the space station? Will they be required to carry some sort of permit, identification, or need-to-know document? And what about the common areas? How will space there be utilized? Will there be a schedule? Will certain nations pick the satellite transmissions on certain days?

The problem is that all of these sound like trivial questions — and for short missions they are. They may reach the stage of minor annoyance, but nothing more serious. On long-term missions, however, these issues take on a level of importance which may be orders of magnitude higher — high enough, in fact, to jeopardize team members and the mission itself.

Technology and Design Issues

Noise — We all know that noise is never going to go away entirely when you live inside a machine. But noise tolerance is distinctly related to cultural experience and, to further complicate the issue, varies considerably from individual to individual. Noise control will be extremely important to mission success. This means more than keeping noise levels at a level that can be tolerated by American service men. There are extremely intensive selection criteria for the people who serve inside our current machines — submarines, maritime surface vessels — for short-term missions. Those criteria will probably suffice for LEO, but we will need to significantly increase our understanding of noise and dampening mechanisms as part of our Lunar program.

Power — U.S. comfort levels seem to tend to two extremes, and both have been reflected by the space program. At one end is the military mandate which says comfort is irrelevant; just get the mission done. The Mercury and Gemini programs clearly reflected that syndrome. At the opposite end is the commitment to elbow room, variable lighting, flexible temperatures, pleasing colors, and plenty of "juice" for telecommunications, computer use, and the like. Frequently, American comfort zones far exceed those of other cultures. In fact, there are many instances where our idea of nominal comfort far exceeds another culture's idea of absolute luxury. There is a very easy way to put this issue in perspective: recollect the joined Apollo and Soyuz spacecraft. By American standards, the Apollo orbiter was cramped and uncomfortable, but reasonably tolerable for short mis-

sions. Compared to the Soyuz, it was a luxury hotel with a large playground. It would be extremely useful, at this early stage of space station development, to spend some serious time with our foreign team mates, examining their plans for specific power sources and user allotments.

Human Issues

About two years ago, I proposed the definition of “long-term mission” as being two years or more. That definition, which has since been adopted and confirmed by others who research extreme environments, is based on a number of factors which apparently cross cultures, gender and age. As we begin to plan for serious Lunar exploration, scientific investigation, and settlement, that number will become critical. Currently planned missions to LEO are much shorter than that, but there are a number of human issues which deserve exploration on LEO and which could, regardless of duration, contribute somewhat to Lunar mission planning as well.

Personnel Selection — One of the most dangerous things that we can do is to assume that, after 40 years of manned space missions, we know enough about personnel selection for long-term (two years or more) missions. The Space Station is not a situation where our standard paradigms for personnel selection, e.g., submarines and Antarctica, serve us well, and the problem of personnel selection for Lunar missions is even more complex. Antarctic facilities belong to the individual nations which built them, just as space station segments do. But each is autonomous, and each nation selects its own personnel, though currently there is shared mission-specific training. In Antarctica, aberrant behavior by scientists from a specific nation is not likely to jeopardize the health or mission of those from other nations. In space, whether on LEO or Luna, such crises may not be so easily rectified. One unstable crew member may very well jeopardize the safety of an entire crew as well as the facility itself.

So — will each nation screen candidates from the others? Will a specific set of standards (which, by definition, could not take into consideration cultural issues) be imposed on everyone who goes? If so, *whose* standards? And who will determine how and if they are met? And who will screen, select, and train the individual candidates and the mission teams? The answers to these questions are not as clear-cut as they might seem. The fact that the United States has taken charge thus far does not, in any way, guarantee that, as the number of participating nations continues to grow, other nations will wish that situation to continue.

Team Size — One thing which people outside the space industry tend to forget about the space station is that it is designed for a very small crew, and for extremely slow expansion. The most recent information called for a crew of four, or perhaps as many as six. Yet, no one who deals with small groups in isolation would ever send a group of six people on a genuine long-term mission. Small, even-numbered groups confined in an isolated extreme environment for a long-term mission (two years or more) will, inevitably, polarize. The jeopardy to personal and professional relationships, and to the mission itself, has been clearly demonstrated by the one genuinely long-term small-group isolation project which has been attempted on planet — Biosphere II.

Regardless of any flaws the Biosphere II experiment may have had, it has been a source of extremely useful information for those of us who study small groups in isolation. The Biosphere II team consisted of four men and four women who spent two years locked away inside a dome containing five separate biomes, a variety of livestock, and both working and recreational facilities. The goal was to spend two years together in entirely self-sufficient isolation.

To put the Biosphere II team and its preparation in context, it is important to remember that NASA presently provides astronaut team training via small-aircraft flights, survival training in the wild, and team problem solving, plus specialized, mission-specific training. Members of the Biosphere II team, however, had a long history of working and playing together. They were deep-water divers, had spent months at a time at sea together, and many of whom had quite literally held each others lives in their hands on multiple occasions.

It is traditionally accepted that one of the most powerful bonding experiences which humans can have is to survive genuinely life-threatening situations together. The Biosphere II team had that experience — several times over. But it was not enough. By the end of the 2-year mission (which had almost ended early on several instances) the team was so thoroughly polarized that four of the members would no longer set foot in the same area as the other four. Team members re-arranged work schedules, task lists, and other mission-related requirements so that they could avoid even seeing each other. Friendships which had been cherished for years did not survive. And a number of totally unexpected behavioral changes — which are apparently tied directly to mission duration — greatly exacerbated the problem. It was only by dint of their commitment to the mission itself — and the fact that the facility was large enough for them to scatter — that the Biosphere II experiment was actually completed.

Social Interaction and Cultural Concerns — It is extremely important to remember that social issues are much more than just being nice to each other, learning when to turn your back and "disappear". There are some issues which are so innate that we don't even know to ask the questions. There are issues of culture having to do with relationships — single and dual gender relationships and roles — there are quarters issues — there are space design issues related to cultural issues. We tend to think that these may not apply on either LEO or Luna. After all, each nation will likely be building its own facilities, so what's the big deal?

Adopting a laissez-faire attitude may actually work for private quarters. Most adults on this planet tend to be reasonably courteous when in someone else's private home, whether it meets their own comfort standards or not. But shared recreational facilities will come with a lot of issues of their own — and joint work areas absolutely MUST be designed with input from more than the culture which is building the unit.

It would be interesting to debrief everyone who has served aboard SpaceLab and get feedback. It is reasonable to assume, as mentioned above, that most Americans who have served aboard tend to find it unusually cramped and with some critical items placed in areas which are at least annoying and perhaps very difficult to use. It seems likely that our team mates from some, if not most, other nations, might be more comfortable, and find completely different sources of annoyance. We tend, as spacefaring *individuals* to write any such annoyances off, and that works for many cultures for short-term missions. But the problem is sure to be substantially exacerbated during multi-national, long-term missions. Debriefings with all astronauts and cosmonauts should always include sessions during which annoyances are examined at length — assuming of course that they can be convinced to be entirely frank.

Multi-Gender Teams — While multi-gender teams have already enjoyed significant success for short-duration missions, the importance of addressing mixed gender teams on long-term missions cannot be over-stated. Extensive debriefings with astronauts and cosmonauts of both genders will be essential to minimize conflict on longer missions, both on LEO and on Luna. It would be extremely valuable to locate and debrief individuals who have served on mixed-gender teams aboard

research vessels, maritime and military vessels, long-established mixed-gender military units (e.g., the Israeli commandos), and as winter-overs in Antarctica.

Three issues are essential if such interviews are to have any value for long-term missions to LEO and Luna:

- Representatives of both genders and every level of hierarchy must be interviewed.

- Absolute confidentiality must be observed and future mission assignments must not be jeop ardized as a result of opinions expressed. (This is a very different issue from fitness for duty.)

- Members of multi-gender teams representing relevant experience in a wide variety of cultures must be interviewed.

Third-Quarter Syndrome — There is a peculiar phenomenon which seems to apply to all missions, regardless of duration, and which should certainly be considered during LEO and Lunar mission planning. That is the so-called Third-Quarter Syndrome. Both individuals and groups seem to encounter the syndrome, which usually manifest shortly after the half-way point of a mission. What occurs, in one form or another, is this: team members wake up on or near the half-way point excited, aware that they have completed half the mission, and "it's all downhill from here." Soon, however, focus begins to shift to mission completion, especially to the return home. At this point, what started as, "Wow! We're already half way there!" deteriorates to, "Wow! We're *only* half way there." Low individual and team morale, significantly reduced productivity, and increased hazard due to lower levels of safety are all linked to Third-Quarter Syndrome. Space station missions will provide increased opportunities to explore this syndrome in an isolated, extreme environment.

Food — Explorers, like armies, advance on their bellies. In an isolated environment, the person who can make or break a mission is the one who has control of the food. It is absolutely essential to recall early space missions in which there were major crew conflicts because someone ate food belonging to someone else. This is *not* a personal foible or some kind of meaningless personality conflict.

Despite the fact that time has weakened our recollections of the intensity of those disagreements, they are extremely important to long-term mission planning. And personal choices are only one part of the food issue. During short missions, unpleasant foods may be tolerated. During a longer mission, they are likely to be a source of serious conflict. And for long-term missions (two years or more) food-related issues are likely to contribute to an environment so tension-laden that missions — and lives — may be jeopardized.

One issue related to food which we will finally have the opportunity to study at length on LEO is local horticulture. There have been many planet-bound experiments which tell us a great deal about growing fresh foods off planet, and Soviet/Russian space travelers have successfully grown a variety of crops. If we have not already done so, we should probably spend some time reviewing radiation-related crop issues such as plant growth rates, fruiting sizes and frequencies, plant and seed mutation, if any.

Conclusions

All current missions to LEO are *visits*, not a permanent life in space. When we talk about a permanent human presence in space, we are still talking about machines, not people. The machine will

stay in space (we hope) and people will visit. This is not the same as developing a permanent facility or even as long term mission, whether on LEO or Luna.

At this point we still plan every mission based on re-supply and rescue from the home planet. Granted that genuine independence from the gravity well — on LEO or Luna — is not coming soon. The fact remains that we must begin now to make the transition in our thinking, to stop assuming that there will always be care packages from home, and to look at the transition between the two phases. Although a great deal of research on local resource utilization has been done, much of the material deals in later stages of development. It is essential to begin now to look at the transitional stages, the points *between* three or four scientists on LEO and a booming industry or mining town on/in Luna.

With due credit to Tsiolkovsky and his comment that earth is the cradle of human kind, it is valuable to think of human exploration and settlement of space as an analog to education. In this analogy, what we have done so far is pretty much all pre-kindergarten. Kindergarten started when we launched and utilized, however briefly, Skylab, and continued as we learned to “play nice” on board Mir. Grade school is when we go to the moon and stay; junior high school is when we start shuffling back and forth between here and Mars; high school is when we have an established habitat and support industry, with families, on Mars. We graduate when we start extrapolating that colony to not only other parts of the solar system but exploring ways to get people beyond this piddly little planet on the outskirts of the universe.