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Final Report

for the Project Entitled

UNSTEADY PANEL METHOD FOR MODELING THE FLOWFIELD DUE TO TIME DEPENDENT VEHICLE'S GEOMETRY OR MOTION

(NCC-2-676)

Submitted to:

NASA Ames Research Center
Moffett-Field, California.
Graduate Student Research Program

by

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SUMMARY

This two-year research program was accomplished as a part of the NASA Ames Research Center Post Baccalaureate Program. During these two years Mr. T. F. Richason has completed the required coursework at the Aerospace Engineering Department at S.D.S.U. and has concluded his thesis related research at NASA Ames Research Center. Mr. Richason research study was focused on incorporating time dependent capability into the aerodynamic computer code (PMARC) which was originally developed for steady state flow fields. During the final phases of this project the modeling of flow fields where several submerged bodies could move along various time dependent flight paths was achieved. Such computational capability can be used to analyze the aerodynamic interference between two aircraft flying along two closely intersecting flight paths or for a helicopter rotor rotating relative to its body. A technical report summarizing the theoretical background of this research along with several examples which were used to validate the above features of the computer code will be submitted directly to the project monitor, Mr. Dale L. Ashby.

SCHEDULE

The Post Baccalaureate Program schedule was:

1. Sept. 1, 1990 - June 1, 1991 : Mr. T. F. Richason studied at SDSU (24 units of coursework and 6 units of thesis) and has completed the literature survey for his Thesis.

2. June 1, 1991 - Feb. 1, 1992 : Research and Thesis work at NASA Ames.

3. Feb. 1, 1992 - June 1, 1992 : Final semester at SDSU.

4. June 1, 1992 - August 30, 1992 : Concluding research at NASA Ames.

RESEARCH PROGRESS

Panel methods, based on the solution of the inviscid flow equations[1–5] are now widely used in industry as well as research institutes. One of the first methods (VSAERO[1]) which had true three-dimensional capability was very successful in calculating the lifting properties of aircraft wings, up to moderate angles of attack. This method was extended such that the unsteady maneuvers of solid bodies in an inviscid fluid could be analyzed[2–5]. However, many important flow conditions in unsteady aerodynamics are a result of relative motion between at least two solid bodies. Such a situation exists in the case of a propeller rotating relative to a steadily flying wing or similarily when a helicopter rotor rotates relative to its body.

During the first year of this project the existing panel code (PMARC[3]) was modified so that the geometry of the boundary (as in the case of a relative motion between two airplanes) can be varied with time. This modification required a time dependent update of the position of the various moving boundaries (and their surface grids) and of the aerodynamic influence coefficients.

During the second year of this project the method was validated against various test cases. The unsteady nature of the code was validated by comparing the calculated results with data measured for an oscillating wing for which experimental data was available. The multicomponent motion capability of the method was later demonstrated by studying the interaction between two airplanes flying along different (but almost intersecting) paths. In the particular case studied for this report the effect of a large airplane's wing on a lighter airplane's stability was investigated. Rolling moments were calculated, as the smaller airplane closely crossed the large airpiane's wake, at various vertical separation locations.

Another possible application for the present method is to study the flow field created by rotors rotating relative to a helicopter's body. Two sets of such data were available for comparison where the advance ratio was such that situations with non-linear nature, such as flow separation or flow reversal on the blades, was avoided.

PUBLICATIONS

The technical results of this research effort were summarized in the following publications.

1. Richason, T. F., Katz, J., and Ashby, D. L., "Unsteady Panel Method for Flows with Multiple Bodies Moving Along Various Paths," submitted to the AIAA Aerospace Science Conf. to be held in Reno, Nevada, in January 1993.

REFERENCES

1. Maskew B., "Program VSAERO, A Computer Program for Calculating the Nonlinear Aerodynamic Characteristics of Arbitrary Configurations, NASA CR-166476, Nov. 1982.

2. Katz, J., and Maskew, B., "Unsteady Low-Speed Aerodynamic Model for Complete Aircraft Configurations," AIAA Paper 86-2180, Aug. 1986, also, J. Aircraft Vol. 25, No. 4. 1988, pp. 302-310.

3. Ashby, D., Dudley, M., and Iguchi, S., "Development and Validation of an Advanced Low-Order Panel Method," NASA TM 101024, 1988.

4. Browne, E. L., and Ashby, D. L., "Study of the Integration of Wind-Tunnel and Computational Methods for Aerodynamic Configurations," NASA TM 102196, July 1989.

5. Ashby, D. L., Dudley, M. R., and Iguchi, S. K., "Development and Validation of an Advanced Low-Order Panel Method," NASA TM 101024, Oct 1988.