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S0317

Project Title
A CFD Study of the Effects of Horizontal Tail Geometrical Properties on Stability Derivatives of a Boeing 787-8 Model

Abstract

Objectives/Goals
The goal was to analyze stability derivative changes based on manipulation of horizontal tail geometrical properties of a Boeing 787-8 Vortex-Lattice model.

Methods/Materials
A Vortex-Lattice Boeing 787-8 model based on the Piano-X Boeing 787-8 geometrical report was set up in the CFD program SURFACES under cruising conditions. Two varying flight conditions were modeled with different flow stream properties in angle of attack, angle of yaw, roll rate, pitch rate, and yaw rate. After HT geometry was manipulated based on 10 geometrical variables into 8 models (including the control), stability derivatives related to lift, drag, and rotational moments were calculated using the function of the vortex-lattice grid console and stability derivatives at both flowstream.

Results
Because over 2720 variables were important in the result, the general trends found were shown instead. HT span, area, arm, volume, and aspect ratio were shown to be directly related, while HT geometric chord inversely related to lift-related and drag-related derivatives, dihedral effect derivative, pitching moment, and distance between the neutral point and CG. Increasing location of centroid with taper ratio was shown to increase longitudinal stability. Sweep, dihedral, and washout were shown to be directly related to directional stability derivatives while inversely related to side force variation, increasingly so at more turbulent conditions.

Conclusions/Discussion
Increasing HT length-related geometrical variables were suggested to increase longitudinal stability, lift to drag ratio until stall drag, and dihedral effect, but decrease directional stability coefficient and side force derivative. However, the lateral instability from increasing HT length-related variables was shown to be reduced by the direct, though insignificant, relationship of incidence angle and sweep to dihedral effect coefficient and side force derivative. From the trends found, five mathematical equations considering stability based on varying HT geometrical properties, and a Boeing 787-7 horizontal tail suggested to be more favorable toward stability than tested models was developed.

Summary Statement
The study found trends between HT geometrical properties and stability at Boeing 787-8's cruising conditions, and developed a horizontal tail indicated to be more favorable toward stability at cruise than the tested horizontal tails.

Help Received
Mother helped make board; Mr. Antrim proofread and gave advice toward project, giving presentation opportunities before science fair; Snorri Gudmundsson, a Surfaces software developer, gave advice on fixing CFD program and online sources regarding derivation and analysis of stability derivatives.