A Review of the Georgia Tech R22 Teetering Rotor Simulation & Comparison with the University of Maryland Study of Low-G Mast Bumping for Teetering Rotor Helicopters

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The following includes a summary of the recommendations by the researchers at Georgia Tech given in the report "Simulation of the Robinson R-22 Helicopter for the Investigation of In-Flight Rotor Dynamics" (Ref. 1), and the measures taken to address these recommendations in the present investigation of mast bumping on teetering rotor helicopters at the University of Maryland (UMD).

The methodology used in the Georgia Tech study to analyze the R22 helicopter is consistent with both legacy and current physics-based modeling tools for rotorcraft. The UMD model takes advantage of advances in computational power that allow a more accurate representation of blade structural dynamics and aerodynamics to be included. The UMD study models the R66 rather than the R22 because of the more extensive availability of flight test data for the R66, which allows a more thorough validation of the model. For the Georgia Tech study, the simulation results were correlated to known trends and general observations of the R22 behavior rather than flight test data.

The UMD study has been divided into two phases, with Phase 1 completed and Phase 2 ongoing. Phase 1 included the development of the basic teetering rotor model to the point where reasonable correlation between predicted and measured trimmed flight conditions were obtained. Phase 2 will endeavor to refine model details such as fuselage aerodynamic properties to the point where reasonable correlation between predicted and measured dynamic flight conditions is achieved.

The Georgia Tech study was performed in a consistent manner with the most representative data set available at that time. Some of the quantitative implications of these predictions need to be updated based on more detailed information that can be gleaned from modern simulations. For example, the aerodynamic characteristics of the airframe were adapted from a Hiller helicopter, and the main rotor sectional aerodynamics did not include Mach number effects.

For the UMD study, rotor aerodynamics are modeled with compressibility effects included as part of the airfoil tables. Some limited maneuver validation was initiated at the end of Phase 1. This validation is contingent on an accurate model of the horizontal tail and fuselage aerodynamic tables. Look-up tables have been generated with computational fluid dynamics (CFD) in Phase 2 before making similar predictions with the R66 simulation model. After establishing confidence in the R66 simulation model through validation against maneuver flight test data, these maneuver flight predictions will be generated for similar inputs as used in the Georgia Tech study.

To date, the results obtained in the UMD study of the R66 do not reveal any significant discrepancies with the approach adopted by, and the results presented in, the Georgia Tech study. The results of the UMD study support the findings of the Georgia Tech study that (1) the main rotor does not show any unusual behavior under low-g conditions that would make the Robinson hub configuration more susceptible to mast bumping than other teetering rotor designs and (2) that mast bumping would not occur within the normal operating range of the helicopter.

The recommendations of the Georgia Tech study were:

1. To perform additional investigation to evaluate the validity of the off-line simulation in the absence of corrective pilot inputs, and correlate this behavior to measured data; and
2. Use a real-time simulation to accurately capture the simultaneous coupled inputs used by pilots during maneuvers.

Phase 1 of the UMD study has addressed the first recommendation through its R66 simulation in which flight test data was used to guide and validate the simulation model in steady flight conditions. Results of Phase 1 of the study are presented in Ref. 2. Additional validation with maneuver test data is being carried out in Phase 2, concurrently with refining the fuselage and empennage models.

The second recommendation is being addressed as part of Phase 2 of the UMD study. Real-time simulation capability was demonstrated in Ref. 3 for the simulation framework used to investigate teeter and blade coning angles in this study. This capability will be therefore be adapted to the R66 simulation.

References:

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