

## **Biomimetic Feather Structures for Localized Flow Control and Gust Alleviation on Aircraft Wings**

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### **ABSTRACT**

This paper introduces a new biomimetic concept whose purpose enhances aircraft stability and maneuverability during flight. The research consists of localized control loop systems being integrated throughout the wing that sense the forces being experienced from turbulent airflow or wind gusts during flight. The design consists of feather-like components installed on both the upper and lower wing surfaces and extending beyond the wing's trailing edge. These structures contain piezoelectric elements that act as sensors, actuators, and load-bearing members. Their purpose is to operate as the aircraft's flaps and ailerons and additionally to sense and react to the forces experienced by the wing surface. Computational Fluid Dynamics studies using  $k-\epsilon$  turbulence models with Reynolds Averaged Navier Stokes equations are performed using the multi-physics software COMSOL. The combination of structure mechanics, CFD, piezoelectricity, and fluid-body interactions are assessed simultaneously. In the present study, several standard airfoil configurations with movable trailing-edge flaps are simulated in order to create a baseline of comparison with the proposed feathered wing system. This research is an initial step into a novel morphing wing design that enables aircraft to operate in a manner more closely inspired by their natural counterparts.

**Keywords:** morphing, piezoelectric, hierarchical control, bio-inspired, gust alleviation

### **1. INTRODUCTION**

In 1903, the Wright brothers achieved man's first flight on the beaches of North Carolina. Since that momentous day the world has continued to design their aircraft predominantly using this archetype. However, since this first flight, turbulence has been a continuous factor that has to be considered in the design of all new aircraft. Notably, turbulent airflow has been deemed a burden on the aircraft industry as it has, and will continue, to apply restrictions to possible design options [1].

During flight, an aircraft has the potential to encounter turbulent weather conditions and gusting winds that cause degradation in handling, flight quality and adverse effects on the aircraft's stability due to varying static and dynamic loads. Gusts have caused several restrictions on aircraft structural configurations and also result in limitations on the flight envelope of the vehicle. To ensure a vehicle's structural integrity fulfills the requirements of the FAA, manufacturers are required to strengthen the airframe to comply with the increased factors of safety that severe weather conditions and turbulent airflows demand [2]. Consequently, if an alternative method of gust alleviation could be developed, the aircraft would require a lower factor of safety as the alleviation system would accomplish the purpose that strengthening the airframe typically fulfilled.