

AIRCRAFT DYNAMICS FOR SYMMETRIC AND ASYMMETRIC V-SHAPE MORPHING WINGS

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ABSTRACT

This paper will present the effect of the aircraft turning dynamics for symmetric and asymmetric V-shape changing wings. The aerodynamic forces will be calculated using a 3D aerodynamic model developed that utilizes a modern adaptation of Prandtl's lifting-line method which can be used for wings of arbitrary camber, sweep and dihedral. The method will be applied to analyze symmetric and asymmetric V-shaped wing configuration of interest for morphing aircraft application. The V-shaped wing has two sections, an out-of-plane dihedral section and a horizontal section. A study of the lift characteristics for symmetric and asymmetric with and without flap deflection will be presented. An investigation as to how the partial dihedral will affect the dynamics of the vehicle, in turning, for wings with asymmetric flap deflection is performed. An comparison of the different turning performance measurements, turning radius, bank angle, load factor, turning rate and roll moment coefficient will be presented.

INTRODUCTION

Presently, most aircraft are designed and optimized for a particular mission. Increasingly it has been considered desirably for an aircraft to perform multiple missions and in different flight regimes. For example, an aircraft that could fly efficiently and morph to be maneuverable, this would enable new missions. As seen in nature, birds morph their bodies in different flight regimes to increase performance. Using birds as an inspiration, research toward the development of a morphing aircraft has been suggested¹. A morphing aircraft is defined as an aircraft vehicle that could perform gross shape changes in-flight to increasing efficiency, adaptability and/or

mission performance^{2, 3}. Recent advances in smart materials and actuators have enabled shape changing structures and, eventually, the development of a morphing aircraft structures without the addition of extra weigh¹.

Morphing technologies are currently being study to expand the range of missions that an aircraft can perform. There have been programs dedicated to study the feasibility of incorporating morphing to aircraft, especially for UAVs, like the DARPA Morphing Aircraft Structures⁴ program. Herein Joshi, et al., has demonstrated the impact of morphing wings on aircraft performance and provided a method for performance metrics for a morphing aircraft⁵. The goal of a morphing aircraft is to impact the performance of different maneuvers and flight conditions for array of different missions.

In this paper, we will investigate the impact of out-of-plane wing shape changes on different flight conditions like turning flight. The wing configuration that we will be studying is a wing configuration that has two sections, an out-of-plane dihedral section and a horizontal configuration, like a V shape wing configuration. Both symmetric and asymmetric dihedral angle changes will be performed. An investigation of the effects of flaps on the wings for both configurations will also be performed. We want to investigate how both symmetric and asymmetric wing shape changes affect the aircraft response for the different flight conditions. We want to see how we can take advantage of these properties by utilizing both symmetric and asymmetric wing shape changes to perform maneuvers that conventional aircraft can not do.

Each of the different performance metrics will have a different importance depending on the aircraft mission. For example, for a fighter aircraft the ability for fast and sharp turns are desirable. But for surveillance missions having small