TELESCOPIC WING FOR IMPROVED FLIGHT PERFORMANCE

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Abstract

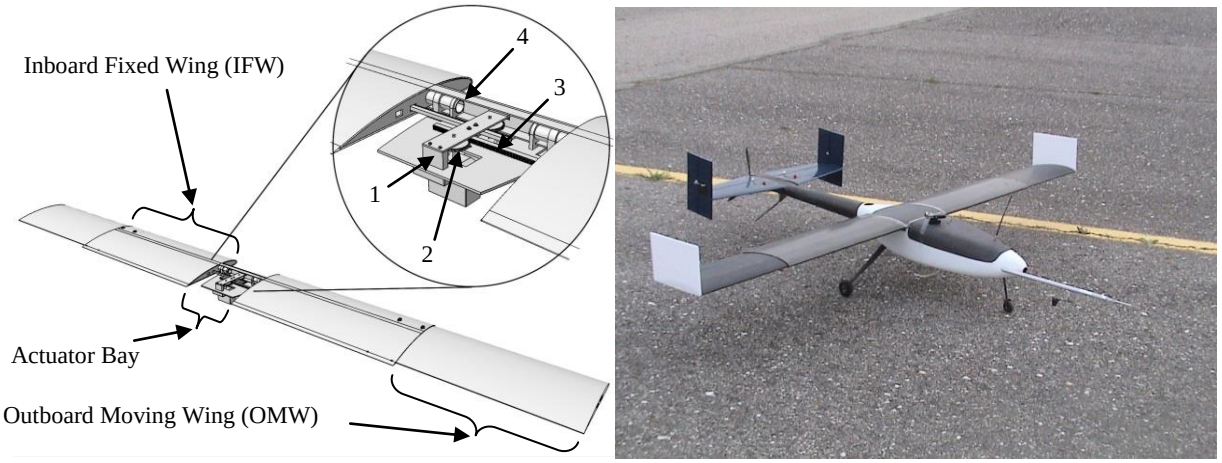
This paper briefly describes the development and testing of a variable-span morphing wing (VSW) concept aimed at improving the performance of a small unmanned aerial vehicle (UAV) which flies in the speed range between 11m/s to 40m/s.

An in-house aerodynamic shape optimization code, which uses a viscous two-dimensional panel method formulation coupled with a non-linear vortex lattice algorithm and a sequential quadratic programming optimization routine, was used to solve a drag minimization problem to determine the optimal values of wing span for various speeds of the vehicle's flight envelope while subject to geometric constraints imposed by the adopted telescopic concept [1]. An analysis was also developed and performed to compute the roll rate available with asymmetric span actuation of the VSW showing that adequate roll control authority exists over the required speed range without the use of ailerons. Computer simulations of the response of the UAV under study fitted with the designed VSW in two different situations, one in which it was required to establish equilibrium after an initial perturbation in the state variables and another in which it was required to follow a target bank angle by controlled dissymmetric span actuation and elevator deflection, were also performed [2]. Good performance in controlling the aircraft with the expected handling quality level was demonstrated. A full scale prototype was built for ground testing the wing/actuator system [3]. The wing is built in composite materials and is made of two parts. An electro-mechanical actuation mechanism was developed using an aluminium rack and pinion system driven by two servomotors. Bench tests performed to evaluate wing under load, showed that the system is capable of performing the required extension/retraction cycles. Structural design and analysis using finite element models were performed on the VSW. The numerical results were compared with experimental data showing good agreement. Adequate strength and stiffness were confirmed [4]. Also, an aeroelastic analysis using the typical aeroelastic section with unsteady linearized potential theory together with the aerodynamic strip theory was performed which revealed sufficient speed margin between the maximum flight speed and the onset of the flutter mode of vibration [5]. As a result of the referred development and testing it is concluded that the designed VSW is suitable to be installed on a UAV for in-flight concept evaluation. For that purpose, a previously developed UAV airframe was modified and instrumented to serve as a suitable test bed with flight data acquisition, telemetry and first person view capabilities [6].

This paper concentrates on the real aerodynamic performance, energy requirements and functionality analyses of the telescopic wing which were carried out following the newly collected data from flight tests. Besides these quantitative results, the qualitative assessment

of the flight handling qualities performed by the pilot are also presented, relative to a conventional fixed wing design with ailerons for roll control. The knowledge gained in the process is being used to develop a new more effective design within the CHANGE project.

Figure 1(a) illustrates the developed VSW concept while Fig. 1(b) shows the UAV prototype fitted with the telescopic wing. The VSW concept exhibits a very simple layout: a hollow wing, the inboard fixed wing (IFW), inside of which a smaller conventional wing, outboard moving wing (OMW), slides actuated by the electromechanical mechanism consisting of a servomotor, a pinion and rack.



(a) (b)

Fig.1 (a) VSW concept: (1) servomotor; (2) transmission pinion; (3) transmission rack; and (4) pultruded carbon spar. (b) UAV fitted with the VSW.

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