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The Use of Multicriterial Optimization Analysis and Sensitivity As a Measure of Risk in Aerospace System Development

Abstract

by

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Affordability analysis enables developers to balance the competing requirements for performance, producibility, cost, and other characteristics that they expect to achieve from their systems. In aerospace, the practice has been to apply factors of safety to those performance parameters that are most crucial to the value of the system in the eyes of its customers. For the more important characteristics, larger safety factors are used. The result has been very safe, high-performance systems; the concomitant penalty has been high costs associated with aerospace systems and the perception by some that they are “gold plated.”

Application of Affordability principles weighs the tradeoffs among the various system objectives, including performance measurands, safety criteria, initial cost, and life-cycle cost, to achieve a more optimal result than that which would emerge from the “performance-at-any-price” approach. The Integrated Product and Process Development (IPPD) process, developed by the Air Force Research Laboratory (AFRL) and adopted as its process for achieving affordable technologies and systems, generates two measures of affordability—desirability and risk. Desirability reflects value from the point of view of a particular stakeholder, while risk (zeta, **z**) represents the probability of failure to meet one or more of the stakeholder’s threshold values for measurands of system criteria.

While goals and objectives are typically clear, establishing meaningful threshold values early in a development process is often difficult. This paper presents a means of achieving a robust design with all the benefits of the affordability process without error associated with controversial thresholds values. The systems engineering approach described here enables the developer of a system, a concept, or a process to

1. Reduce development time and cost
2. Produce a better design
3. Allocate development resources appropriately
4. Understand uncertainty (risk), and
5. Develop more robust products and processes.

Desirability optimization analysis, a multicriterial optimization method, was used to evaluate candidate designs for a Structurally Integrated Compact Inlet Technology (STRICT). Inherent in the process are the activities of establishing desirability curves and weighting factors. Desirability curves reflect the level of customer satisfaction at different values of characteristics of interest, while weighting factors signify the relative importance of these characteristics in the context of the goals of the development program.

The robustness of each alternative design was assessed by investigating the multidimensional solution space within ±5% of the predicted outcome. The sensitivity of the design's desirability in the vicinity of the design point was examined. The analysis provided sufficient information about uncertainty near the design point, obviating the need for computation of $\mathbf{z}$ with its associated, unquantified error.

The authors found that sensitivity analysis on the various designs permitted selection of the best concept and aided optimization of that concept, leading to a robust system for STRICT. The robustness of customer satisfaction metrics was included among the criteria by which to select a single alternative for further development and to plan the program to optimize the selected alternative. Understanding the sensitivity of resulting customer value to the multiple competing criteria by which a system under development will be judged enabled project leadership to make informed decisions concerning resource investment and to proceed with development while keeping affordability and customer value in focus.