ABSTRACT

Optimum Packaging Design and Component Sparing Policies for Extended Manned Space Missions. (August 1968)

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The primary objective of this research is to provide an analytical solution to the problem of optimizing the design of manned spacecraft systems with respect to the modular level at which on-board replacement of failed modules should be carried out. Failed modules are assumed to be non-repairable. The optimum design is considered as a system with the minimum weight, consistent with mission requirements, for which a required reliability can be attained. A specific set of design alternatives in the form of a hierarchy of candidate replacement modules is used as the framework from which an optimum design is selected.

The reliability expressions for spared systems are derived under the assumption that the components follow a negative exponential failure distribution. A detailed derivation of the reliability of a series-parallel system with spares is presented, and comparisons are made with a series spared system.

The effect of having common components in spared systems is discussed and illustrated in graphs for specific cases. An advantage of increasing component weight to achieve commonality of components is demonstrated.

The optimum module level problem is solved using a dynamic programming approach for the case where each module is unique. For the case with common modules an integer programming model is formulated. A solution is obtained by a specialized algorithm of the branch and bound type which uses dynamic programming as a bounding method. The attendant assumptions, considerations, and data requirements for the model are outlined.

Some assumptions are (1) that there is no degradation of the reliability of spares while not in use, (2) each of the modules in the basic system are required for the successful completion of the mission, and (3) the penalties for sparing a given module, such as fault isolation and replacement times, can be expressed in terms of a common parameter.

An example problem is presented and used as a basis for discussion. The solution is illustrated by a tree of feasible solutions.