

Dissemination of Risk Preferences in Organizations through MDO Frameworks

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Highly complex systems, such as aircraft, are generally products of large organizations with hundreds, if not thousands, of individuals making decisions that will impact the final design. Multidisciplinary Design Optimization (MDO) provides frameworks to these organizations which enables the determination of optimal designs. The process of choosing amongst design alternatives of highly complex engineering systems is inherently a decision-making process. As such, the selection of an optimal design is directly impacted by the amount of risk deemed acceptable. The inherent aversion or proversion to risk by individuals is commonly believed to an indefinable trait. Through the use of decision theory, in particular utility theory, risk preferences are able to be mathematically defined through utility functions. This paper will examine how risk preferences of top-tier decision makers in organizations are communicated to lower-tier designers in current practices. The paper will then examine how risk preferences can be communicated through MDO frameworks using value-driven design (VDD) and the impact of various preferences on the optimal design.

In the current systems engineering process, objective functions are created at the top tier of an organization. Requirements, or constraints on the objective function, are also formed at this tier through past experience and predicted targets. The objective function and requirements are flowed down the hierarchical chain of the organization to the lower tier design engineers who make decisions on component alternatives. The design alternatives typically have inherent uncertainties which impact the evaluation of the alternative's objective function. It is at this stage of decision making where the risk preference of an individual plays a role in the determination of the best alternative. The current practice of flowing down an objective function and requirements does not communicate the risk preferences of the top tier decision maker to the lower tiers of a hierarchical organization, leaving the best alternative to be biased by the lower-level decision makers' risk preferences.

Risk preferences are an inherently individualistic trait. Correlations exist between certain general population traits, such as age, sex and culture, and a person's risk aversion. Correlations between risk aversion and an individual's position within a hierarchical organization also exist. This paper will focus on how to communicate the risk preferences of the top tier decision maker throughout the organization. This paper will examine the use of value-driven design to create a utility function to be used in MDO frameworks. Through proper structuring of the utility function the top tier decision-maker's risk preferences can be captured. This process eliminates the risk biases of the lower-level design engineers, enabling the risk preferences of the top tier decision-maker to be used throughout the organization.

To demonstrate how risk preferences can impact final design selection, multiple examples will be established. In these examples hierarchical organizations will be used, with a single top-tier decision maker and multiple lower level subsystems in an MDO framework. Multiple risk preferences, both averse and proverse, will be established and disseminated through the framework with identical measurement functions and alternative selections. The optimal design will be determined for each risk preference to demonstrate the impact risk has on design. These examples will provide a realistic view on implementation of the developed ideas.

The amount of risk an organization is willing to take concerning designs is generally established at the top tiers of the organization's hierarchy. Without proper dissemination of the preferences to lower tiers of the organizations the design engineers' personal risk biases will impact the alternatives selected. This paper introduces the use of VDD in combination with MDO to eliminate lower-tier decision makers' risk preferences from the decision-making process.