THE FIRST LUNAR OUTPOST: THE DESIGN REFERENCE MISSION AND A NEW ERA IN LUNAR SCIENCE; Gary E. Lofgren, Code SN-4, NASA-Johnson Space Center, Houston, TX 77058

The content of the First Lunar Outpost (FLO) Design Reference Mission has been formulated and a "strawman" science program has been established. The mission consists of two independent launches using heavy lift vehicles that land directly on the lunar surface. A habitat module and support systems are flown to the Moon first. After confirmation of a successful deployment of the habitat systems, the crewed lunar lander is launched and piloted to within easy walking distance (2 km) of the habitat. By eliminating the Apollo style lunar orbit rendezvous, landing sites at very high latitudes can be considered. A surface rover and the science experiments will accompany the crew. The planned stay time is 45 days, 2 lunar days and one night. A payload of 3.3 metric tons will support a series of geophysics, geology, astronomy, space physics, resource utilization, and life science experiments. Sample return is 150 to 200 kg. The rover is unpressurized and can carry 4 astronauts or 2 astronauts and 500 kg of payload. The rover can also operate in robotic mode with the addition of a robotics package. The science and engineering experiment strategy is built around a representative set of place holder experiments.

An experiment station similar to ALSEP on Apollo will include instruments to measure heat flow, magnetic fields, seismic activity, micrometeorite and secondary ejecta flux, and the precise distance to Earth. A solar system physics experiment package will be deployed at the same locality and measure particles and fields and the lunar atmosphere and its variations. The stations will be deployed by the crew and operated remotely from Earth.

Astronomy experiments will be deployed in a remote locality (10 km from habitat) after the area has been explored geologically to avoid dust contamination. The experiments currently include a lunar transit telescope, a small research telescope, and a small solar telescope. The lunar transit telescope will take advantage of the lack of an atmosphere to survey the sky in the UV spectral range providing images of stars, galaxies, clusters, and the interstellar medium. The research telescope will be pointable and used to observe various astronomy targets as well as provide engineering and operating data for future telescope design. The solar telescope will provide high resolution images of the sun to examine solar flare tracking and other solar processes. All of the telescopes will be deployed by the crew and will be operated from the earth.

In Situ Resource Utilization (ISRU) experiments will demonstrate and allow testing of possible utilization and engineering concepts that could be used in future lunar outpost design. Three concepts are being considered for early evaluation. Oxygen extraction from lunar materials which uses imported hydrogen will be evaluated to possibly provide oxygen for chemical propulsion systems and to make water. Methods will be studied to optimize brick fabrication from lunar soil. A gas flow unit will test pneumatic transport and pneumatic size sorting methods to be used primarily for preparing feedstocks for other processes.

Life science EVA experiments will consist of monitoring equipment for human performance during EVA. There will specialized testing for such attributes as vision, locomotion, balance, orientation etc. An exobiology experiment might consist of a cosmic dust collector deployed on the lunar surface to be returned on a later mission for analysis.

Extensive geologic traverses are planned. The unpressurized rover is similar to the one used on Apollo but with an increased payload. Rover traverses will be limited to distances with a walk back capability, approximately 20 km. Robotic rover traverses can extend the radius to 100 km. There is a traverse geophysical package which includes an electromagnetic sounder for subsurface data collection, an active seismic experiment to determine the structure of the upper few kilometers, a traverse gravimeter, an electrical properties experiment which will also return data on subsurface structure, and a profiling magnetometer. Geologic field studies will have specific objectives similar to Apollo field studies, but with considerably more latitude to adapt the traverse to targets of opportunity. EVA's will occur nearly every day with alternating crews. The total EVA traverse time in one 45 day mission will more that double the total Apollo EVA time. EVA's will be a maximum of 8 hours when conditions are favorable and of shorter duration when heating or light conditions are less opportune. The tools available to the astronauts will be patterned on those used on Apollo including the 3 meter drill and drive tubes for sampling the regolith. In addition a drill capable of drilling rock is being considered. The geologic investigation should cover an area about 50 km in diameter around the outpost.

Robotic operations with the rover would allow excursions of up to 100 km from the outpost; beyond the area that can be explored by the crew. Robotic missions could be operated from the habitat or from Earth when the habitat is not occupied. Samples of rocks and soils could be collected and documented. A manipulator arm will be available to dig, scoop, and sample soil and rocks. Many of the geophysical traverse instruments could still be used and some basic analysis instruments might also be included. Samples collected between outpost missions could be returned when the outpost is next occupied. Up to four 200 km round trip traverses could be accomplished per year in remote mode. It would also be possible to do preliminary traverses to help planning the crew explorations.

Science experiments conducted within the habitat may include basic characterization of the lunar samples. The samples can be examined and subsamples taken for return to Earth. A binocular microscope and some kind of spectral analysis device will be available to assist in the characterization. Other IVA experiments may include gravitational biology and physiological experiments. For example the mutagenicity of cosmic radiation and the nature of chloroplast movement could be studied. Physiological experiments on the central nervous system, thermoregulation in the body and body fluid analysis are being considered.

The sortie missions are an important aspect of the FLO exploration. The sortie mission resembles an Apollo mission. It will be a two week mission with 2 crew and a single landing vehicle; the same vehicle used to occupy the outpost. The crew with have an unpressurized rover with similar capabilities to the one mentioned above. They will deploy appropriate instruments with the objective of establishing the desired network science, i.e. seismology.

The FLO mission will have a large scientific return in the form of samples and scientific instrument deployed. This information will provide input to future planning for a Lunar Base and for missions to Mars.