

Spacecraft Flight Operability Assessment Technique

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The design of a human-rated spacecraft is a complex and costly process requiring the integrated assessment of many considerations. Historically, it has been difficult to include, in that integrated assessment, the design's full impact on the flight operations community. The unique "operability" requirements have not been well understood, nor has there been a well-defined set of criteria for assessing operability. As programs approach their operational phases, program managers and flight operations organizations alike are often surprised when faced with difficult and costly operations implementations. A formal means of forecasting operability issues during the development phases of a program is therefore necessary to reduce operations phase costs.

The challenge in addressing flight operability needs for a new program is threefold: (1) there is no accepted universal definition of flight operability; (2) there is no clear mapping of flight operability needs to program and vehicle requirements; and (3) there is no formal method to assess flight operability characteristics given a spacecraft design and mission definition. These challenges are similar to those faced by the aircraft flight test community in the 1950s and 1960s. Over the course of years, a technique for the characterization of an aircraft's handling techniques—as assessed by the pilot operating the aircraft—was developed by George Cooper and Robert Harper and has long stood as the standard tool for aircraft handling

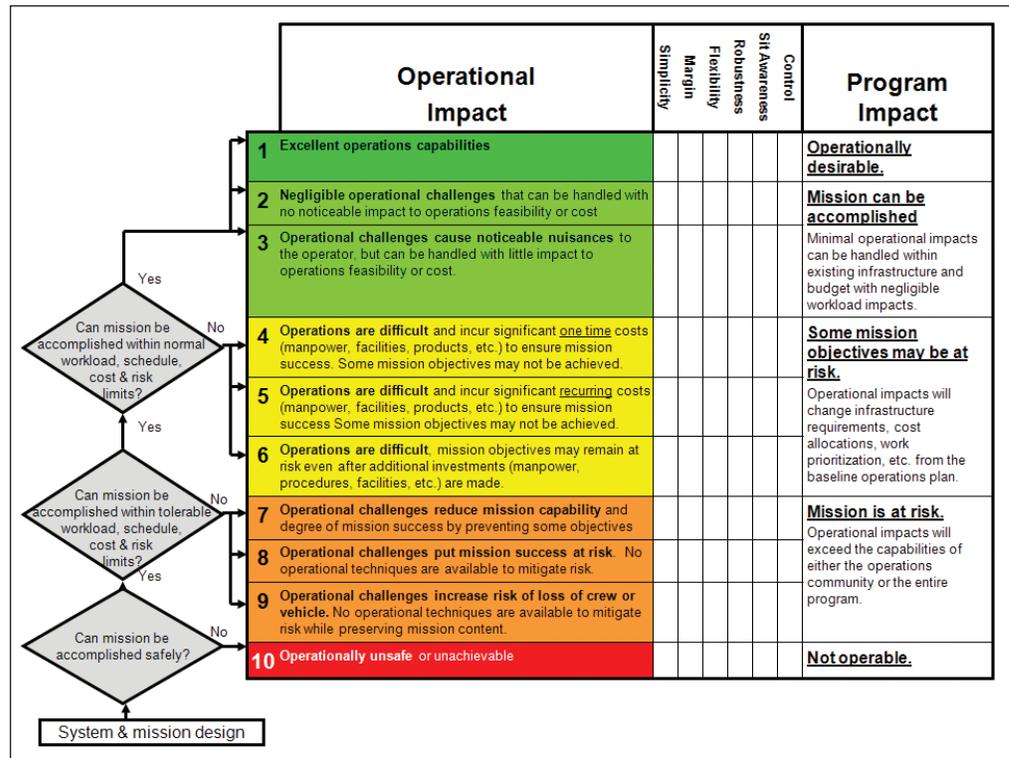


Fig. 1. Flight operability assessment technique.

assessment. Modified versions of this scale are employed widely in the assessment of crew equipment and interfaces for NASA human-rated spacecraft.

In response to these challenges, the Mission Operations Directorate at Johnson Space Center established a formal method for the evaluation and communication of a spacecraft system design's operational characteristics. The spacecraft flight operability assessment method is born of the need to identify the operations systems' drivers and critical requirements that are a significant influence on operations cost, schedule, performance, and risk. This process is not intended to replace or replicate other critical assessments such as risk, reliability, or safety assessments. Instead, this new technique adds to a program's assessment toolset a means to address the concerns and potential cost drivers that are unique to the operational phase of a program and the flight operations community.

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The scale incorporates three basic elements: a set of operability themes to be evaluated; criteria with which to evaluate each characteristic; and a grading scale to normalize the results. The operability themes correspond to six operability themes—simplicity, margin, flexibility, robustness, situation awareness, and control. Flight operability criteria are imposed to categorize assessments of each operability theme: “Can the mission be accomplished?”; “Can it be accomplished within tolerable limits (workload, cost, risk)?”; “Can it be accomplished within normal limits?”; and “To what degree?”. These four questions guide the assessor in determining which color-coded range within the possible 10 scores should be assigned for an operability theme (figure 1).

Formal flight operability assessment practices may be applied to both development and operational programs. For development programs, the Spacecraft Flight Operability Assessment Scale can and should be employed in generating inputs at formal design reviews (Subsystem Design Review, Preliminary Design Review, Critical Design Review) in less-formal design team forums, and in the assessment of formal change requests. For operational programs, the scale may be applied to proposed incremental vehicle changes such as hardware upgrades and flight software updates.

The Mission Operations Directorate began using this scale as a tool both for operational vehicles such as the space shuttle and for new vehicle designs such as those developed under the Constellation Program. Initial use of this scale has yielded encouraging results. Evaluators find the scale easy to use, and the resulting evaluations quickly identify and isolate operability issues within specific subsystems and scenarios.