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MACRO-SCALE RECONFIGURABLE UNMANNED AERIAL VEHICLES FOR CIVILIAN OFFSHORE APPLICATIONS

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Abstract

The development of products with a modular structure, where the constituent modules could be derived from a set of common platforms to suit different market niches, provides unique engineering and economic advantages. However, the quantitative design of such modular product platforms could become significantly challenging for complex products such as Unmanned Aerial Vehicles (UAVs). The *Comprehensive Product Platform Planning* (CP^3) method, extended to modular product families, was recently applied by the authors to design a family of three "twin-boom" UAVs for civilian applications with three distinct combinations of payload capacity and endurance. The six key modules that participated in the platform planning process are: (i) the fuselage/pod, (ii) the wing, (iii) the booms, (iv) the vertical tails, (v) the horizontal tail, and (vi) the fuel tank. The results suggest that among the best tradeoff UAV families obtained by mixed-discrete Particle Swarm Optimization, the family with the maximum commonality required a compromise of 66% on the UAVs' range/fuel-consumption performance. This represents a sharing of the horizontal tail and fuel tank among all three UAVs and sharing of the fuselage and booms among two UAVs.

Such a modular UAV design, derived from common platforms, can also enable *pre-mission reconfiguration* of the UAV – *i.e.*, the user can readily assemble (or re-assemble) a set of unique parts to configure a UAV suited for the immediate application just prior to the mission. Such multi-mission capabilities provides two uniquely important advantages: (i) the ability to address different applications such as *cargo transportation*, *search and surveillance*, and *environmental/scientific survey*, and (ii) the ability to fly efficiently in differing flying conditions (e.g., search operation in stormy weather and survey operation in calm freezing weather conditions) – without requiring separate UAVs (which can be economically prohibitive).

This paper further extends the CP^3 framework to design a family of three *reconfigurable* twin-boom UAVs for offshore applications. Of particular interest is identifying industries for potential application of reconfigurable UAVs, so the same customer can take advantage of the modular capability of the UAV family and operate all three UAVs for different tasks and offshore weather conditions. An example of an industry where this is pragmatic is the Offshore Petroleum industry, specifically the extraction of oil and natural gas from deep-water platforms. In this context, we would like to *quantitatively* address the following important end-user considerations in the full manuscript: (i) what are the cost and mission execution benefits of a *macro-scale reconfigurable* UAV family compared to individual UAVs; (ii) how does *reconfigurability* assist in dealing with adverse offshore flying conditions; and (iii) how does a general UAV design evolve through *modularity and reconfigurability*. The latter has implications on the twin-boom UAV design considered in this paper, which could point towards the effective use of emerging technologies such as "*virtual aero-shaping through active flow control*" and "*in-flight or real-time macro-scale reconfiguration*".