SPACE HARDWARE

DESIGN AND DEVELOPMENT

INTEGRATING THE MANNED INTERFACE

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FOREWORD

Studies by NASA contractors and others over the last fifteen years have emphasized the potential benefits, including costs, of selected manned operations. A satellite servicing study in the late sixties summarized the problem:

> "Since so many aspects of space are dynamic, it should be clear that it would be foolhardy to expect that satellites could be manufactured so that they would never deteriorate, have a limitless useful life, be absolutely reliable, and be inexpensive and standardized instead of complex. . . ."
>
> "One possibility is to devote more of society's limited resources to greater pre-orbit efforts of design, manufacture, test, and launch. However, the incremental improvement in the listed problem area . . . would probably be very small relative to the effort involved."
>
> "An alternate way to improve the present situation would be to . . . launch the satellite, let it malfunction, run-down, deteriorate, or become partially obsolete, then take corrective actions while it is in orbit."
>
> "This technique has the tremendous advantage of pin pointing a problem for that specific satellite thereby creating a high probability that a specific relative improvement can be made . . . this improvement can usually be accomplished in a short time and with less expense relative to any pre-orbit effort."
>
> "The obvious superiority of the in-orbit correction method led space program planners to suggest the creation of a space vehicle that would be designed to perform the necessary corrections."

The Space Transportation System (STS) provides the basic tools required for an on-orbit servicing and maintenance capability. With man onboard the STS, he represents an STS subsystem that can be used to accomplish planned payload mission objectives, as well as contingency service and maintenance functions.

INTEGRATING THE MANNED INTERFACE

The manned interface is defined as the equipment and systems manipulated or used directly by man in performance of a payload function. Previous manned space flight experience has shown that the effective use of man's capabilities requires careful attention to integration of the manned interface. A variety of techniques have been used to facilitate the integration process. These techniques have included desk-top modeling and analysis; task simulations using part-task and full-scale models of task hardware; and space environment simulation using thermal vacuum and water immersion facilities. One of the techniques used early in the integration process is the "operations scenario." Development of the operations scenario enhances the analysis of manned operations. It is presented as an initial link between the hardware as conceptualized and the design required for successful manned operations.

An "operations scenario" may be defined as the end-to-end sequencing of all subtasks required to perform an operation. The development of an operations scenario involves the identification of all hardware and software systems, personnel, and other items required for each subtask to be accomplished. A sample format for developing an operations scenario is illustrated in Figure 1. This particular format was prepared for development of an Extravehicular Activity (EVA) function, but it could be modified and used for development of aft crew station or other Intravehicular Activity (IVA) functions. All items required for subtask performance are identified as operational support requirements. Other requirements should be added as needed to accomplish the subtasks. Development of the scenario begins with the identification of a potential manned task. Potential manned tasks can be identified from an analysis of system functions. Initially, the task may be a general statement of some operation to be performed. The operation should be broken into the lowest meaningful subtasks. The sequence of tasks is determined by the objective of the operation. Several iterations may be required to identify the lowest subtask and the most effective sequence.

As the performance of each task is considered, all items required for performance are identified. For example, if a subtask identified as "4.3 Power Switch - On" required performance from the aft crew station, the "perform 4.3" would be entered into the personnel column title "AFT C/S" (i.e., at Orbiter crew station). The location column identifies the position of the individual performing the particular subtasks. This data locates personnel during the performance of all subtasks, and it may be used to determine a more efficient subtask sequence. It may also be used to determine a more effective location of the subtasks. This column may also serve as a cue for documenting environmental requirements such as radiation protection, spacecraft attitude, or solar flux limits. Other columns for environmental requirements may be added if they are relevant issues.

POTENTIAL MANNED TASK / EVA FUNCTION				OPERATIONAL SUPPORT REQUIREMENTS										
TIME		TASK	SUBTASK	PERSONNEL				LOCATION/ ENVIRONMENT		TASK HARDWARE/ SOFTWARE	TASK SUPPORT HW/SW	TASK PERFORMANCE REQUIREMENT	CAPABILITY TECHNOLOGY STATUS	SPECIAL/ STOWAGE REQUIREMENTS
TOTAL	TASK			EVA 1	EVA 2	AFT C/S	GROUND	EVA 1	EVA 2					

FIGURE 1 – Operation Scenario Development

The task hardware/software column identifies the hardware/software required for direct performance of the task. In the aft crew station example, a power control switch may be required. If a unique control panel for the switch is required, it would also be entered in this column. Software or wiring may also be required to perform this subtask. The adjacent column identifies requirements for task support hardware/software. Support hardware facilitates the performance of the subtasks or contributes to maintaining the capability to perform the subtask. Examples of this hardware include body restraints, stowage devices, and portable lighting. Task performance requirements identify either performance limits or requirements for hardware/software. A performance limit on the rotation of a power control switch may be identified as "10 in-lbs." "Body restraint" in this column may identify the performance requirement for a handhold. The capability/technology status column may be used to qualify the performance of any subtasks. (A "check mark" may be entered to indicate that there is no capability or technology concerns relative to the subtask performance). The capability/technology status column may also be used to indicate that the subtask has been performed in the past or that a demonstration is required to verify its performance. The column could also identify a state-of-the-art technology concern or deficiency. The last column may be used to identify special requirements that may surface as a result of scenario development. The existence of off-the-shelf hardware is a note that could be entered. The column may also identify and track stowage requirements for loose equipment.

Once the operations scenario has been developed, each subtask should be reviewed to estimate the time required for its completion and this time should be entered in the time task column. If the subtask performance time is unknown, personnel familiar with the task or task performance records may provide an estimate. In some cases, a subtask demonstration may be required to determine the performance time. Once the subtask's performance times have been estimated or determined, the accumulated total provides a preliminary timeline for the scenario. Development of the scenario may be repeated as new data on potential manned tasks, task hardware, or task support hardware becomes available. A refined operations scenario provides a source of data for reference prior to the availability of hardware for demonstration and evaluation.

An analysis of the refined operations scenario will provide a source of preliminary data for program documentation, such as system design and performance requirements. The subtasks and timeline data will also provide an input into preliminary flight data file articles such as the flight plan and checklists. Preliminary training plans and training facility plans can be generated from the task data and the operational support requirements data. A sample matrix of operations scenario products referenced to preliminary program documents is shown in Figure 2. A subtask opera-

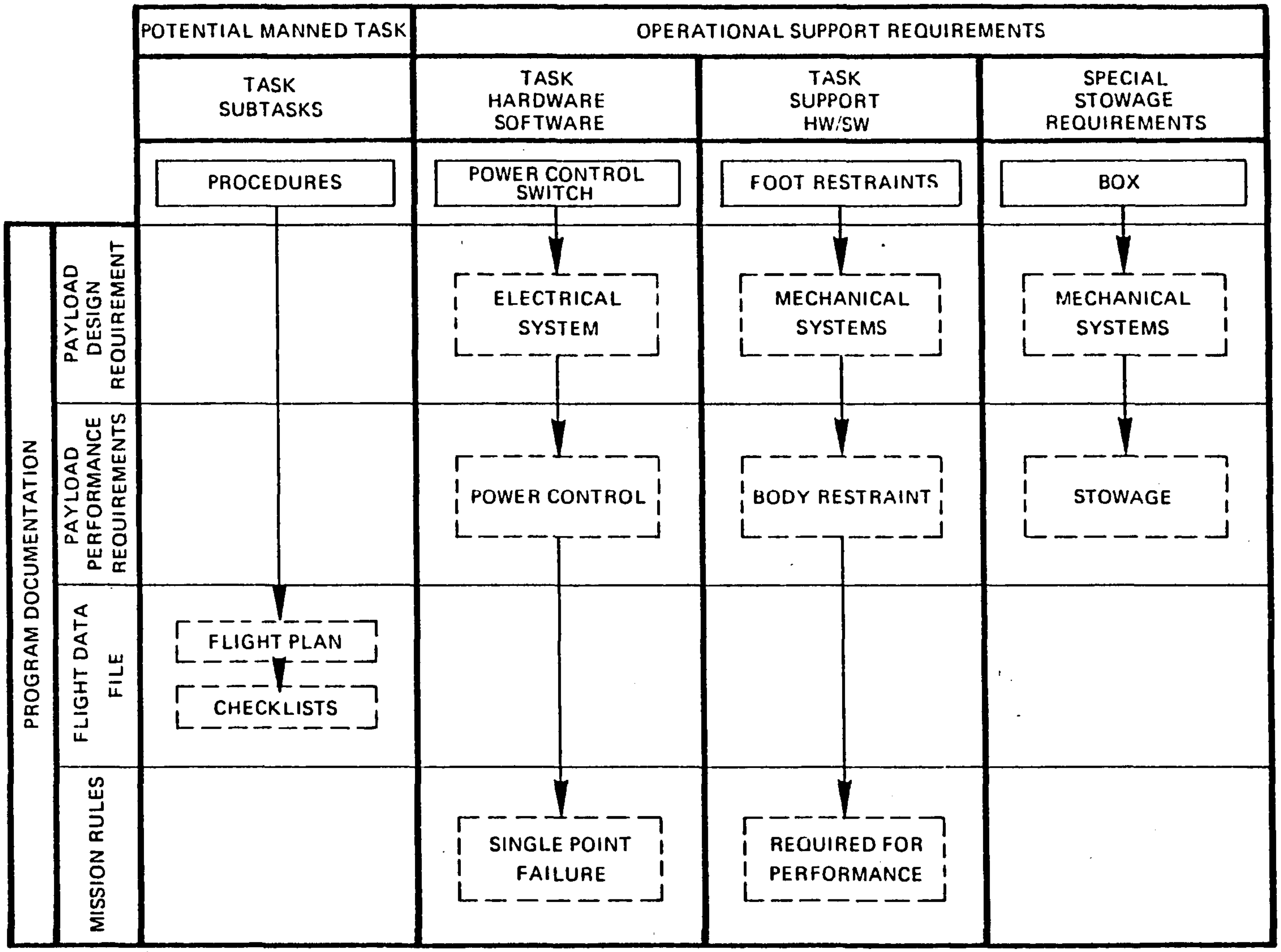

FIGURE 2 – Scenario Products Matrix

tional support requirement, such as foot restraints, provides an input into the payload program's preliminary design and performance requirements document. This input may affect the payload's mechanical systems requirements or the crew systems requirements depending upon the subdivisions of the requirements document.

The operations scenario data can be used to generate concept demonstration and evaluation plans. Low-cost mockups or prototype hardware may be used to refine and revise the operations scenario or the requirements generated by scenario development. The data generated by development of one operations scenario may be used in concept evaluation and development and trade-off studies with an alternate approach or another potential manned task.