Prediction of aircraft dynamics with shape changing wings

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ABSTRACT

This paper will present the effect of the vehicle dynamics of an aircraft with 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 the dynamics of different out-of-plane wing configuration of interest for morphing aircraft application. One particular wing configuration of interest is the wing configuration that has two sections, an out-of-plane dihedral section and a horizontal configuration, like a V shape wing configuration. An investigation as to how the partial dihedral will affect the dynamics of the vehicle, in turning is performed. A Comparison for symmetric and asymmetric wing configurations is performed.

Keywords: Aerodynamic, Morphing, Prandtl's Lifting-line, Turning, Aircraft Dynamics

1. 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 suggested[1]. 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 weigh[1].

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 Structures[4] 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 aircraft[5]. 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 in 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. We are going to consider both symmetric and asymmetric wing shapes changes. We want to investigate how both symmetric and asymmetric wing shape changes affect the turning radius, and rate, the bank angle and load factor. Each of the turning 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 bank angles during a turn to keep the surveillance equipment pointing at a certain direction is desirable. An application where small bank angles are desirable is for when the aircraft

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