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SPACE AND ELECTRONICS

INITIAL RELIABILITY GOALS AND APPORTIONMENT
LUNAR FACSIMILE CAPSULE

Prepared for: Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Under Contract: JPL Contract 950462

Prepared by: L. R. Lerum

Approved by: R. J. Langlie, Manager, Reliability Department
W. Hostetler, Manager, Space Programs

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INTRODUCTION

This Reliability Goals and Apportionment report for the Landing Sphere Assembly has been prepared under Jet Propulsion Laboratory, Contract 950462. The purpose of this document is to establish and report a Landing Sphere Assembly reliability goal and the apportionment of this objective to appropriate subassembly levels.

Any necessary revision or updating of the initial goal or apportionment objectives will be transmitted in the Reliability Analysis and Failure Mode Study Reports scheduled for submission during the program.

RELIABILITY GOALS AND APPORTIONMENT

In order to assure that the desired attributes of a system are present in a completed design, it is necessary to establish definitive objectives toward which those responsible for the design direct their efforts. This is true not only for such design parameters as weight and performance, but for reliability as well. To favorably influence the design to the greatest extent, it is necessary that reliability design objectives for the overall assembly and comprising subassemblies be established early in the design concept stage. The purpose of establishing subassembly reliability goals is to provide each equipment designer with a design parameter, compatible with the overall assembly reliability goal, with which his design is expected to comply. Establishment of these goals also provides for greater program visibility in that it facilitates evaluations, comparisons, and trade-offs; directs proper engineering emphasis to potential problem areas; and provides a measure to which the design can be compared as the design progresses, improvements are made, and test results are analyzed.

Reliability objectives of subassemblies comprising an assembly must be based upon an overall assembly probability of success. This assembly reliability goal must take into account the overall mission tasks to be accomplished, the complexity and types of equipments required to perform these tasks, the environments to which the equipments will be exposed, and the desired operating time; as well as the constraints imposed by weight, cost, and schedule requirements. These considerations have taken into account in establishing the reliability objectives for the Landing Sphere Assembly.

The scope of the present program does not include the design and development of a complete Landing Sphere Assembly. It has been necessary, however, in establishing reliability goals for the Phase I equipments, to establish an overall assembly objective and an apportionment for all major subassemblies. The Landing Sphere Assembly reliability goal and the goals for the major subassemblies are listed in Table I.

The reliability objectives of Table I represent the probability of the assembly and respective subassemblies performing their designed mission functions without degradation or failure which would cause compromise of the mission objectives. For instance, the reliability goal for the battery represents the minimum desired probability of it withstanding pre-launch, launch, flight, and impact conditions and providing the specified power for the designed operating time.

It should be noted that this definition for success is the most stringent that can exist; that is, no allowance has been made for partial success such as operation for six hours instead of the desired eight. Future studies will consider possible partial success modes of operation for the system.

TABLE I

Landing Sphere Assembly	0.95
25 g Inertia Switch	0.999
Payload Power Supply	0.994
Post-Impact Timer	0.996
Cage/Uncage Mechanism	0.998
Porting Device	0.994
Deployment Mechanism, Top Tube and Antenna	0.997
Antenna	0.999
Facsimile System	0.983
Transmitter	0.993
Structure	0.999
Impact Limiter	0.999
Flotation System	0.999

To provide design objectives for the Phase I effort the Facsimile system reliability objective has been further apportioned as shown in Table II. Again this apportionment has been based upon the functions performed and the relative complexity of subassemblies required.

TABLE II

Facsimile System	0.983
Top Tube Assembly	0.994
Signal Electronics	0.992
Azimuth Drive Assembly	0.999
Motor Drive Electronics	0.998

METHOD OF ARRIVING AT APPORTIONMENT

The apportionment of the overall Landing Sphere Assembly goal among the comprising subassemblies necessitates evaluation of the subassemblies both individually and collectively. A subassembly objective must represent a realistic goal in view of the particular function to be performed, the means available to provide that function, and the inevitable failure modes expected to exist. The aggregate of subassembly objectives, when considered in the above light, must be compatible with the overall assembly objective. Since the functions to which an apportionment has been assigned are considered to be in series, reliability wise (that is, the failure of any one to perform its desired function will result in assembly failure), the product of the subassembly reliabilities is equal to the assembly goal.

The 25 g inertia switch is utilized to maintain an open electrical circuit between the payload power supply and the post-impact timer until it closes upon sensing the designated g level after retromotor ignition. Since this is a relatively simple function, it has been assigned a high reliability objective of 0.999.

Past experience with power supplies similar to the one required for the Lunar Facsimile Capsule payload and examination of possible failure modes has indicated that the assigned reliability of 0.994 is a realistic objective.

The post-impact timer utilized to provide initiation of four sequenced events at approximately one minute intervals. Based upon experience with similar timers and its relative complexity as compared to the other electronic subassemblies, it has been assigned a reliability objective of 0.996.

Experience on the Lunar Seismometer Program has shown that highly reliable methods can be devised to perform the caging/uncaging function. Redundancy can be utilized with negligible cost and weight increases to provide actuation of the caging and uncaging mechanism. For these reasons a reliability objective of 0.998 has been assigned to this mechanism.

Reliable methods can be devised for the initiation and actuation of a porting device. However, the overall function to be performed is relatively difficult especially in light of possible impulse effects on the capsule. For this reason a relatively low reliability of 0.994 is considered to be a realistic design objective for this device.

The reliability of the top tube and antenna deployment mechanisms is expected to be quite high due to the relatively simple means that are available to perform these functions. Because of this relative simplicity, a reliability objective of 0.997 has been assigned.

The inflatable antenna is expected to have a high inherent reliability due to its passive nature. A reliability objective of 0.999, which takes into account expected failure modes associated with the electrical connections and transmission lines, has been assigned.

A comparison of the facsimile system with the other Landing Sphere subassemblies has indicated that it is the most complex and is expected to present the most difficult problems in attaining high reliability. A reliability goal of 0.983 has been apportioned to this assembly. During this contract, the design of this system will be carried to the final prototype stage. Therefore, secondary reliability objectives have been assigned to the major subsystems, as shown in Table II.

As a result of a preliminary reliability analysis performed on the transmitter and comparing it with the estimated complexities of the other assemblies, a reliability objective of 0.993 has been allocated to this assembly.

Since this payload structure is a passive assembly and any possible failure modes can effectively be "designed out" by providing strengths greater than the expected stresses, its reliability is expected to be quite high. Experience on the Seismometer program has indicated this to be true. Therefore, a relatively high reliability of 0.999 has been apportioned to the structure.

The impact limiter is a passive assembly. Adequate Quality Control coverage to assure Manufacturing compliance to engineering requirements is expected to provide a very low probability of failure for this subassembly. Correspondently, a reliability objective of 0.999 has been assigned.

The flotation system has very few failure modes excepting those that result from failures in other subassemblies previously considered. A reliability goal of 0.999 has been assigned to this system.

The subassembly reliability goals listed are believed attainable within the scope of this program; however, it should be emphasized that for the most part they are derived from engineering judgment based upon past experience and the estimated relative complexities of the subassemblies.

It should also be emphasized that this apportionment is preliminary and is subject to revision as increased program visibility is obtained.

Recommended increases or decreases in the assembly goals and possible apportionment to lower levels will be transmitted in the Reliability Analysis and Failure Mode Study Reports scheduled for submission during the program.