UNIVERSITY OF Southampton

Engineering and the Environment

Aeronautics, Astronautics and Computational Engineering

Development of Value Metrics and Decision Support Framework in Systems Architecting

UTC for Computational Engineering

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Introduction

The recent expansion of design space in aerospace systems beyond traditional concepts has driven a shift in the design boundaries between individual systems in a System of Systems (SoS). As individual systems are becoming more tightly integrated the boundary defining its role is becoming blurred. Traditionally the role of the propulsion system is to provide propulsive power to the aircraft. However, recent advancements in propulsion technology and electric power systems have enabled the propulsion system to not only provide propulsive power but also all other power requirements for the aircraft i.e. electrical and hydraulic. The expansion of the design envelope of the propulsion systems combined with the additional flexibility offered by future aircraft concepts regarding the location and installation of power plants introduces increased design complexity. This leads to a shift in the way designers need to formulate goals, objective functions and optimisation techniques in order to find 'good', 'better' and 'best' solutions. This optimisation needs to use some form of value function to be able to trade across the full suite of product attributes, e.g. manufacturing, assembly, cost, performance, reliability, maintainability, efficiency etc.

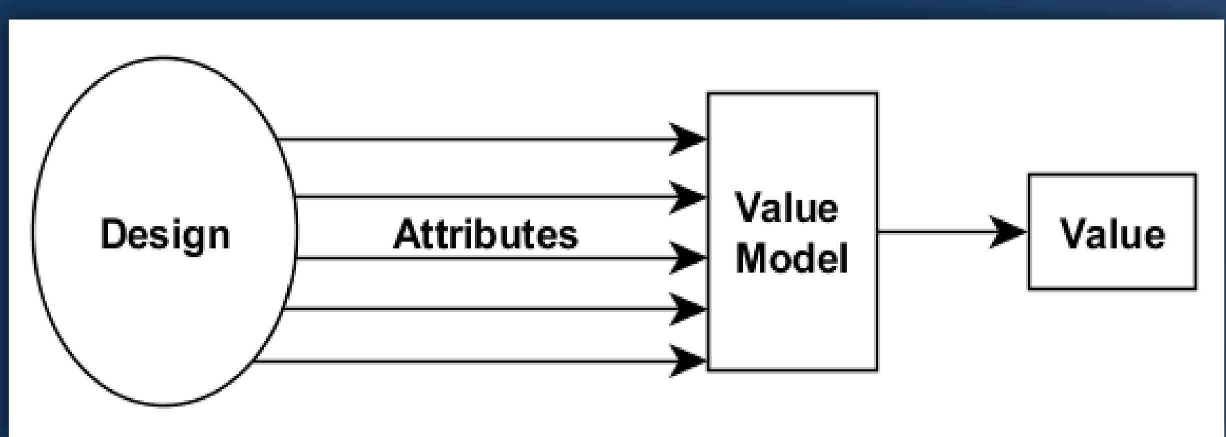

Figure 1 : Representation of a generic value model

System Value Function

The system value function can be defined as the value of satisfying customer and stakeholder requirements. In the context of requirements engineering, the system value can be quantified by means of multi-attribute utility theory. Multi-Attribute utility theory quantifies the impact on system value due to changes in customer needs, expectations, and other statements paralleling with traditional requirements engineering. The degree to which the system requirements are met can be measured numerically with the scale ranging from zero to one, one being that the requirements are satisfied to its fullest and zero being that the requirements are not satisfied at all. The numerical measurement of satisfying system requirements allows the decision maker to trade between the satisfaction of system requirements versus the cost of implementing and operating the system.

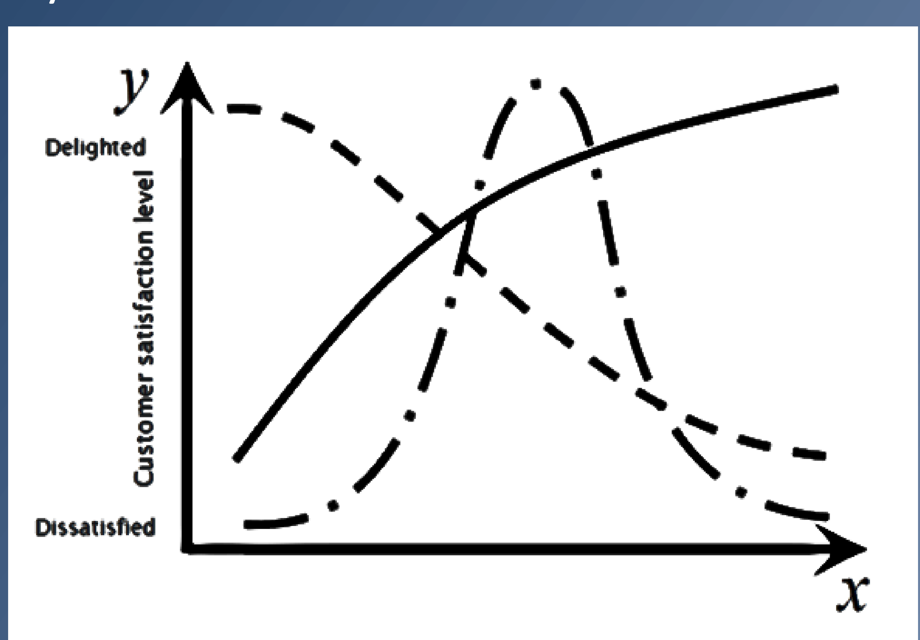

Figure 2: Utility curves represent non-linear customer preference

Decision Support System

The current focus of the research is in accounting for system value (by means of multi attribute utility theory) and life-cycle-cost; to develop a decision support framework that enables high system level architectural decisions to be analysed more comprehensively and effectively compared to traditional approaches (i.e. weight, SFC, direct operating cost, etc.). This decision framework would allow system architects to more readily identify '*high impact decisions*' that strongly influence the overall system value and identify the interconnectivity between decisions. The methodology works by connecting different decisions to form a graph network where each node represents a decision to be made and the branches of the node represent the alternatives to that decision. The intended outcome of this model is to allow design engineers to rationally trade between different decisions and provide a means of numerically capturing the rationale behind the decisions made.

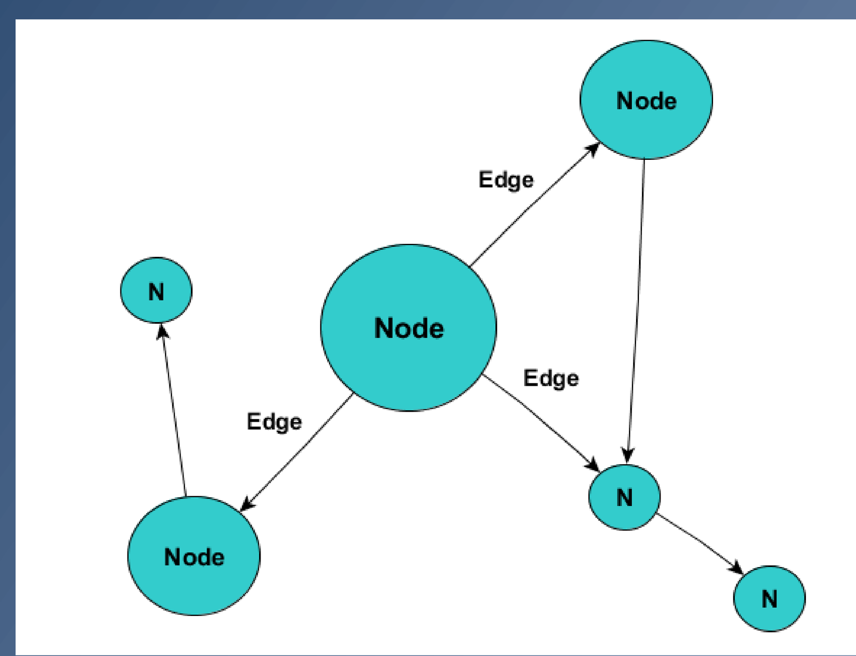

Figure 3: Representation of a decision network

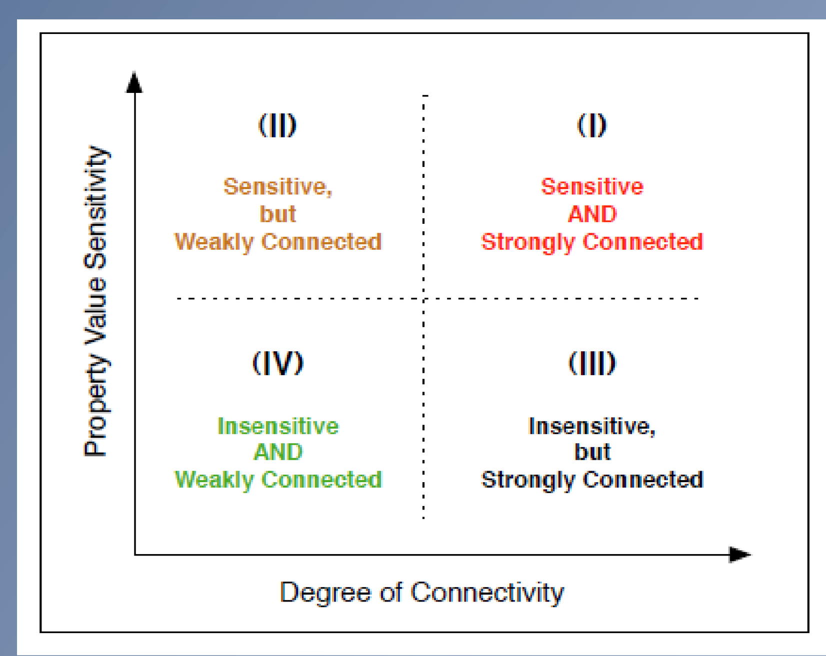

Figure 4: Identifying high impact decisions

Simulation Framework

Several simulation tools are used to model the system design. These are used to calculate engine and aircraft performance parameters and size the aircraft to meet certain performance requirements. The sized aircraft is then fed into a discrete event simulation, modelled in Matlab, that models the operational environment and hence determines the operating cost of the aircraft. The output of the simulation is the Life-Cycle-Cost (LCC) and system value, which are plotted against each other to identify the cost of maximizing customer value.

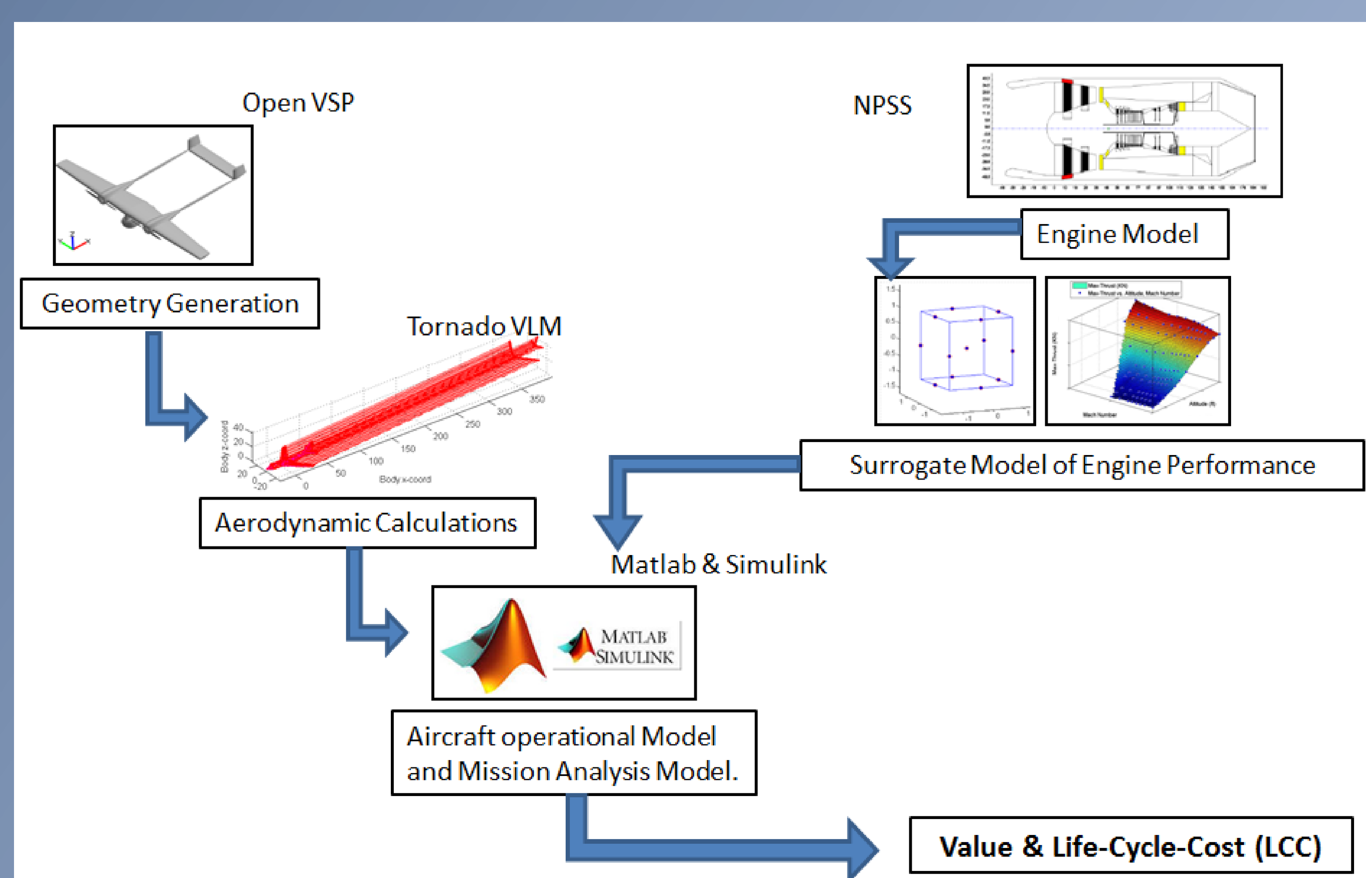

Figure 5: System design simulation framework.

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