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Title

Coherent solutions to roll damping derivatives evaluation for a generic rocket model

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Abstract

In the design and operation of rockets, it is essential to understand the dynamic behavior of the vehicle, particularly with regards to its stability and control characteristics. One important aspect of this behavior is the roll damping derivatives, which describe the relationship between the roll damping moment and the rate of change of angular velocity. Accurate evaluation of these derivatives is crucial for the proper design of control systems and the prediction of rocket performance in various operating conditions.

This paper continues the studies developed in [1], [2], [3] and [4], and presents a coherent approach to evaluate roll damping derivatives for the standard Basic Finner Model. The study compares and analyzes the results from a range of techniques, including experimental testing, numerical simulations and analytical models. The study aims to evaluate the reliability and accuracy of these methods, and to identify the factors that contribute to their sensitivity.

The experimental, numerical and analytic analysis were performed under various operating conditions (Mach number from 0.4 to 3.5, angle of attack from 0º to 20º and different angular velocities) to provide a comprehensive evaluation of the roll damping behavior of the rocket.

The experimental tests were performed in INCAS trisonic wind tunnel using a dynamic test rig, named Roll Damping Rig, which allows the measurement of the roll damping coefficient by two independent methods: the forced rotation method, where the model spins constantly measuring the damping moment, and the free rotation method, where the model spins up to a desired angular velocity and then it is released to spin freely under flow condition.

The numerical simulations were performed using two different models: the URANS model and the nonlinear potential model. The simulations were used to validate and complement the experimental results and to provide additional insight into the underlying physical mechanisms that drive roll damping. The analytical models were based on established theories and models of rocket dynamics.

However, the study also showed that the numerical simulations provided the most reliable and accurate estimates of the roll damping moment, with the experimental tests providing valuable validation and verification of the results.

The paper concludes by summarizing the findings of the study and discussing the implications of the results for the design and operation of rockets. The experimental and numerical analysis used in this study provides a robust and comprehensive evaluation of the roll damping coefficient of a generic rocket model, enabling engineers to make informed decisions about the design of control systems and the prediction of rocket performance in various operating conditions.

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