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A Systems Engineering Approach to the Design of Control Surfaces for UAVs

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Abstract

The process of control surface design for an Unmanned Aerial Vehicle (UAV) is a complex combination of numerous disciplines which have to be blended together to yield the optimum configuration to meet given set of requirements. In this paper, a systems engineering methodology for control power evaluation of conceptual and early preliminary design configurations against requirements at critical flight conditions is established. The design of the control surfaces includes the configuration design, the geometry calculation, and the evaluation of the design against the requirements. The conventional control surfaces include the elevator, the aileron, and the rudder. Unconventional examples are surfaces such as elevons, ruddervators, and flaprons. Since there is no human pilot on a UAV, most of the flying qualities criteria do not impose any requirement on the design of the control surfaces. The last step in the design of the control surfaces is the evaluation process, which is accomplished here using systems engineering techniques. An example implementing this approach for a UAV design is provided.

1. Introduction

A successful controls designer needs not only a good understanding of aerodynamics and flight dynamics, but also a good understanding of the systems engineering approach. All UAVs must meet controllability requirements to be certified for commercial use or adopted by the military. Many military UAVs such as UCAVs also have additional maneuverability requirements. A UAV's ability to meet these requirements is often limited by the amount of control authority available. Thus, it is essential for designers to evaluate the control authority of candidate concepts early in the conceptual design phase.

Normally, the conceptual designer considers numerous possible aircraft configurations before the stability and control group starts their analysis. An early evaluation by the designer, before detailed control system design work starts, makes the design process much more efficient. The only requirements, other than controllability requirements, are the structural limitations of the UAV that can be interpreted in terms of g forces.

First, the critical flight conditions to be considered using this methodology are discussed. Next, to examine a variety of control surface configurations and to accelerate the process of calculating stability and control derivatives, an approach using systems engineering to determine control surface geometry is described. Then, a simple technique is used to combine the aerodynamic and geometric data to assess whether the design concept possesses adequate control power to satisfy the requirements at the critical flight conditions. This allows the designer to perform 'what if" studies to decide how to modify the design to satisfy the requirements.

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