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Comprehensive Preliminary Sizing/Resizing Method for a Fixed Wing - VTOL Electric UAV

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Abstract

A Fixed Wing (FW) aircraft with Vertical Takeoff and Landing (VTOL) is a new type of aircraft that inherits the hovering, VTOL, and maneuvering properties of multicopters and the power-efficient cruising of an FW aircraft. This paper presents a comprehensive method for FW-VTOL electric UAV sizing and resizing. The method uses newly developed integrated analysis that combines the VTOL propulsion sizing method with modified FW aircraft sizing theories. Performance requirements are specified as a set of functional relations. Several new empirical equations are derived using available data. The required battery capacity and total mass are determined from mission analysis that includes both VTOL and FW mission segments. The design is iteratively resized when the actual components of the propulsion system are selected. A case study of a 3.5-kg FW-VTOL electric UAV is presented in this research. The results of sizing and resizing are compared to parameters of the actual aircraft manufactured. Prediction of most parameters stays within a 10% error threshold.

Keywords: electric propulsion, aircraft design, integrated analysis, UAV, VTOL, sizing/resizing

Nomenclature

AR	Wing aspect ratio	R/C	Rate of climb, m/s
b	Wing span, m	ρ	Air density, kg/m^3
b_{HT}	Horizontal tail span, m	S_w	Wing area, sq. m
b_{VT}	Vertical tail span, m	S_{HT}	Horizontal tail area, m^2
C_D	Drag coefficient	S_{VT}	Vertical tail area, m^2
C_L	Lift coefficient	S_p	Propeller disc area, m^2
$C_{L_{max}}$	Maximum lift coefficient	S_{tot}	Total projected area of an aircraft, m^2
c_{prop}	Propeller clearance, m	t	Flight endurance, sec
C_{HT}	Horizontal tail volume coefficient	T	Thrust, N
C_{VT}	Vertical tail volume coefficient	U	Battery voltage, V