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UAV INITIAL PARAMETER ESTIMATION

Gabriel George da Silva, Lucas Campos Carmona, Eduardo Bauzer Medeiros
Universidade Federal de Minas Gerais - UFMG

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Abstract

In recent years UAV operation has grown in importance. As a result, there is now a growing demand for design solutions for UAV including those which take place during the initial project design procedure. Because of a variety of constraints and configuration conventional aircraft parameters may vary considerably when compared to UAV parameter estimation. The present study addresses the problem of preliminary estimation, using empirical corrections more suitable for UAVs. The proposed study and the initial set of results suggest that the method should prove to be a useful tool in UAV design.

1 Introduction

During the last decade the unmanned aerial vehicles (UAV) have gained a position of importance. They have been extensively deployed in a variety of missions, previously carried out by conventional aircraft and it has also introduced new not previously existing missions.

At the same time, other technological developments not even previously considered as a viable proposition have become the best design solution for many cases. Electric propulsion is arguably the best example of how a previously unsuitable configuration can introduce such a dramatic change in a parametric evaluation, completely modifying issues such as payload and range.

Other conditions such as distributed propulsion have introduced other remarkable changes in overall project design.

It has been common practice for many decades that the initial configuration of aircraft starts with a global parameter determination based on a comparison of previously well-established configurations. Classical references such as [1] and [2] suggest a comprehensive set of empirical and analytical equations with varying parameters according to the aircraft type and mission. Convergence is thus more quickly obtained for the initial configuration which can then be optimized using more precise tools such as Computational Fluid Dynamics (CFD) or wind tunnel testing.

Because UAVs have introduced so many previously unconventional configurations, also varying significantly between UAVs of different classes, these initial estimates are hardly useful for UAV and RPAS design. Even though a step by step procedure can be used instead, corrections in these procedures are likely to abbreviate some of these time-consuming activities.

2 Procedure

The first part of the present study classifies UAVs according to mission, payload and basic configuration, the latter taking into account rotary or fixed wing, type of propulsion and so on. Once this procedure has been completed the relevant parameters used in initial project design such as cruising speed or wing span are then organized in a matrix form, which enables the establishment of correlations between these parameters. The resulting correlations are then used to verify already known parameters of aircraft, including those designed and built at the Federal University of Minas Gerais (UFMG) facilities.

In a further development the obtained correlations should be compared with the existing classical correlations recommended for “conventional” aircraft to establish the range of validity when classic formulae provided by a variety of references are the chosen alternative. It is also expected that in the near future these correlations should be compared with results obtained from construction and flight testing of RPAS designed and built at UFMG.

3 Initial Results

Some typical results representative of light medium range fixed wing UAVs are to be observed in Figures 1 and 2.

In Figure 1 the classical relationship between Empty Weight and Maximum Take Off Weight for a set of UAVs is shown, and compared to the results obtained for General Aviation Homebuilt aircraft. It is interesting to observe that the slope for both the lower (General Aviation) curve and the upper (UAV) present a similar behavior, with approximately the same slope. Now, the constant term in the logarithmic equations is slghtly higher for UAVs

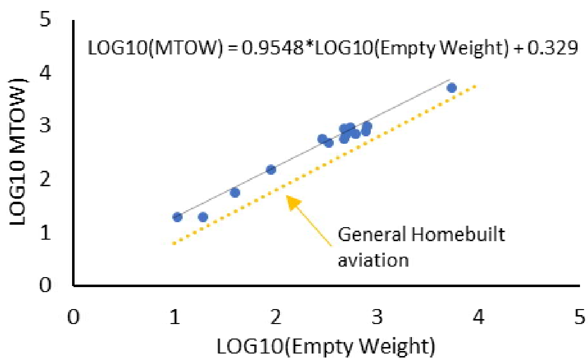

Figure 1 – Correlation between empty and maximum take-off weight

These results apparently result from similar constructive configurations and techniques for both cases. Generally speaking UAVs, because of relative dimensions tend to have higher stiffness to weight ratios than general aviation aircraft. It is in the authors ´experience that more efficient and hence lighter structural weight is feasible, even if general aviation aircraft requirements and specifications [4], [6] are taken into account. It should be mentioned however, that strong design head winds may somehow demand heavier structures.

In Figure 2 power to weight ratios can be observed.

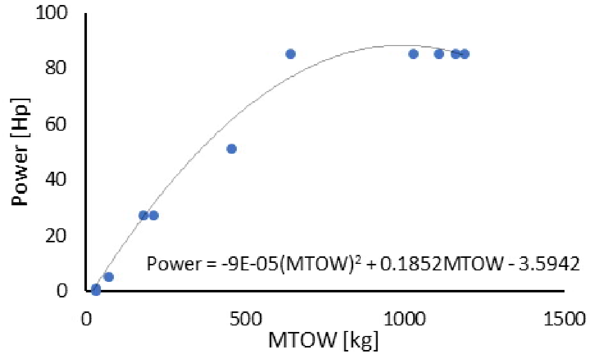

Figure 2 - Typical Power to Weight Ratio

However it is well known that power loading values have to be examined with care as they strongly depend on mission requirements. As such the given equation should only be considered as a general recommendation. Mission requirements need to be adjusted with the use of the setting point diagram [3]. Figure 3 shows this diagram for a typical UAV designed by the authors.

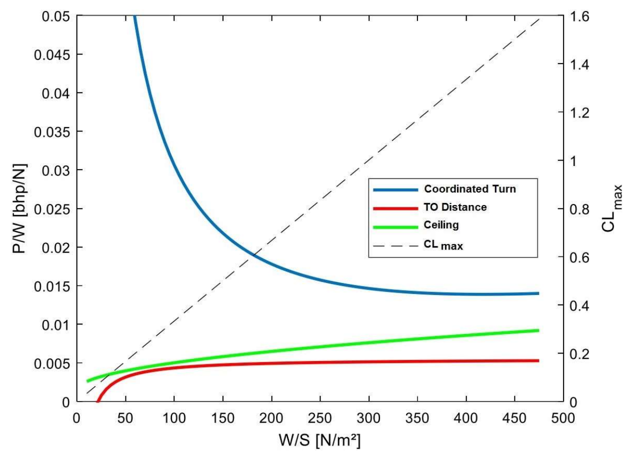

Figure 3 – Setting point diagram for a typical UAV

These results have been compared with the equations indicated in [1], [2], and [3]. It has been found that even thought the tendency is roughly the given equations can have different constant coefficients.

On the other hand, since feasible passenger carrying aircraft have a minimum weight the existing empirical equations do not provide an insight into the light UAV domain.

4 Preliminary Conclusions

Preliminary verifications carried out with existing aircraft, including those manufactured at UFMG, indicate that conventional construction techniques have a major influence on the existing empirical relationships used in conceptual UAV project design As UAVs tend to have over dimensioned, and hence heavier, structures.

Equations which provide more realistic results for UAV show a similar tendency when compared with those more suitable for General Aviation Aircraft. However the equation coefficients and range of application can be improved to obtain better results in initial aircraft assessment.

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8 Contact Author Email Address

mailto:ebauzerm@ufmg.br ;
gabrielgeorge@hotmail.co.uk ;
lcarmona@ufmg.br

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