NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ROUTING SLIP

<table>
<thead>
<tr>
<th>MAIL CODE</th>
<th>NAME</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>403</td>
<td>11547-4</td>
<td>Approval</td>
</tr>
</tbody>
</table>

Dr. Whitcomb

FILE INFORMATION
INVESTIGATE AND ADVISE
NOTE AND FORWARD
NOTE AND RETURN
PER REQUEST
PER TELEPHONE-CONVERSATION
RECOMMENDATION
SEE-ME
SIGNATURE
CIRCULATE AND DESTROY

PLEASE ADVISE AS TO STATUS OF ATTACHED PROPOSAL. REPLY-BY 2/24/75.

J. Royall

CODE (or other designation) DATE 4/17/75
MEMORANDUM

TO:  103/Deputy Director

FROM:  102A/Chief Mathematical Scientist

SUBJECT:  Proposed Publication of Report "A Theory of Transonic Wing Sections, With Computer Programs and Examples," by Paul Garabedian, Frances Bauer, and David Korn

The subject report has been produced by New York University under an open grant of about 200K over a 2-year time period. Professor Paul Garabedian who is in charge of the program at NYU is among the most notable and capable applied mathematicians active today. Garabedian has objected to publication in the format of the contractor report (NASA CR), and has proposed instead publication of the report in a mathematical monograph series published by J. Springer. We have suggested as an alternative consideration of the NASA Special Publication (SP) for the report, and Professor Garabedian has stated he will discuss this with us when he visits Langley this month.

In the meantime, the question of possible classification of some of the material has arisen and therefore additional information on the background on the grant and various publications related to it should be helpful in arriving at a proper decision.

Dr. Richard T. Whitcomb, monitor of the grant, is of the opinion that the 2-d theoretical transonic aerodynamics which the report treats, while a scientific tool, is not readily extended to 3-d wings; and since a large part of the information generated has already been disseminated in various reports it is not logical or feasible to classify this work.

My own opinion as co-monitor is that the only portion of the present work that would be time consuming for another group to develop is the software - and I do not believe the computer program should be security classified.
Some informal notes by Jerry South relating to background are attached to this memorandum. They indicate that a large number of previous publications have already given the gist and details of the theory. Moreover comparisons of 2-d theory with experiments made in the Canadian wind tunnel in Ottawa have also been published widely (AIAA Paper No. 71-567); another paper "Analysis of Transonic Airfoils," by P. R. Garabedian and D. G. Korn, is in press to appear in the Communications on Pure and Applied Mathematics; still another paper entitled "Numerical Design of Transonic Airfoils," by the same authors, has appeared in a book Numerical Solution of Partial Differential Equations-II, Academic Press 1971.

Since the authors of the subject report are coming to Langley soon, it is desirable to resolve the question of classification which clouds the picture. I feel that unless we are given other instructions by management we should proceed with the recommendation of unclassified publication of the above work.

Enclosure

I. E. Garrick
2471
NOTES ON GARABEDIAN-KORN-BAUER TRANSONIC AIRFOIL DESIGN
AND ANALYSIS METHOD AND DOCUMENTATION

1. The package consists of theory, user's manual, and listings of three computer programs which can be used independently, and which complement one another so as to arrive at 2-D supercritical airfoil designs which:

   (a) are shockless at one design condition (say, for a certain \( M_{\infty} \), \( C_L \), \( \alpha \), and thickness ratio)

   (b) have favorable characteristics in regard to turbulent boundary-layer separation (i.e., separation is prevented by proper design at the design condition)

   (c) may have shocks and probably separation at off-design conditions.

2. Program A - Design procedure for shockless 2-D airfoil, using a unique method of complex characteristics combined with analytic continuation of the 2-D hodograph plane into a complex four-dimensional space. (Inviscid.)

Program B - 2-D turbulent boundary-layer program for determining the displacement thickness and separation points (if separation occurs) for a given pressure distribution.

Program C - Analysis method for off-design cases where shocks may occur. Combines the ideas of CCL Sells (RAE) and Murman and Cole (USA), whereby the given airfoil is conformally mapped onto a circle (Sells) and then a relaxation procedure using a mixed difference scheme (Murman and Cole) is applied to solve the inviscid mixed-flow (subsonic stream with embedded supersonic pockets terminated by shocks) problem.

3. Program A is the only one which would be difficult to develop, since the theory is highly sophisticated and the implementation of this theory in a computer program requires considerable ingenuity.

4. Considering the number of different people in the U.S.A. now solving the analysis problem, as in program C, it is likely that foreign nationals have already developed, or are now developing, their own relaxation-analysis programs.

5. Program B is a standard item which nearly everyone possesses, I assume.

6. Historical development and publications pertaining to Program A.


In (1), it was demonstrated that well-posed, stable, numerical solutions of the detached shock (mixed flow) problem could be obtained by analytic continuation of one of the independent variables into complex values. (2) and (4) to (6) were further extensions of this original work. (3) sets out the general theory of analytic continuation of Real PDE's in Complex Space. (7) gives a complete description of the theory and a listing of the computer program for the symmetric-airfoil (nonlifting) case.

The extension to lift is a little more complicated, but about 95 percent of the most difficult part is in (7).

7. The Dutch have been theoretically designing shock-free transonic airfoils since pre-1964, viz.


(1) sets out the general theory for the nonlifting case, (2) is extended to the weakly-lifting case. This procedure is not as efficient or flexible as Garabedian-Korn (Program A).

8. Program A is a vastly improved version of Korn's symmetric-airfoil program. Much of the preliminary calculation has been automated so that an engineer can get "near" to a viable, shock-free shape in a reasonable time. With program A and user's manual, it is likely that any foreign
countries could design good supercritical airfoils. Without program A and the user's manual, it would take some clever people to extend Korn's published program to the lifting case and then exercise the program to efficiently design airfoils. I estimate that it would require about two years of work and refinement to do so, starting from Korn's publication (7).

Jerry South