LUNAR MISSION ONE

22nd August 2016

LM1 project ideas for SGAC

Issues with a *direct* influence on the space mission.

Borehole lining

While it is being drilled, the borehole needs to be stable and strong, to be able to transmit the forces of the drill as it anchors itself to the surrounding rock. The vibration alone is likely to cause the borehole to collapse at some stage. The physical structure of the rock may well vary with depth, from strong solid to easily breakable.

So we need to line the borehole with something strong and relatively easy to place as we drill, every 20cm. The normal placing of a casing tube, as for drilling on Earth, would be too complicated and heavy and we need a new solution. The candidates seem to be (1) placing flexible segments of tube that expand against the circular wall, (2) the additive manufacturing (AM, sometimes called 3D Printing) of a lining using a new composite material based on graphene for example, and (3) sintering or vitrifying the rock with a low power laser.

Landing site selection

Selecting the landing site involves a complex trade-off between several factors: Sun visibility for power, Earth visibility for communications, landing hazards, drilling risk, geological interest, manned exploration interest, subsurface preservation temperature. What are the high level priorities for selecting a short-list? What are the detailed features of the candidates? What landing accuracy is required? How can we use NASA's Lunar Mapping & Modelling Project (LMMP)?

Archive digital material

The archive needs to be able to survive with its digital information for a billion years. What material can hold data for this time? The environment is very benign for preservation (protected, very cold and a perfect vacuum), but the material must not degrade internally. How can the data be recorded on or in the material. How can it be written, and read? What data density can be achieved, and how much capacity would that give for an expected 5 litres of volume? How would the background radiation of the surrounding rock limit the data density?

Archive container technology

Both the digital and DNA archives need some form of container for packing, spaceflight, deposit and storage. They should provide physical and radiological protection for all these mission stages, for example rocket launch forces, solar/cosmic radiation during spaceflight

and on the lunar surface, meteorite/asteroid strikes on the Moon, and long term background radiation in the borehole. What shape should be canisters be, and of what material should they be made? Note they should exploit the borehole's natural vacuum.

Borehole background rock radiation

Although the archive should be deep enough to be protected from non-lunar ionising radiation, from cosmic or solar sources, there will be some radiation from the surrounding lunar rock itself. It is likely to be small, but over the geological timescale that the archive could survive its accumulation may be significant enough to degrade the archive's information. It might place constraints on the archive material we use, or require extra protection from the canisters.

What kind of radioactive material can we expect at depth, for example the radionuclides Potassium (in its ^{40}K isotope form), Uranium or Thorium. How much radioactive material does the surrounding rock contain? What kind of radiation (Alpha, Beta or Gamma) do they emit? What are their half-lives and what levels can we expect over the next billion years?

Issues with an *indirect* influence on the space mission

Archive survival

Can we create an online model that predicts how long the archive could survive, that can be used and developed by anyone? What are the limiting environmental factors, for example how do the following affect survivability: random asteroid strikes (size, velocity, proximity), background radiation (surrounding rock, solar/cosmic), temperature, Moonquakes, mission contamination, long term Earth-Moon orbital dynamics, long term solar life-cycle? What are the mitigating mission factors: depth, capsule strength and material?

How should this prediction model be built and presented, for both educational and marketing purposes and also for influencing the mission objectives?

Planetary contamination

What constitutes contamination of the Moon, and what would LM1's impact be? Is there a biological issue? What are the accepted rules for space exploration? What is required to minimise contamination of the archive, to prevent flows of matter or energy into or out of the archive, and so to improve its survival as an information repository?

Light beacon homing

Navigating to land at a small site (~100 meters) is challenging and several techniques have been, or are being, developed for course corrections during the powered descent stage. One additional idea that exploits the natural conditions of the polar region is to use the

illumination of the landing site itself to home in on, visually, as an aid to both automated navigation systems and manual supervision and control. It would appear first as a spot from a distance on the horizon and exist in the presence of a known pattern of other illuminations. Several recent orbiting spacecraft have provided sufficient data that could be used to provide the necessary picture at all stages of the descent before the more precise hazard avoidance in the final minute.

Archive content

Archive data structure(s)

For both compilation and reading, the archive will need some form of data structure for making sense of it all. The species database in particular is likely to be very complex. What would it look like, and how would it be designed. How might the data structure vary for different parts of the archive? Can the data structure evolve? What information tools would be needed?

Wikipedia as base encyclopedia

As the largest encyclopedia online, Wikipedia is an obvious choice to form the basis for the public archive. What needs to be done to develop it for LM1? How can it be used for LM1's education program, with large scale additions by schoolchildren and the general public? Can we organise and manage a multi-layered approach to information quality - from highly qualified and officially approved material, to children's contributions with only teacher approval? Can it be made inclusive of all cultures around the World? How?

Instructions to finders

How should future explorers be able to understand the archive's contents when they find it? We can assume they are clever to have reached it, but cannot assume they know how to read it. How do we tell them?

Associated issues

Moonbase (future space exploration and LM1)

The international space agency community seems to be moving towards the creation of a permanent manned presence on the Moon, together with orbital facilities in nearby “cis-lunar” space, as a base for science and as part of a future logistics chain for solar system exploration. What is the role of the Moon in the exploration of Mars, and beyond? How would ESA's DG (Jan Wörner) "Moon Village" be implemented? What are the current lunar intentions of the major space agencies (NASA, China, ESA, Russia, India, Japan) and how might they develop or change?

The "New Space" movement of private initiatives is expected to be involved. What are the investment conditions for private investment? How could or should the public and private sectors interact? What are the politics, and the technological and financial issues, that will determine what happens? LM1 sees itself as part of that whole development. Assuming LM1's financial success sufficient to contribute to further missions, how can it play a future role, in accordance with its declared objectives? What difference could LM1 make?

Space law & jurisdiction

The internationally accepted governing law for space activity is the UN's 1967 Outer Space Treaty. It is very general and assumes actions by nations. Future exploration is likely to require a substantial increase in detailed provisions for rights and obligations, to cover the ownership, protection and exploitation of material and intellectual assets. Even jurisdiction needs to be developed, ie a generally accepted system of legal authorities with bodies of applicable law and processes for applying and maintaining it. Even if LM1 can be seen to confirm to currently accepted standards, it is likely at least to prompt the requirements for more substantial law. What would the required law look like? Who should implement it? What can we learn from the law of the sea, and from international agreements for the Antarctic?

Archive discovery & ETI

We have no scientific predictions of the archive's discovery - who/what, when, how. But thanks to the long timescale of preservation and a suitable method of pointing to it, we do have a much better chance of discovery than other messages sent into space. It might be by an advanced form of humankind, or another species evolved on Earth – what are the prospects for future life on Earth?

Or it might be by an "extra-terrestrial" intelligence on a voyage of discovery – what are the chances we are not alone, and if so is the Galaxy populated enough for a nearby civilisation to make the journey to our solar system? ETI is still a fundamental unknown, but the much greater chance of discovering basic forms of life, quite possibly in our lifetime, would dramatically alter the likelihood of advanced life somewhere. The standard formula for calculating ETI probability is the Drake Equation. How does it affect what people imagine might happen to LM1's archive? How soon might it be discovered? What is the scientific basis for interstellar travel, especially for return journeys?

Archive recovery

Assuming the archive is discovered, what might happen to it? Will it be properly read and interpreted? What might be done with the information? Will it be the subject of scientific interest or of commercial exploitation? Can we influence the outcome by its contents? What would we want to happen to our archive, and does it matter anyway? What would that tell

us about ourselves? What would we do if, for illustration as a thought exercise, we found a time capsule during our current exploration of Mars, left to us by an equivalent civilisation long ago?

Bioethics

LM1's market research picked up that about 10% of people are concerned about the existence of DNA in the archive; "It feels wrong". A hair shaft is biochemically inactive, its cells are dead and the DNA is broken up. Yet the DNA information can still be read long into the future, for digital resequencing and copying. Though there can be no cloning or re-use of bio-material, there may be a hypothetical bodily construction to create different individuals, even though that is not possible today, either scientifically or technologically.

Who owns a genome? What are the effects of "project intent" (for the mission's archive and its education) and of "customer consent"? What information should be made available to paying customers? What are the ethics involved? What exactly is bioethics anyway?