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Design and integration sensitivity of a morphing trailing edge on a reference airfoil: The effect on high-altitude long-endurance aircraft performance

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Abstract
Trailing edge modification is one of the most effective ways to achieve camber variations. Usual flaps and aileron implement this concept and allow facing the different needs related to take-off, landing, and maneuver operations. The extension of this idea to meet other necessities, less dramatic in terms of geometry change yet useful a lot to increase the aircraft performance, moves toward the so-called morphing architectures, a compact version of the formers and inserted within the frame of the smart structures' design philosophy. Mechanic (whether compliant or kinematic), actuation and sensor systems, together with all the other devices necessary for its proper working, are embedded into the body envelope. After the successful experiences, gained inside the SARISTU (SmARt Intelligent Aircraft STrUctures) project where an adaptive trailing edge was developed with the aim of compensating the weight variations in a medium-size commercial aircraft (for instance, occurring during cruise), the team herein exploits the defined architecture in the wing of a typical airfoil, used on high-altitude long-endurance aircraft such as the Global Hawk. Among the peculiarities of this kind of aerial vehicle, there is the long endurance, in turn, associated with a massive fuel storage (approximately around 50% of the total weight). A segmented, finger-like, rib layout is considered to physically implement the transition from the baseline airfoil to the target configurations. This article deals with an extensive estimation of the possible benefits related to the implementation of this device on that class of planes. Parametric aerodynamic analyses are performed to evaluate the effects of different architectural layouts (in-plane geometry extension) and different shape envelopes (namely, the rotation boundaries). Finally, the expected improvements in the global high-altitude long-endurance aircraft performance are evaluated, following the implementation of the referred morphing device.

Keywords
Morphing structure, high-altitude long-endurance aircraft, aircraft performance

Introduction

Morphing is one of the most active research fields, currently. It deals with continuous modifications of the geometrical shape of a reference surface through actuator systems that are completely embedded into the structure. The reason behind this technology can be searched to the willingness of having more and more performant wings, in terms of aerodynamics or operational envelope. As presented, in fact, the fulfillment of this capability would open the door to many breakthrough improvements. For instance, it would allow avoiding any structural discontinuity in the command appliances, having no more nacelles to cover the massive mechanisms currently used to move flaps, slats, and the other flight control and maneuver devices (getting lightest and cleanest wings), introducing new aircraft capabilities by enlarging its operable degrees of freedom. As usual, however, a technology that envisages exceptional advantages also opens the window to many criticalities. An aerodynamic system with augmented degrees of freedom presents a complex response

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