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NACELLE AERODYNAMIC PERFORMANCE

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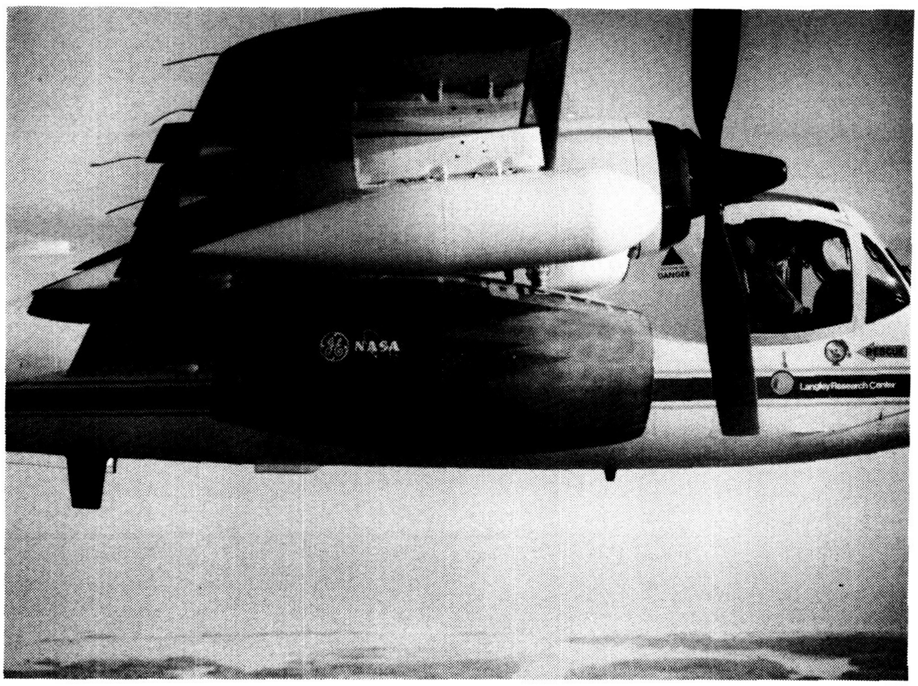
MEASURED TRANSITION LOCATION USING SUBLIMATING CHEMICALS

The boundary-layer transition location was measured on nacelle shape GE2 using the sublimating chemical flow visualization technique. This technique involves coating the surface with a thin film of volatile chemical solid, which, during exposure to free-stream airflow, rapidly sublimates in the turbulent boundary layer as a result of high shear stress and high mass transfer near the surface. Transition is indicated because the chemical coating remains relatively unaffected in the laminar region due to lower shear and low mass transfer (Reference 1). The slow response time of the chemical in a laminar boundary layer allowed for two test conditions during the same flight. The aircraft was first flown at the desired airspeed and altitude with the noise source off. Once a pattern had developed, the noise source was turned on to the desired setting and a new chemical pattern was sought. In this fashion a direct comparison of the effect of the noise could be determined.

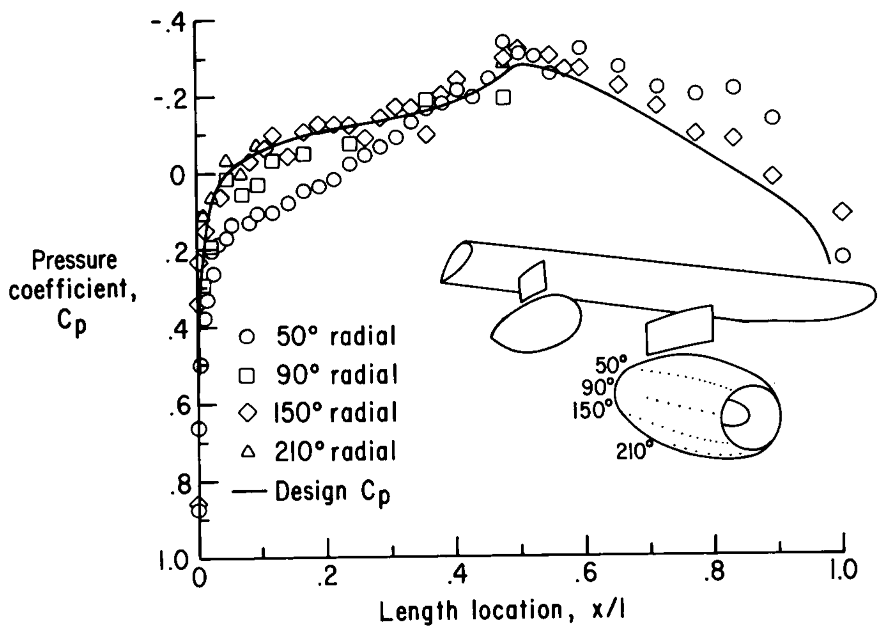
The photograph shows a chemical pattern for test conditions of V = 163 knots, h = 1300 ft, $R = 1.8 \times 10^6$ ft^{-1}, and M = 0.25. The transition location occured at 50% of the nacelle length along the forebody to afterbody joint, which had a significantly high aft-facing step to cause the premature transition. Turbulent wedges caused by dirt particles are evident on the forebody. The same flight conditions were held after the noise source was set to 1500 Hz and 80 volts (132 dB). No effect of this added disturbance could be visualized in the sublimating chemical pattern. In addition, other noise source settings showed no effect on the transition location.



MEASURED PRESSURE DISTRIBUTION

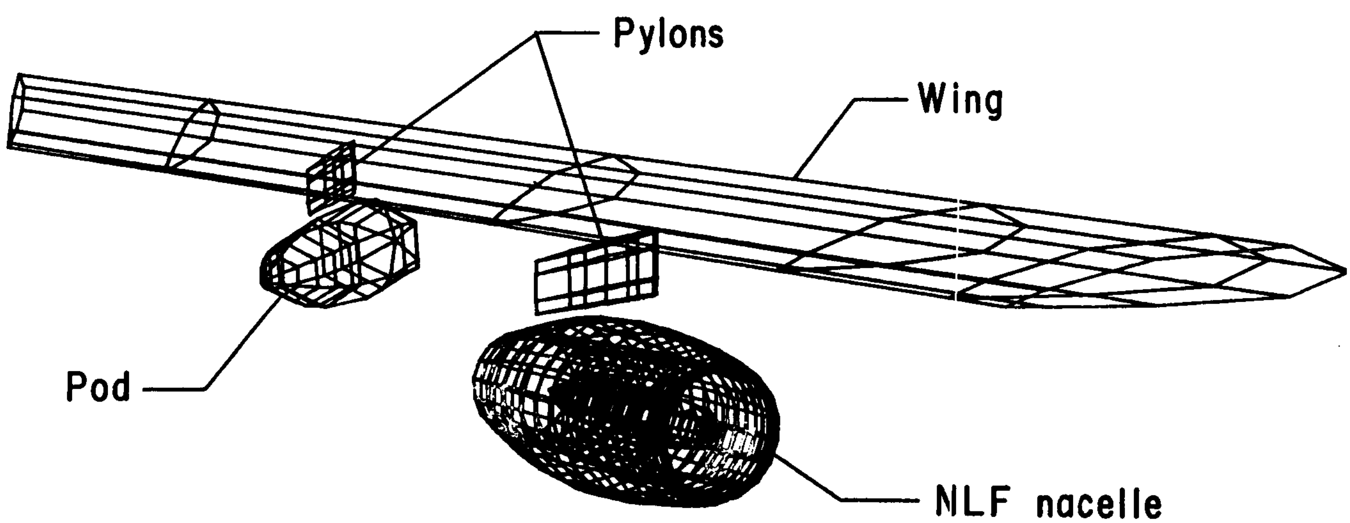
The surface pressure distribution was measured under the same flight conditions as those flown for the flow visualization tests (V = 163 knots, h = 1300 ft, R = 1.8×10^{6} ft^{-1}, and M = 0.25). There are 4 radial rows of pressure ports of which 2 have 60 pressure ports each (50° and 150°), while the remaining rows have 10 each (90° and 210°). Early flight tests attempted to match the measured pressure distributions with the desired pressure distribution as determined during the nacelle design process. Although an exact match was not made, the pressure gradients were kept similar, forsaking a uniform flow over the entire nacelle surface.

The measured distribution is shown in the diagram along with the design pressure distribution. The pressures remain favorable up to 50% length location over the entire surface. The pressure distribution for the 50° row has a steeper gradient probably caused by the proximity to the wing. Within the region of primary interest (90° to 150° radially) the measured pressure distribution agrees fairly well with the design distribution. It was decided that this distribution would provide the best response to any acoustic disturbance that might alter the location of boundary-layer transition.



COMPUTATIONAL PANEL GEOMETRY FOR OV-1 AIRCRAFT WITH NLF NACELLE

Pressure distributions for the NLF nacelle shape GE2 were calculated for the same flight conditions. The predictions were made using a low-order surface-panel method (Reference 2). The method is based on piecewise constant doublet and source singularities, and can take into account the effects of compressibility. Using this three-dimensional surface-panel code, the nacelle, instrument pod, support pylons, and wing were modeled as shown in the diagram. The wake from the configuration was also modeled using the panel code, but is omitted in the diagram for the sake of clarity. The wing was modeled by using 8 panels in the chordwise direction (upper and lower surface combined) and 8 panels in the spanwise direction. The pylons were modeled by 12 lengthwise (left and right surface) and 5 vertical panels. As many contour details as possible were retained in the model of the nacelle, including the flow-through feature of the nacelle. More panels were used on the nacelle surface than on the wing to obtain detailed aerodynamic pressures and boundary-layer flow characteristics. The nacelle was modeled by 22 panels characteristics along the length (inner and outer surfaces) and 25 circumferential panels. The centerbody was modeled by 14 panels along its length and 8 panels circumferentially.



PREDICTED PRESSURE DISTRIBUTION

The predicted pressure distribution is presented in this figure for the 90° and 150° radial rows. A comparison is made to the previously presented measured pressure distributions. The data show that for the two rows the agreement between the measured and predicted pressures is reasonable in terms of the pressure gradient; however, the magnitude differs somewhat. This difference is most dramatic beyond about 35% of the nacelle length.

The panel code of Reference 2 has an additional capability of computing the boundary-layer development using integral methods. Therefore, this method was also able to predict boundary-layer transition location on the nacelle surface (using the Granville transition criterion). Transition is predicted to occur at 61% of the nacelle length for both the 90° and 150° radial rows. Since the measured transition location on shape GE2 occurred at the forebody to afterbody joint (50% of the length), it can be speculated that the predicted transition location would have agreed well with the natural transition location flight.