Mr. Cyril R. Taylor  
Ministry of Aviation Supply  
8- By 9-Foot Wind Tunnel  
Royal Aircraft Establishment  
Bedford, England  

Subject: Panel on "Transonic Wind Tunnel Techniques Including High Reynolds Number Scaling", NASA-RAE Cooperative R & D Program in Transonic Aerodynamics  

Dear Mr. Taylor:  

I have been designated the Langley Research Center representative to the subject panel. I am looking forward to working with you and Mr. Stuart L. Treon of the Ames Research Center with regard to an exchange of information or in the formulation of programs in transonic aerodynamics which would be of mutual benefit to the RAE and NASA. I have received a copy of your letter to Mr. Treon and therefore, I shall restrict my comments to some of the activities underway at Langley which I consider to be interesting to our panel.  

I. Wind Tunnel Testing Techniques  

We at Langley, as our counterpart at Ames, are very much concerned about improving our capability for making accurate aerodynamic measurements at transonic speeds in our transonic wind tunnels. As part of this program to improve the quality of the data, we are continually examining new instrumentation for measuring temperature, pressure, model angle of attack, quality of flow in the test section, internal strain-gage balances having improved accuracy, and new data acquisition systems having improved sampling rates and response times. With regard to the quality of the flow in the test section, it is known that humidity effects can materially affect the validity of aerodynamic data at transonic speeds, for it is rather difficult to find data indicating these effects. Recently, some research has been made in the Langley 9-foot transonic pressure tunnel to determine the effects of humidity on the aerodynamic characteristics of a typical swept-wing airplane configuration. Since the tunnel is closed
and sealed to the atmosphere, we can control humidity, temperature, and pressure independently. Some results of this study are shown in Figures 1 and 2. The data are for a Mach number of 0.93 and a lift coefficient of 0.60. Shown on the left side of Figure 1 is the variation of drag coefficient, \( C_d \), with dewpoint temperature, \( T_{dp} \) (humidity measured at stagnation pressure) for a tunnel stagnation temperature (\( T_0 \)) of 120°F. The arrow indicates the normal operating dewpoint temperature of 25°F for the 8-foot transonic pressure tunnel for the above conditions. Note that the drag coefficient remains unchanged for dewpoint temperatures of 25°F and below. However, as the dewpoint temperature is increased above 25°F, the drag coefficient increases very rapidly. There are no known methods for correcting the data for these humidity effects and consequently, data obtained under these conditions are useless. Since some tunnels are open to the atmosphere and are more subject to humidity effects, these tunnels are operated at considerably higher stagnation temperatures than indicated on the data to the left. The data shown to the right of Figure 1 indicates the effect of increasing the tunnel stagnation temperature for a dewpoint temperature of 60°F, which is about normal for Hampton, Virginia, during the spring, summer, and fall of the year. Note that there is a reduction in the drag for the stagnation temperature range from 110°F to 135°F which is about the upper limit for our tunnel; however, the drag level is still considerably higher than that for normal operating conditions. Shown in Figure 2 are the chordwise pressure distributions for two angles of attack for the same swept-wing model of Figure 1. The test Mach number is 0.93. It is obvious that increasing the dewpoint temperature from 0°F to 60°F causes a loss in the section normal force as well as a forward shift in the shock location on the wing. These data are still in the preliminary analysis stage, but a report describing the results should be published in the near future.

We at Langley are also concerned about correlation of data from one wind-tunnel facility to the next. Our experience has indicated that if proper test techniques and data-reduction methods developed for the facilities are adhered to, then the results of such tests can be used with confidence. As an example of a tunnel-to-tunnel correlation, I am enclosing for your retention a copy of NASA TN X-1650, a technical memorandum, which describes the subsonic longitudinal aerodynamic measurements on a transport model in the Langley 16-foot transonic tunnel and the Langley 8-foot transonic pressure tunnel.

As stated by Mr. Treon in his letter to you, the Langley Research Center will be involved in transonic wind-tunnel tests of the C-5A correlation model. The tests will be made in the Langley 16-foot transonic tunnel.
and the Langley 8-foot transonic pressure tunnel which are slotted tunnels. These tests have been scheduled for late spring or early summer 1971. It is realized that the C-5A model may be somewhat large for the 8-foot transonic pressure tunnel (actual dimensions of the test section are 7.1 x 7.1 feet); however, the results of the tests should give a good indication of the blockage which can be tolerated in this facility at high subsonic Mach numbers. The principal investigators at Langley for this program will be Messrs. Arvo A. Luoma and Richard J. Re.

II. Sting Support Interference

Model support interference at transonic speeds has always been a continuing problem and there are numerous publications dealing with this subject. I have enclosed for your retention NASA TN D-4021 which is concerned with the sting-support interference on the longitudinal aerodynamic characteristics of cargo-type airplane models at high subsonic Mach numbers. We intend to do some additional sting interference investigations in the Langley 8-foot transonic pressure tunnel using a model of the C-141 airplane. The support technique will be different from that shown in NASA TN D-4021 in that the model will be supported by a blade sting at the forward end of the fuselage rather than by the conventional sting support through the aft end. This program is scheduled for the summer of 1971 and the principal investigator will be Mr. Arvo A. Luoma.

III. Wind-Tunnel Wall Interference at M = 1.0

Considerable attention has been focused on the problem of wind-tunnel wall interference effects at sonic velocities since recent research has indicated that flight near a Mach number of 1.0 may be feasible. At the present, there are no known theories which provide solutions to this problem. We are looking into this area using experimental techniques which consist of testing bodies of revolution differing in size in the Langley 8-foot transonic pressure tunnel and comparing the data with a drop body of one of the configurations using the aircraft drop technique. The data obtained by the aircraft drop technique provide sting-free and wind-tunnel wall-interference free data near a Mach number of 1.0.

Another method that we have used was to test the same model of a swept-wing configuration in the Langley 8-foot transonic pressure tunnel and in the Ames 11- x 11-foot transonic tunnel. Some preliminary results of this experimental investigation for a Mach number of 0.93 are shown in figure 3. With an exception of some scatter in the pitching-moment data, it would appear that the wind-tunnel wall-interference effects are small for this configuration. However, considerably more effort must be expended in this area and this could be a subject of mutual interest. Additional information on this subject is discussed in Section V, Flight Projects.
IV. Half-Span Model Testing

In answer to your question regarding half-span model testing capability, we have conducted such tests in the Langley 8-foot transonic pressure tunnel. Enclosed for your retention is NASA TN D-6067 which is illustrative of our experimental set-up for model powered engine testing. However, we do have plans to utilize this equipment for other types of research. Depending upon model size, we can test up to speeds approaching a Mach number of 1.0 and Reynolds numbers up to about 6.0 million per foot.

As you are well aware, Langley has done considerable research in the area of the effects of Reynolds number and boundary-layer transition location on shock-induced separation. Those results have been reported by Mr. Donald L. Loving in NASA TN D-3580 and Mr. James A. Blackwell in NASA TN D-5003. However, the findings strictly apply only to two-dimensional tests. We plan to extend this effort to the three-dimensional case employing the half-span model testing technique mentioned above. This program is scheduled for late 1971 and the principal Langley investigator will be Mr. Arvo A. Luoma.

V. Flight Projects

The High Reynolds Number Aerodynamic Data Program, HIRAD, was developed as an aeronautics program to obtain free-flight data at high Reynolds numbers. These data are for use in the design of better aircraft through advanced technology. The first phase of the program, recently completed, has provided sting-free and wall-interference-free data on the drag rise Mach number of a body of revolution which has been shown in wind-tunnel tests to have favorable transonic drag characteristics. These data were obtained using the aircraft drop technique with the bodies instrumented with telemetry and tracked with radar. The test bodies had the same smoothness as the comparative wind-tunnel models, and were the same size (45 inches in length, 5 inches in diameter).

Additional free-flight tests at larger scale (2 to 1 and 8 to 1), some with complete aircraft configurations, are expected to provide aerodynamic data including pressure distribution at Reynolds numbers comparable to full-scale aircraft (higher than present wind-tunnel capabilities). Also expected are data for determining the minimum level of Reynolds number for valid testing. These data should help define the upper limit of Reynolds number requirements for future ground test facilities.

Transonic Airplane Model Tests. – Preliminary designs and studies are underway to define the feasibility of model flight tests of a complete airplane configuration (F-8 with supercritical wing) for comparison with
transonic wind-tunnel results and flight tests of the full-scale airplane. The models will probably be ground-launched with rocket boosters and will attain test conditions similar to those for the wind-tunnel tests.

The principal investigator for the above programs is Mr. Clarence L. Gillis, Staff Scientist, Space Technology Division.

VI. AGARD Specialists' Meeting

Langley Research Center is contemplating the presentation of three papers at the AGARD Specialists' Meeting, Gottingen, Germany, April 26-23, 1971, which will be of considerable interest to our panel. Two of the papers will be delivered by Mr. Donald D. Baals, Assistant Chief, High-Speed Aircraft Division, and the third by Mr. Clarence L. Gillis, Staff Scientist, Space Technology Division. Although the papers are still in the rough draft stage of preparation, I am providing you the titles and authors so that you might be able to obtain copies of the meeting:

1. Igoe, William B.; and Baals, Donald D.: Reynolds Number Requirements for Valid Testing at Transonic Speeds;
2. Baals, Donald D.; and Stokes, George H.: A Facility Concept for Valid Testing at Transonic Speeds; and

The above generally summarizes the activities at Langley Research Center which are considered to be of interest to this panel. In addition, I am enclosing a copy of NASA Memorandum from Head, Subsonic Aerodynamics Branch, HSAD, to Assistant Head, 8-Foot Tunnels Branch, dated January 21, 1971. This memorandum indicates joint research programs and areas of cooperation between the British and Langley which you may be aware of. I shall be happy to cooperate with any plans regarding the functioning of this panel which may be formulated by you and Mr. Treon of the Ames Research Center.

Sincerely,

Ralph P. Bielatae
Assistant Head, 8-Foot Tunnels Branch, HSAD

cc: Mr. Lawrence K. Loftin, Director for Aeronautics, M/S 116
    Mr. Ralph P. Bielat, 8-Foot Tunnels Branch, HSAD, M/S 403
    NASA, Code RA - Attention: Mr. W. S. Aiken, Jr. (with 1 copy Langley Memorandum and 1 copy figures)
    ARC - Attention: Mr. Stuart L. Treon (with 1 copy Langley Memorandum and 1 copy figures)