Integration and Control of Morphing Wing Structures for Fuel Efficiency/Performance

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In the substantial body of research involving aircraft shape morphing, wing-shape camber and profile morphing distributed along the span has shown to be a promising but challenging concept. Studies have shown potential for substantial and wide-ranging improvements across nearly all flight conditions, including increased aerodynamic efficiency, drag reduction and enhanced lift-to-drag performance, enhanced maneuverability and control effectiveness especially at high angles of attack, reduced fuel consumption, increased control robustness, decreased required takeoff/landing length, increased flutter margin, reduced airframe noise, increased stability and reduced stall susceptibility. However, a number of challenges remain in actuation, materials, modeling, and control design. Despite a long heritage of research, no adaptive wing technology has yet to be approved by the FAA for use in commercial aviation. If the remaining challenges can be overcome, wing morphing technology has the potential to substantially alter design and operation of future generations of aircraft. Recently, KU has developed the Pressure Adaptive Honeycomb (PAH) technique for wing shape morphing actuation. PAH actuators can achieve large gross deformations quickly, generally has favorable performance compared to alternative contemporary techniques, can scale to larger sizes without issue, and is made of flight certified materials. This research investigates active distributed morphing of wing profile and camber along the span for flight control and aerodynamic efficiency in lieu of conventional leading and trailing edge control surface actuators. The goal is to develop guidance, navigation and control (GN&C) laws for of a flight vehicle with the goal of drag reduction, increased efficiency, and enhanced capabilities. The objectives of this research are to build a prototype Pressure Adaptive Wing System (PAWS) at a scale relevant to manned flight, develop models and tools to predict flight-vehicle dynamic-response and performance, and develop a Distributed Morphing Wing Control (DMoWC) system to control the pressure adaptive wing morphing system. This presentation outlines the project schedule and plan. We provide an update on development of the PAWS prototype and present result of a small-scale 2D study to estimate effectiveness and feasibility. We present vehicle flight-dynamics models for wing-morphing actuation control and show results from simulation studies. We present plans for completing the current phase of the research, then present possible paths forward to continue this research.