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## Final Technical Report

# NUMERICAL DESIGN OF TRANSONIC SHOCKLESS AIRFOILS

Principal Investigator: Paul R. Garabedian



NASA--Langley Research Center
Grant NGR-33-016-167

Period:
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The work on the contract has been presented in considerable detail in five major publications [1 through 5]. In this final report we shall only attempt to indicate the most significant achievements.

The original goal of the contract was to develop a code that would be available to engineers to design shockless airfoils for transonic aerodynamics. This turned out to be far more difficult than was anticipated, and several early versions of the code failed to gain much acceptance by industry. However, in the last year we have brought out a final version that seems to overcome all the difficulties. It enables one to design a shockless airfoil that assumes a given pressure distribution up to a reasonable tolerance in transonic conditions. It is easy to obtain airfoils with minimal drag creep using this code. The code is now in use by several aircraft companies, including Pratt & Whitney, Lockheed and Fairchild Industries.

Perhaps the most successful contribution from the contract has been the code for two dimensional analysis of airfoils in transonic flow. This includes viscous effects through a turbulent boundary layer correction. The simulation of wind tunnel data is excellent and the code is widely used as a replacement for two dimensional testing. Predictions of performance of supercritical wing sections can be made rapidly and cheaply with this tool.

The third line of research on the contract was the development of a swept wing code and of codes that simulate the flow past wing body combinations. These codes are now in great demand by industry and are used to reduce wave drag on operational aircraft. Major contributions have been made to speed up the iterative schemes and mathematical methods involved in these calculations, which are in general far more time consuming than is the case for two dimensional flow.

At the stage of this final report it can be said that the mathematical problems in computational fluid dynamics for two dimensional transonic flow are well in hand; what remains to be done there is more in the line of development than of research. On the other hand, for three dimensional problems such as that of the swept wing, what has been achieved is rather a very promising beginning that opens up major possibilities for the future. The activities of the contract have provided a turning point for computational fluid dynamics, which now promises to become a major tool for future research in transonic aerodynamics.

The scientific personnel on the contract received a NASA Public Service Group Achievement Award in the fall of 1976.

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