A Summary of Data and Findings from the First Aeroelastic Prediction Workshop

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Abstract: This paper summarizes data and findings from the first Aeroelastic Prediction Workshop (AePW) held in April, 2012. The workshop has been designed as a series of technical interchange meetings to assess the state of the art of computational methods for predicting unsteady flow fields and static and dynamic aeroelastic response. The goals are to provide an impartial forum to evaluate the effectiveness of existing computer codes and modeling techniques to simulate aeroelastic problems, and to identify computational and experimental areas needing additional research and development. For this initial workshop, three subject configurations have been chosen from existing wind tunnel data sets where there is pertinent experimental data available for comparison. Participant researchers analyzed one or more of the subject configurations and results from all of these computations were compared at the workshop.

The AePW has been patterned after two very successful workshops conducted over the past decade: the Drag Prediction Worshop [1] and the High Lift Prediction Workshop [2]. The AePW assembles an international slate of participant to analyze a carefully selected set of unsteady aerodynamics and aeroelastic problems for which experimental validation data is available. The intent of the workshop is to investigate the ability of our present computational aeroelastic tools to predict nonlinear aeroelastic phenomena, particularly those arising from the formation of shock waves, vortices, and separated flow.

Many static and dynamic aeroelastic phenomena are influenced by, or a result of, these flow phenomena. Static aeroelastic loadings and deflections, reduced control effectiveness, control reversal, and structural divergence boundaries can be a strong function of these nonlinear aerodynamic phenomena, particularly when aerospace vehicles are operating away from their nominal design point. Dynamic aeroelastic problems such as buffet, control surface buzz and other limit cycle oscillations are a direct result of some type of nonlinearity, whether it is structural or aerodynamic. Flow nonlinearities, particularly separated flow, can limit the amount of aerodynamic load that can be applied to a structure and cause otherwise divergent aeroelastic instabilities, like flutter, to become a limited-amplitude oscillation prior to structural failure. This is an example of a beneficial result of flow nonlinearity. Unfortunately there are just as many, if not more, examples of aeroelastic problems that are triggered by the flow nonlinearities themselves, well before any aeroelastic instability is encountered. Buffeting and buzz are two examples of these nonbeneficial instances.

Aeroelastic analysis requires the coupling of a structural representation with an aerodynamic model and the two disciplines must be simulated in a coupled manner. Sometimes assumptions or errors in the aerodynamic simulation can be masked by assumptions and errors in the structural model, and vice versa. In an attempt to limit or at least minimize this issue, it is typically desirable to first analyze and evaluate these two disciplines in an uncoupled manner prior to coupling them for an aeroelastic simulation. Thus the AePW Organizing Committee (OC) has decided to initially focus on test cases that stress the unsteady aerodynamic prediction component of the problem and initially minimize the aeroelastic coupling required to simulate the cases. Future workshops hope to introduce stronger aeroelastic coupling as a good understanding of the uncoupled aerodynamic and structural analysis capability is understood. The AePW OC has selected three datasets for the initial workshop, all of which have detailed unsteady aerodynamic wind tunnel data under forced oscillation test conditions.

Two of the cases, the Rectangular Supercritical Wing (RSW) [3] and the Benchmark Supercritical Wing (BSCW) [4] are simple, structurally rigid, rectangular planform wings that are oscillated at a specified pitch amplitude and frequency. The cases selected for analysis represent off-design conditions and involve strong shocks and separated flow, which are key ingredients to accurately predicting many nonlinear aeroelastic phenomena. The BSCW case includes a "blind" test case where experimental data will not be provided to the participants prior to the workshop. This case exhibits some unique flow behavior that should be a particular challenge to today's methods. The third case selected for this intial workshop is the High Reynolds Number Aero-Structural Dynamics (HIRENASD) [5] wing tested in the European Transonic Wind Tunnel. This wing is geometrically more complex than the previous rectangular planform wings, and the wind tunnel model has a small amount of measured structural flexibility that is used to oscillate the wing in its structural modes and acquire unsteady aerodynamic data for these oscillations. This case represents a step toward a coupled aeroelastic analysis in that the wing is oscillated in one of it's structural mode shapes to generate the unsteady flow.

For the full paper, participants in the AePW will have analyzed the three cases and presented their results at the first workshop. This paper will summarize the results of that workshop comparing the various methods applied to the test cases. It will also outline the plan for future workshops and the cases to be analyzed in the future.

References

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