RELATIONSHIP BETWEEN THE MANNED AND UNMANNED PROGRAMS

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As man thrusts himself ever deeper into the broad reaches of space, one of the pacing items is the understanding of this new, relatively unknown environment. The spacecraft of unmanned programs are the windows through which we glimpse the realities of space. Data from their experiments are, to be sure, of transcendent scientific importance. At the same time, however, they provide the basis for design specifications or design verifications for the vehicles which will transport man to the moon and beyond.

Although the relationship between the manned and unmanned programs influences the entire NASA program, from vehicle requirements to mission planning, this paper will discuss the data requirements for the Apollo manned lunar landing program and the plans for obtaining the data through the unmanned lunar programs.

DATA REQUIREMENTS

The Apollo program data requirements can be divided into three broad categories: 1) cislunar and lunar environment, 2) reconnaissance and topography, 3) surface physical characteristics. These data affect the design of the spacecraft, the planning of the mission, and the landing and operations on the lunar surface.

Spacecraft design is influenced by two major elements of the cislunar environment - micrometeoroid flux and radiation intensity. Present design is based on Whipple's distribution for sporadic meteoroids, a conservative extrapolation from meteor observations. Watson's theory and McCracken's analysis of the relatively sparse direct measurements available indicate the problem may not be as severe as presently imposed specifications. Area-time measurements of micrometeorite-flux

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and damage mechanisms will be important inputs to the Apollo design.

Knowledge of the radiation environment beyond the Van Allen Belts is equally sketchy. The spectrum of solar radiation in cislunar space and of the background radiation at the moon must be determined. Intensity and distribution of solar storms must be measured. If possible, better means of predicting their occurrences must be developed.

The influence of both micrometeoroid and radiation data on the design of the spacecraft is obvious. The outer structure of all space stages, the shielding required in the Command and Lunar Excursion Modules, and the design of the space suits for lunar exploration are affected.

LUNAR RECONNAISSANCE

The initial Apollo landing sites must be established early so that effort may be focused toward surveying these areas intensively. The choice of the Lunar Orbital Rendezvous technique as the prime mission mode limits the initial Apollo landing to a belt within $\pm 10^{\circ}$ of the lunar equator. The areas which can be easily reached by the unmanned vehicles lie on the leading quadrant of the moon. Hence the first lunar landings will occur in a space bounded by lunar latitudes $\pm 10^{\circ}$ and longitudes 270° to 360°. The actual sites will be chosen for their apparent scientific potential. Fifteen sites have been recommended by the Astrogeology Branch, U. S. Geological Survey, and several of these sites fall within the preferred landing space.

Before the actual Apollo landing site is selected, more detailed reconnaissance is required. One of the best lunar maps available today, with a scale of 1:1,000,000, shows much detail. However, for the landing area we require detailed maps at a scale of 1:250,000 over 10-mile-square areas with a horizontal accuracy of $\pm$ 800 ft and vertical accuracy of $\pm$ 150 ft. For the landing site, maps should be available at a scale of 1:25,000 over a 1-mile-square area with a horizontal accuracy of $\pm$ 80 ft and a vertical accuracy of $\pm$ 15 ft. These accuracies are required for navigational fixes as well as initial exploration.

The accuracies quoted above are equivalent to the minimum National Mapping Accuracy Standards. The area requirement is about equivalent to that for planning strategic military operations, the site requirement to that for tactical operations.

In addition to maps, detailed pictures of the lunar surface are required. Stereoscopic imagery is preferred but early monoscopic pictures will be useful. In the landing areas the pictures should be indexed to existing maps and have resolution adequate to identify objects with 50- to 150-ft dimensions. At the landing site, pictures which can identify 4- to 6-ft objects are required. At the actual landing site imagery taken from a landed unmanned spacecraft is required covering a 360° horizontal scan and sweeping out a vertical angle from approximately 45° below the horizontal to 5° above the lunar horizon, with resolution to permit identifying $\frac{1}{2}$-in. objects 10 ft from the camera. In addition, vertical or "angle down" imagery is required, with the same resolution, to indicate surface texture at the touchdown point.

SURFACE CHARACTERISTICS

The lunar landing maneuver and the operations on the moon are strongly influenced by the detailed surface characteristics. The major factors are:

1) Roughness, which should be measured to 0.5 in. over areas 10 ft in diameter.

2) Slope, particularly to identify areas where the grade exceeds 20°.

3) Dust, particularly to bound the depth of the layer. Depths less than 5 in. should present no problem, those above 20 in. will hamper operations seriously.

4) Surface strength, including static load and total sinkage.

5) Electromagnetic reflectivity within the L, S, and C bands.

If these data are obtained prior to the initial manned landings, the operations can be carried out with a high degree of confidence that the mission will hold no surprises in store for the astronauts.

UNMANNED LUNAR SPACECRAFT

The unmanned lunar program will be the source of extensive scientific data, as well as the engineering information indicated in the foregoing. Both the Ranger and Surveyor programs are expected to "make straight the way" for the first manned lunar missions.

The Ranger will provide both landing data and high resolution TV. The television coverage will be a series of nested photographs, covering successively smaller areas with increasing resolution. The last photograph prior to impact should provide 1 ft per line pair resolution. In addition to television, the Ranger also carries particle flux detectors, cosmic dust analyzers, magnetometers, and geiger counters.

Rangers no. 5 through no. 9 are presently scheduled. An additional five Rangers are under consideration. These payloads may continue the high resolution television series or may be designed for high resolution facsimile and hardness measurements on the lunar surface.

The second major unmanned lunar program, Surveyor, is divided into two phases, the Lander and the Orbiter. The early Lander will place a 100- to 200-lb useful payload on the lunar surface including a multiple camera TV system to provide panoramic viewing of the local landscape and telescopic optics to permit high acuity examination of the nearby terrain and the texture of the surface material at the touchdown point. Surface drills and a sample transport system, observed by TV cameras, may provide information on the hardness of the surface and subsurface. Samples of lunar material will be analyzed chemically to define their composition. The Surveyor payload may also include radiation detectors, soil mechanics experiments, and magnetometers.

The Surveyor Orbiter payload will be used primarily for reconnaissance and high resolution TV mapping of the lunar surface, as well as for determining lunar gravity anomalies.

In the flight schedule the proposed five additional Ranger payloads would fill the gap between the end of the present Ranger series and the beginning of the Surveyor Lander program.

SUMMARY

The design of the spacecraft for the initial manned lunar landings is already under way, based on the best conservative estimates that can be made of the lunar environment. The unmanned lunar program will be the major source of data to verify or modify the assumptions. The experiments projected in Ranger and Surveyor are capable of measuring the required data, and the present program schedules will provide these data in time for verification of the Apollo design.