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Estimating Reliability by Application of Matrix Representation

In estimating the reliability of a manned spacecraft in performing a predetermined mission there are two probabilities to calculate: (1) the probability of mission success—the probability of completing the mission objectives with no loss of life, and (2) the probability of crew safety—the probability of returning the crew safely to earth with or without having accomplished the objectives of the mission. The large number of factors that must be taken into consideration when estimating these probabilities, such as the changing hardware configuration and the large number of components in a manned space vehicle, make computations complicated. A new and simplifying technique for performing this calculation has been developed, based upon matrix representation and matrix collapsing. This technique provides analytic expressions of mission success and crew safety for each subsystem, making it possible to relate changes in subsystem reliability directly to mission success and crew safety.

The reason for the development of the concepts of matrix representation and matrix collapsing is that ordinary Boolean techniques are quite cumbersome in cases where the configuration of a complicated subsystem is permitted to change with respect to time. These configuration changes may be due to changing functional or reliability requirements on the subsystem.

The functional and reliability requirements of any given subsystem, "i", for any phase, K, are represented in matrix form in order to facilitate deriving an analytic reliability function for the subsystem which is valid from time zero to the end of that particular phase. Even though there are three mutually exclu-

sive states to consider—mission success, abort enabling failure, and fatal failure—the only two matrices which need to be determined are the success matrix which contains all of the distinct success paths through the subsystem, and the abort enabling failure matrix which contains all of the distinct abort enabling failure paths through the subsystem. The probability of a fatal failure at the end of any phase K, is the probability of success at the end of phase K-1 minus the probability of crew safety to the end of phase K, with the total probability of a fatal failure being the sum of all the phase fatal-failure probabilities. The problem of determining the unconditional success matrix can be solved by utilizing the concept of matrix collapsing.

Given two success matrices, A and B, where A is valid for the first mission phase and B is valid for the next mission phase in which the subsystem occurs, every row of A is intersected with every row of B and all redundant paths are eliminated. This process is continued for all subsequent mission phases in which the subsystem occurs; this is the same as intersecting the Boolean phase models, but is a simpler way of doing it. The abort enabling failure ground rules are applied to the unconditional success matrix to determine the unconditional abort enabling failure matrix. In order to include the aborts, the unconditional success matrix and the unconditional abort enabling failure matrix, are collapsed with the subsystem functional and reliability requirements abort matrix. Once the unconditional matrices are determined, a reliability measure may be applied to them and the necessary functions are then derived in order to determine the probabilities of mission success and crew safety.

(continued overleaf)

Note:

Requests for further information may be directed to:
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