The Sailplane Airliner: Conceptual Design with Active Load Control and Natural Laminar Flow

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Introduction

Maneuver load alleviation (MLA) and wing natural laminar flow (NLF) trace their origins to the early days of aviation. Applied independently, each can net modest improvements in efficiency. Use in combination, they can enable the economically viable and environmentally responsible aircraft of the future. NLF wings utilize reduced sweep to suppress attachment line and crossflow instabilities. The limited wing sweep impose a severe aerostructural penalty in the transonic regime. Maneuver load alleviation (MLA) can move the centroid of load inboard to reduce lift stress. This allows the wing to be made longer or thinner at the same weight.

Our goal is to quantify the synergy between NLF and MLA using a rational, physics-based design method.

Natural Laminar Flow Design

We use a hybrid inverse airfoil solver to link transition to section structural and aerodynamic properties. The basic aerodynamic method is similar to those of Liebeck (1978), Srilatha (1990) and Lee (1998).

A linear rooftop models the laminar run. The recovery is defined by a modified Stratford criterion. We use Thwaites and Head integral methods to solve the boundary layer. The profile drag is estimated using the Squire-Young equation.

To eliminate internal iterations we treat the x location of transition as an optimization variable and use a compatibility constraint to enforce laminar flow before transition. The criterion of Wazzan (1983) is used to qualify transition.

Maneuver Load Alleviation (MLA)

We simulate MLA aileron and flap deflections by changing the local incidence of wing sections in maneuver conditions. The effectiveness of the MLA system is limited largely by the wing maximum lift.

The spanwise lift distribution is computed under trimmed conditions using the Weissinger method with compressibility corrections. (Melin, 2009; Ning, 2010)

The lift distributions for different flight segments impose maximum lift and wing stress constraints. The structure is modeled as a linear hexagonal wing box.

Aircraft Design Studies

Vapor

Turbofan

Manufacturing

Takeoff Rotation

Mach 0.66, 100,000 lbs

Initial Cruise

Fuel

Table 1: Summary of design study results

With respect to the aircraft variables and attachment line transition modes. Under these assumptions the now decoupled boundary layer can be

that better controllable power models for transonic deflections may be needed to settle the issue of deflection

To maintain consistency the profile drag on the turbulent and laminar wings are computed using the same

Laminar & MLA & Sweep

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Laminar

Laminar & MLA

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