Life Cycle Cost Modeling of UAVs

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Introduction

This research concerns with the development of a framework to estimate the life cycle cost (LCC) of unmanned air vehicles (UAVs). The LCC of a UAV includes the material and the manufacturing costs along with the costs necessary for operation, maintenance and repair of a fleet of aircraft.

Need

In the past, technology has been the dominant driver in the design process, but there has always been a demand for cost reduction in the aircraft industry to satisfy the customer´s needs. There has been a realization by the aircraft producers that cost reduction needs to be tackled at the conceptual design phase because it is widely believed that typically 70% of the total avoidable cost is controllable at this stage.

Cost estimation has been used extensively for many years in the aircraft industry but there is a need for further research. Figure 1 shows cost estimation in the past and present and an idea for future cost estimation.

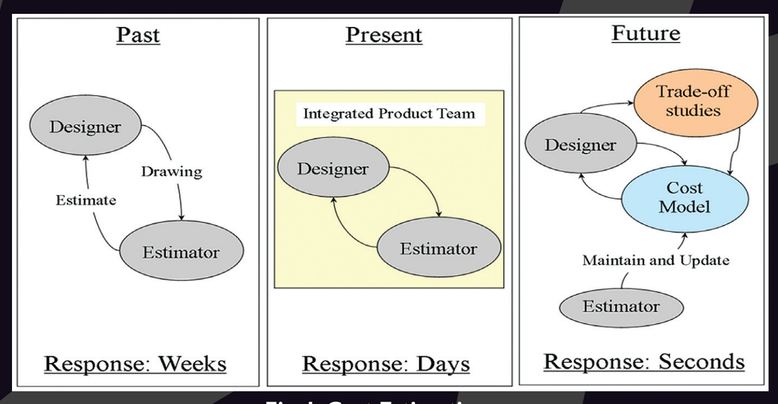

Fig. 1. Cost Estimation.

Objective

The objective of this project is to develop a framework which allows us to estimate the LCC of a UAV, given its specifications. The framework can then be integrated into the design process to facilitate the comparison between different configurations. A schematic sketch describing the framework of the LCC model is shown in the flowchart (Figure 2).

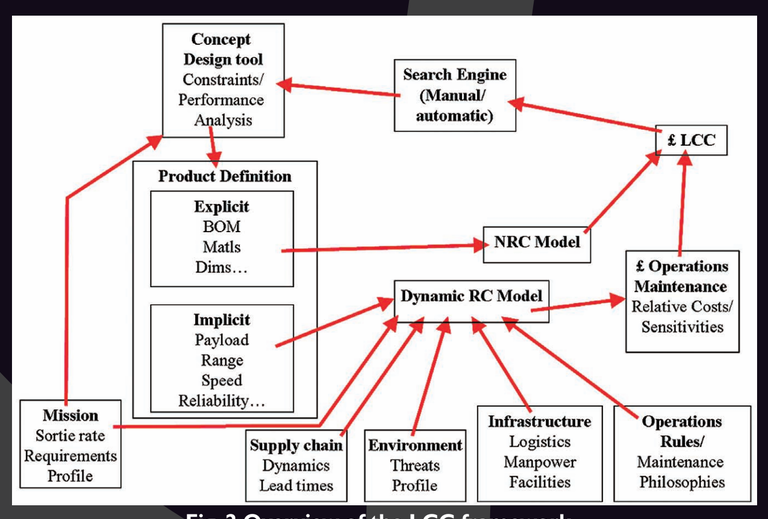

Fig. 2 Overview of the LCC framework

Acquisition Cost Model

The model shown here is capable of estimating the acquisition costs of a UAV, given its product specifications. It has the capability to estimate the material and manufacturing costs for structures manufactured using metallic as well as non-metallic materials. The model has a hierarchical structure and makes use of an object oriented approach to cost estimation. For example, the cost of the structure represented as "Structural cost", as shown in Figure 3, is split into wing and fuselage costs which are further divided into different categories.

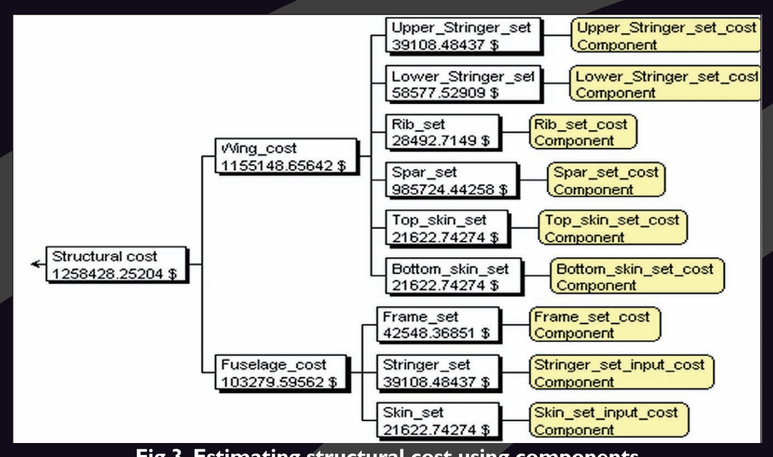

Fig 3. Estimating structural cost using components

Each structural set is an independent model of its own, which can be integrated into the 'higher', level model, as shown in Figure 4. Libraries of materials, processes and features have also been created for integration into the cost model.

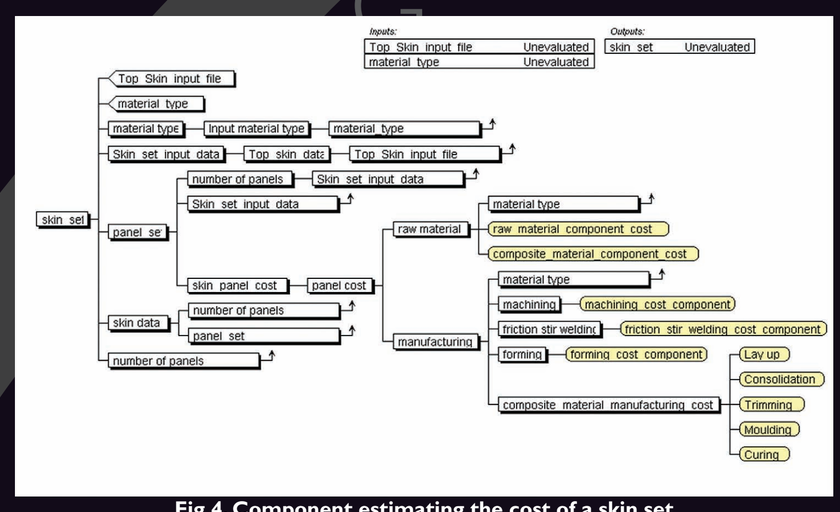

Fig 4. Component estimating the cost of a skin set

Simulation Model

The structure of the simulation model that is developed to estimate the operating and maintenance costs for a fleet of UAV is as shown in Figure 5.

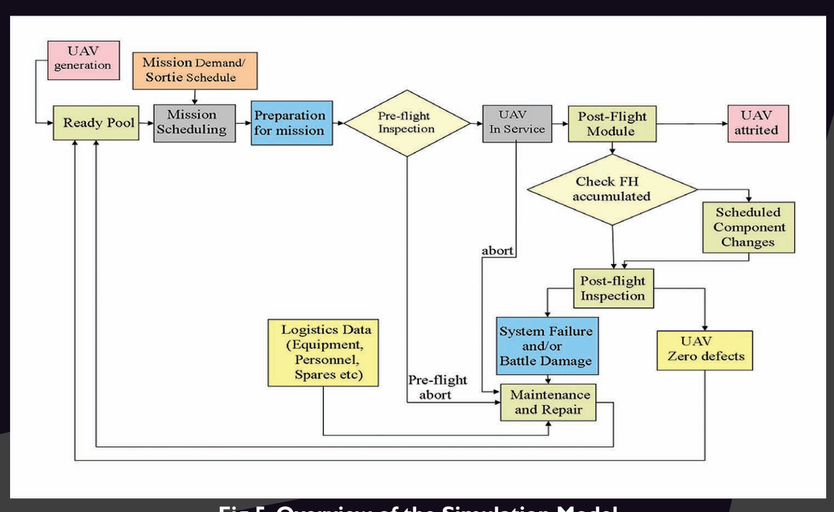

Fig 5. Overview of the Simulation Model

The first step is the preparation of a flying schedule covering each aircraft over the time span to be simulated. The rate at which missions are called, the numbers of aircraft required, and the mission lengths can be generated from statistical distributions or as a pre-determined schedule. Aircraft are drawn from a ready pool, inspected, and launched on the mission. In the course of the mission, system failures are experienced and the aircraft receive combat damage. Aircraft are lost and missions are aborted according to specified probability functions. When missions are completed, aircraft are recovered and serviced. Required scheduled and unscheduled maintenance tasks are performed to return the aircraft to a ready status. The maintenance performed on the aircraft is subject to manpower and supply constraints, and aircraft wait for maintenance when resources are unavailable. Statistics are generated at the end of a simulation to evaluate the combat effectiveness of the aircraft under various sets of conditions.

The model detailed here is a discrete-event simulation model which is capable of estimating the operation and maintenance costs of a fleet of aircraft. The simulation model is also equipped with survivability and FMECA analysis. The model consists of a number of hierarchical levels with each succeeding level containing more detail. The highest level is shown in Figure 6.

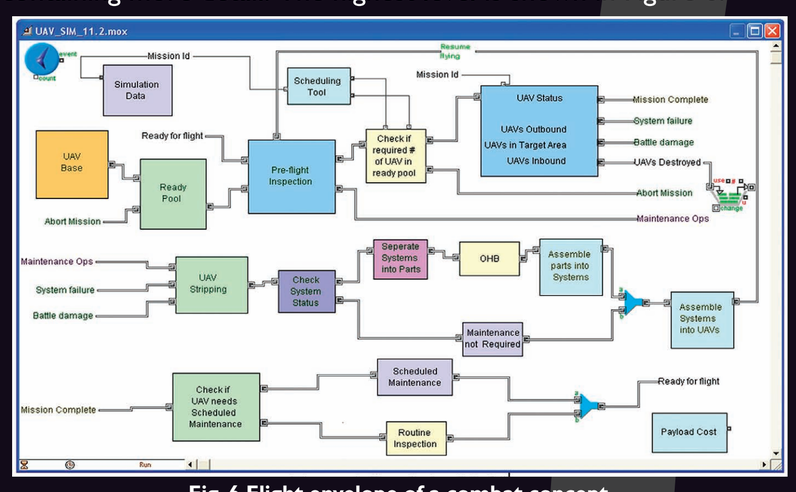

Fig. 6 Flight envelope of a combat concept.

Future work

We plan to perform trade-off studies between cost and performance for aircraft. The framework can be used to evaluate the cost penalty of survivability enhancement concepts. We also plan to integrate the cost model with a concept design tool that is being built at the University of Southampton to perform cost based design optimisation.

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