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DEVELOPMENT AND APPLICATION OF OPTIMUM SENSITIVITY ANALYSIS OF STRUCTURES

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The work funded through NASA Research Grant NAG-1-145 was begun in January 1981. It was initially in the area of optimum sensitivity analysis, a technique which permits one to find derivatives of optimum design variables and objective function with respect to the parameters held fixed during optimization. The research then focused on developing an algorithm applying optimum sensitivity analysis for multilevel optimization. Since June 1983, the research efforts have been devoted to assisting NASA Langley's Interdisciplinary Research Office (IRO) in the development of a mature methodology for a multilevel approach to the design of complex (large and multidisciplinary) engineering systems. The multilevel approach to design is discussed extensively in [1] and [2] for example.

During the previous reporting period, an effort was undertaken to identify promising multilevel optimization algorithms. This work is being conducted in collaboration with Michael Riley of Kentron International Inc. who carries out the required programing. In the current reporting period, the computer program generating baseline single-level solutions was completed and tested out. Four baseline solutions were generated: a local constraint dominated three-bar truss design, a global constraint dominated three-bar truss design, a local constraint dominated ten-bar

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truss design and a global constraint dominated ten-bar truss design. Furthermore, the computer program conducting two-level design following the method of Sobieski et al ([3]) was coded and is undergoing final checkout. In the upcoming reporting period, it is expected that we will complete experimentation with this method and work will begin on implementation of that proposed by Haftka ([4]). A presentation titled "A Comparative Study of Multilevel Optimization Algorithms for Engineering Design" has been proposed for the work-in-progress session of the AIAA/ASME/ASCE/AHS 26th Structures, Structural Dynamics and Materials Conference that will be held 15-17 April 1985 in Orlando, Florida.

A new project was begun in the context of continuing support to IRO's effort in the area of multidisciplinary optimization. This project aims at studying the sensitivity of aeroelastic responses to changes in wing shape parameters. This type of derivative is necessary when optimizing the configuration of flexible wings. It was decided to initiate that project by a proof-of-concept study in order to identify the difficulties and requirements of such sensitivity analysis. That study is concerned with the sensitivity of the elastic loads on a wing flying at constant lift to changes in thickness ratio, camber and twist angle. The structural analysis is conducted by the classical finite element method. The subsonic aerodynamic analysis uses the nonlinear potential method developed by D. R. Bristow and presented in [5]. Sensitivity analysis of aeroelastic response requires the

capability to perform sensitivity analysis of structural and aerodynamic responses. Most of these derivatives are derived analytically. The aerodynamic derivatives are generated by the method introduced in [5]. This work is being conducted in collaboration with Brenton Weathered of Kentron International Inc. who carries out the wing modeling as well as the computer programing. At the end of this reporting period, the analytical formulation of the problem is completed and the computer program generating aerodynamic and structural models also. It is hoped that initial sensitivity results will become available by the end of the next reporting period.

It was mentioned in the previous project report that some efforts were to be devoted to assisting a joint IRO-CALAC (Lockheed California) design project. This assistance has continued throughout the current reporting period and has included coordination of the exchanges with CALAC as well as participation in the formulation of the design process and in the definition of the testing of the resulting computer system.

Finally, a paper coauthored by J. Sobieszczanski-Sobieski and J.-F. Barthelemy and titled "Improving Engineering System Design by Formal Decomposition, Sensitivity Analysis, and Optimization" will be presented at the International Conference on Engineering Design in Hamburg, West Germany 26-28 August 1985. Also, a paper coauthored by J. Rogers and J.-F. Barthelemy and titled "An Expert System for Choosing the Best Option for Automated Design

Synthesis," will be presented at the International Computers in Engineering Conference and Exhibition, Boston, Mass., 4-8 August 1985.

REFERENCES

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3. Sobieszczanski-Sobieski, J., James, B., and Dovi, A., "Structural Optimization by Multilevel Decomposition," AIAA Paper No. 83-0832-CP, presented at the 24th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, Lake Tahoe, Nevada, May 2-4 1983.

4. Haftka, R. T., "An Improved Computational Approach for Multi-Level Optimum Design," accepted for publication in the Journal of Structural Mechanics (as of September, 1983).

5. Bristow, D. R., "Development of Panel Methods for Subsonic Analysis and Design," NASA CR-3234, 1980.