RELIABILITY ALLOCATION - REQUIREMENTS MODELING

Purpose:

This write up illustrates the concept of reliability allocation or apportionment. **Reliability allocation** provides a means to assign the reliability requirement for complex systems to lower levels. Assume the reliability requirement is: *"The program shall be designed so that the cumulative probability of safe crew return over the life of the program exceeds 0.99. This will be accomplished through the use of all available mechanisms including mission success, abort, save haven, and crew escape."*

There are many ways of allocating reliability. The allocation process is complex and must be accomplished in order to guide the design engineer. Thus, one major benefit of reliability allocation is that it facilitates the decision making process to occur early and in an orderly and knowledgeable fashion.

Assumptions:

1. The **spacecraft** in this illustration is assumed to be a reusable earth-to-orbit type vehicle. The "reusable" assumption means that the reliability requirement will have to be allocated over all of the flights during the life of the program as well as over all of the spacecraft's systems. The strategy of reliability growth, the continuous improvement in the system performance over the life of the program, is not modeled.
2. The **reliability requirement** for the mentioned spacecraft will use 0.9999, an improvement factor of 100 over the minimum 0.99 requirement.
3. The **allocation model** for the reliability of this spacecraft is based on the logic presented in the fault tree diagram found on page 2. The top event or output of this fault tree is the probability of failure (or unreliability) on a per mission basis and is generated by working the fault tree from the bottom events to the top event. For simplicity purposes, this fault tree is at a high level and has been populated only with illustrative type data. An expanded allocation model would address other risk drivers such as catastrophic failures in the propulsion system, common cause failures, environment (e.g., weather and orbital debris), human error, and maintenance and repair.
4. The **output** of the allocation model is based on the six **inputs** found on page 3, under the "If" columns. These inputs are 1) number of flights, 2) number of major critical systems which includes the propulsion system, and 3) reliability or probability of successful (Ps) operation of four items, namely, the propulsion system, critical major systems other than the propulsion system, intact abort, and crew escape system.
5. Reliability inputs are "point estimates" and not "interval estimates." Thus, confidence intervals being one way to address **uncertainty** of the fault tree's output are not used.

Reading The Scenario Table:

1. The "If-Then" table on page 3 contains eighteen **scenarios**. The first scenario is a "base scenario;" the remaining seventeen scenarios, organized in six groups, illustrate the sensitivity of the six input variables and the logic used in the allocation model.
2. A **shaded input** means its value is different from the input value used in the base scenario.
3. Whenever the output of the allocation model meets or exceeds the 0.9999 goal, the last quantity on the right has been marked in bold print.

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