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Value-Driven-Design of Unmanned Aerial Vehicles at a Conceptual Design Stage

UTC for Computational Engineering
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Introduction

The use of Unmanned-Aerial-Vehicles (UAVs) within both the military and civil sectors has gained popularity over the past decade. UAVs provide a relatively cheap and flexible solution compared to that of manned aircrafts, with applications ranging from surveillance and reconnaissance in the military to search and rescue operations and earth observation in the civil sector. Over the next 3-4 years (until 2015) the UAV market in the United States is predicated to reach $16 billion, with the Department of Defense (DoD) continuing to increase investments in UAVs, the DoD requested $6.1 billion in 2010 for the procurement of new UAV systems.

Most of the applications in UAV systems design involve the development and integration of new technologies that make the overall system flexible, cost efficient, and revolutionary in aerospace design. This introduces the existence of different UAV platforms of different sizes and shapes (e.g. Blended-Wing-Body, twin boom, V-tail, etc.) and the integration of new technologies, such as radar, high-resolution cameras, sensors, etc., into UAV systems, which has caused an expansion of the design space beyond the traditional airframe and propulsion system designs. The additional flexibility offered by UAVs regarding the location and installation of power introduces significant increase in design complexity. Addressing the issue of complexity and the satisfaction of stakeholder needs during the design phase requires a shift in the way designers need to formulate goals, objective functions and optimisation techniques in order to find the 'best' solution. This requires the formulation of a value function to be able to trade across the full suite of product attributes e.g. performance, reliability, maintenance, cost, etc.

BAE Systems: TARANIS

BAE Systems: MANTIS

Value-Driven Design

The study of Value-Driven Design (VDD) consists of three disciplines; economics, optimisation and systems engineering. The combination of these three disciplines provides the designer with a numerical measure of 'design goodness', allowing the designer to make an informative design choice; a choice that takes into account of the desires of the customer and translates them to tangible terms that are meaningful to design engineers.

The Value-Driven Design process allows the development of large systems by providing a means by which to compare different designs and be used for design optimisation. An example of a design optimisation cycle is shown in figure 1 below.

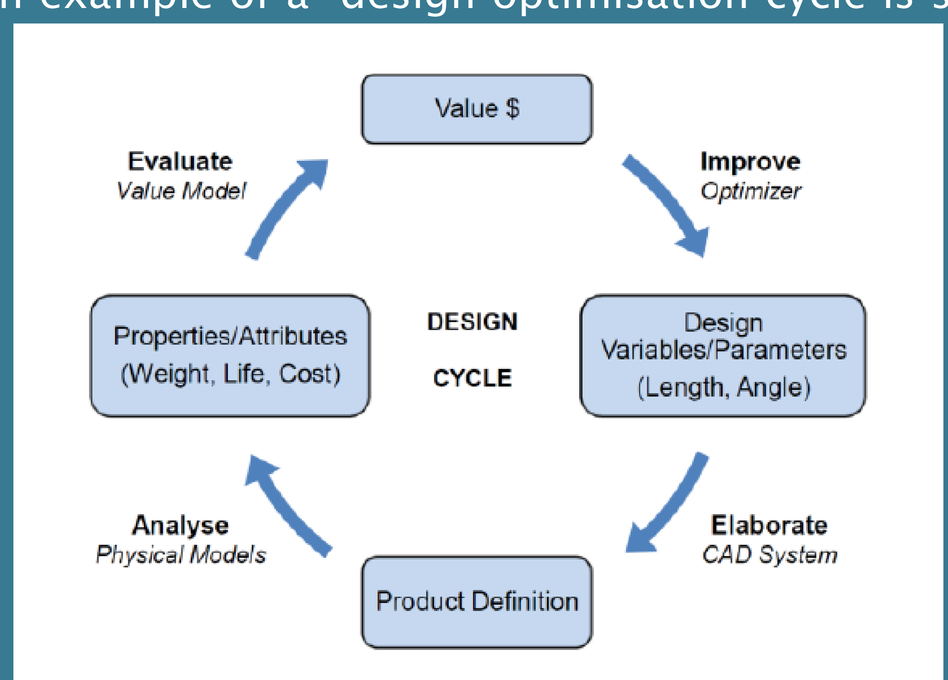

Figure 1: Design Cycle for Optimisation

Source: Collopy, P., and Hollingsworth, P. "Value-Driven Design," 9th *AIAA Aviation Technology, Integrated and Operations (ATIO) Conference.* Hilton Head, South Carolina USA, 2009.

Value-Driven-Design Methodology

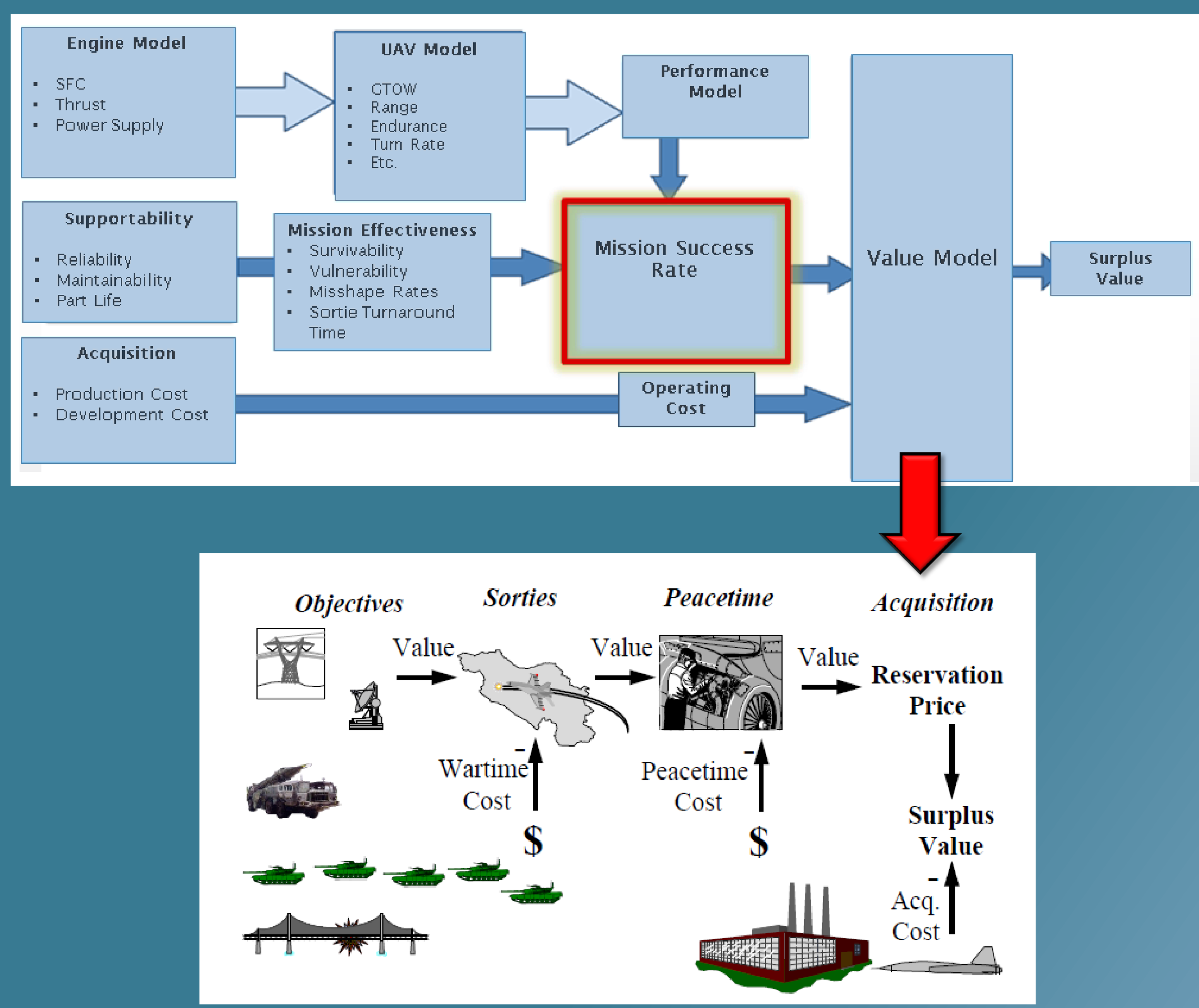

Figure 2: Value Model methodology.

Figure 2 illustrates the proposed arrangement of the system value model for a given UAV design. The properties of the UAV system are split into five categories: performance, acquisition cost, supportability, mission effectiveness, and operating cost. The advantage of the proposed framework is that all the performance, supportability and mission effectiveness parameters are linked directly to the mission success rate, therefore to construct a value model based on monetary units only the mission success rate is required to be converted to a monetary value. Thus the surplus value is simplified to essentially the value of mission success minus the life-cycle-cost of the UAV system. This simplified value model accounts for and quantifies all the attributes that are important to the stakeholder; hence, it provides a tangible metric (surplus value) that identifies the design decisions that lead to the best product.

Surplus Value = Overall value of mission success – Life-Cycle Cost

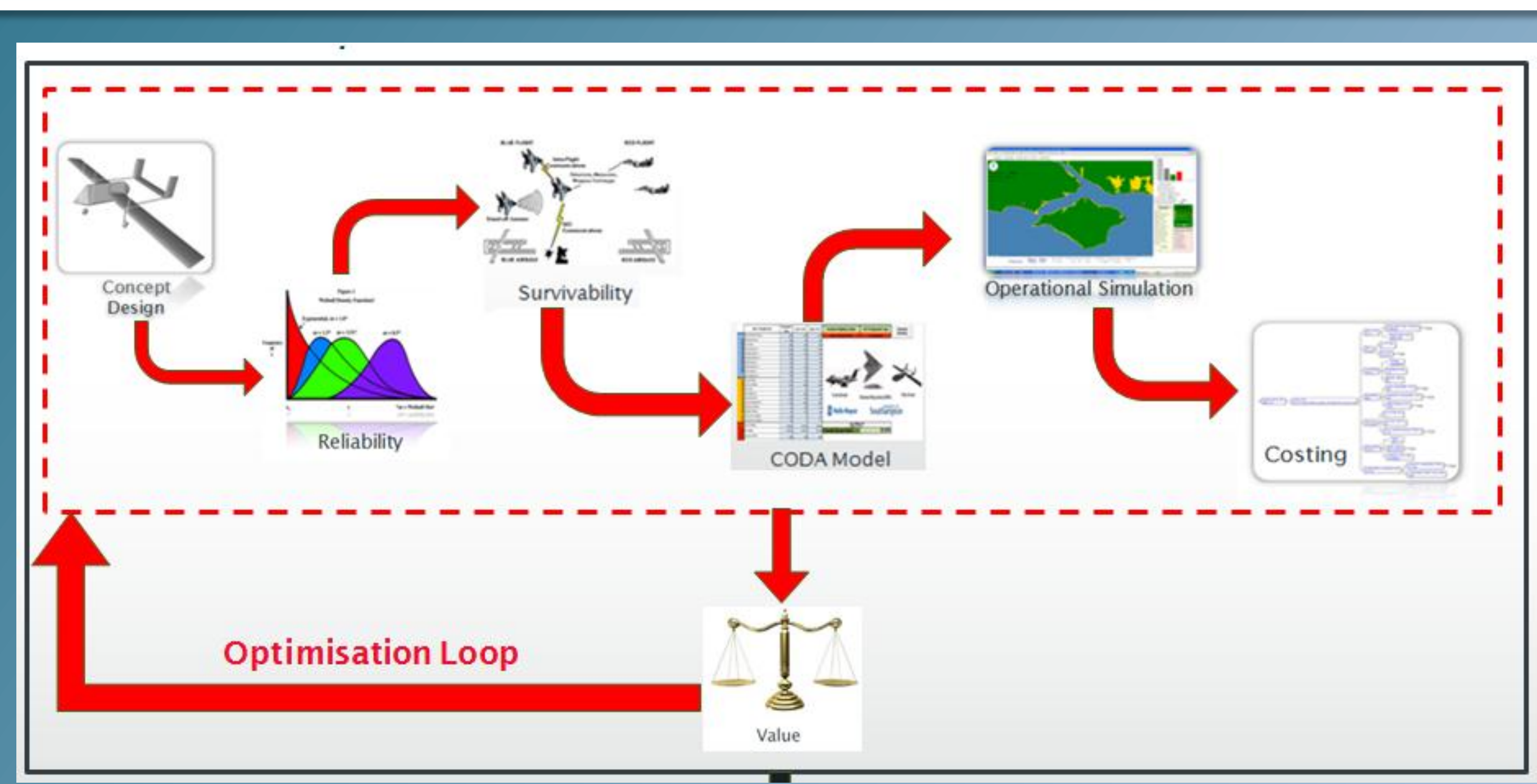

Figure 3: Architecture of the proposed value model.

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