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NORFOLK, VIRGINIA

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FLEXSTAB ANALYSIS

By

Harold E. Lowder, Jr.

Principal Investigator: Earl A. Thornton

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Final Report of Supplement A Task Under
Grant NSG 1093 (Thermal Structural Analysis of SCRAMJET Structures)
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SUMMARY

Two studies have been conducted using FLEXSTAB to predict the wing differential pressure distributions of two vehicles. Three space shuttle configurations were investigated. Comparisons were made of wind tunnel and analytical data for a selected range of angle of attack, angle of sideslip, and Mach number. A report was initiated that assesses FLEXSTAB's capability for these selected cases. Finally, a drone-type vehicle was investigated and comparisons were made between flight and analytical data of wing pressure distributions and static longitudinal stability derivatives.

INTRODUCTION

In the December 1974 to June 1975 period, the investigator was engaged in familiarization and direct application of the FLEXSTAB computer program. Developed under contract for NASA, FLEXSTAB (ref. 1) is a major tool for stability and loads analyses of flexible flight vehicles. As a means of assessing this program's capability to predict wing pressure distributions, two flight vehicles were selected for which wind tunnel or flight data were available for comparison.

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FLEXSTAB STUDIES

The vehicle used in the first study was the space shuttle. Three shuttle configurations were investigated: (1) the orbiter, (2) the orbiter and external tank, and (3) the orbiter, external tank and two solid rocket boosters. Figure 1 shows the wind tunnel and analytical models of configuration (3). The predicted differential pressures on the delta wing of the orbiter were compared with wind tunnel data for all configurations. These comparisons covered ranges of angle-of-attack and angle-of-sideslip for five different Mach numbers from $M = .6$ to $M = 1.4$. In addition, results were obtained to determine the effects of fuselage shape and wing parameters such as twist, dihedral, and thickness on the wing pressure distributions. Finally, to assess analytical modelling, the effect of aerodynamic panel density in the chordwise and spanwise directions was studied. The results of this study are being incorporated into a proposed NASA Technical Memorandum. Some typical results are presented in figure 2. Angle-of-attack and angle-of-sideslip pressure data for two Mach numbers (.6 and 1.4) are shown for a particular spanwise station.

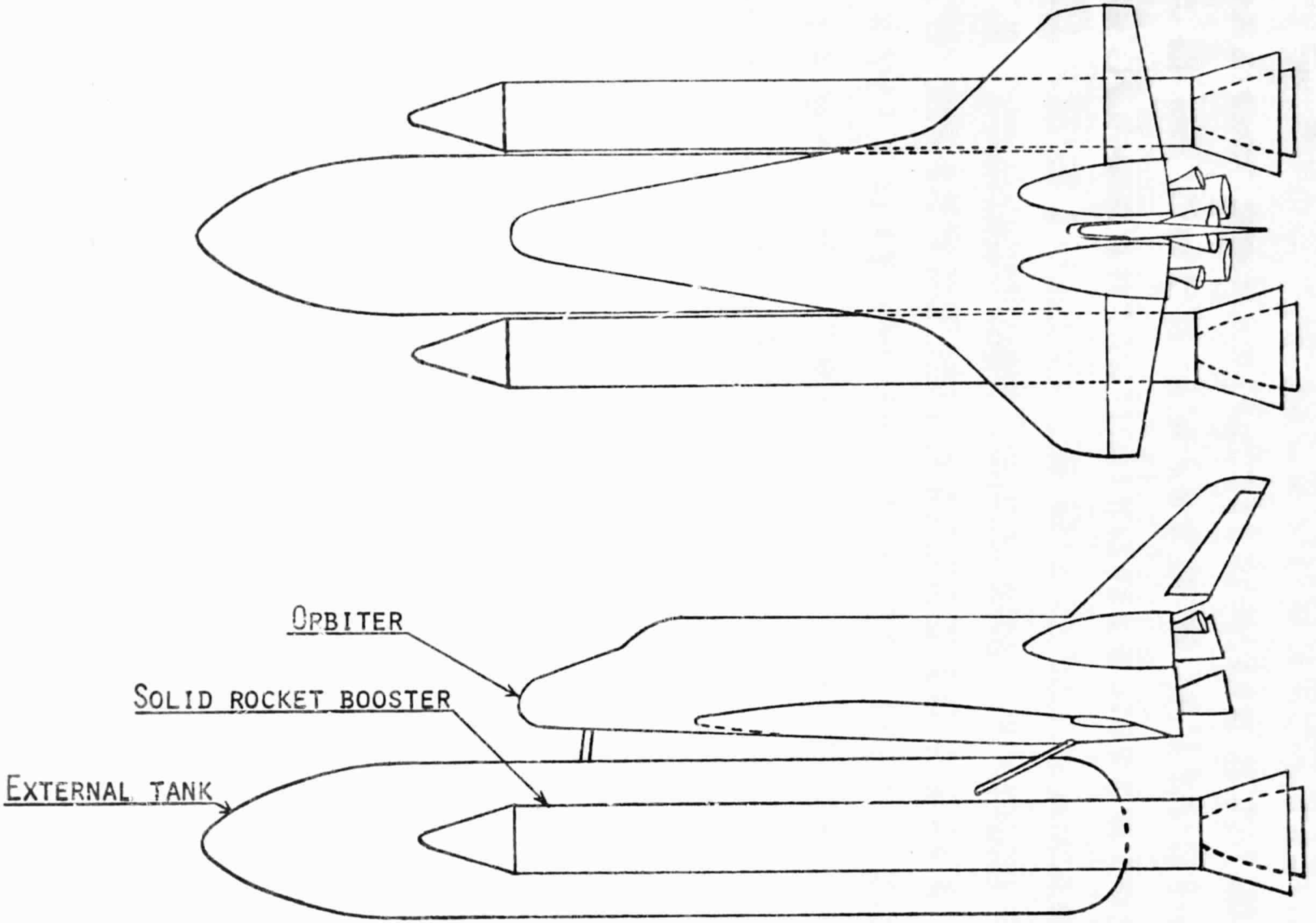
In addition to this study, a preliminary evaluation was made for a drone-type vehicle. This analytical effort was in conjunction with an existing flight and wind tunnel test program. In this two-phase program the drone vehicle will be used as a test bed for two different wing configurations. These are a low aspect ratio swept wing (phase 1) and a high aspect ratio flexible supercritical research wing (phase 2). Figures 3a and 3c show the flight configurations for both phases. In addition, the analytical model is presented in figure 3b for the low aspect ratio wing configuration. In evaluating the phase 1 configuration flexibility effects were not considered because of the wing's structural rigidity. Flight and analytical pressure distributions were obtained. Data used for comparison were the wing differential pressure distributions and the static longitudinal stability derivative. Pressure data for a particular angle-of-attack are shown in figure 4 for two Mach numbers. Figure 5 shows a comparison of lift curve slope stability data for a range of Mach numbers. For the elastic supercritical wing analysis, preparations were made to develop a finite element structural model using the ATLAS (ref. 3) structures program. ATLAS can be interfaced with FLEXSTAB to provide a detailed analysis of flexibility effects on stability derivatives and wing loads.

REFERENCES

1. The Boeing Company: A Method for Predicting the Stability Characteristics of an Elastic Airplane - Volume II, FLEXSTAB Users Manual 1.02.00, NASA CR-114713, October 1974.

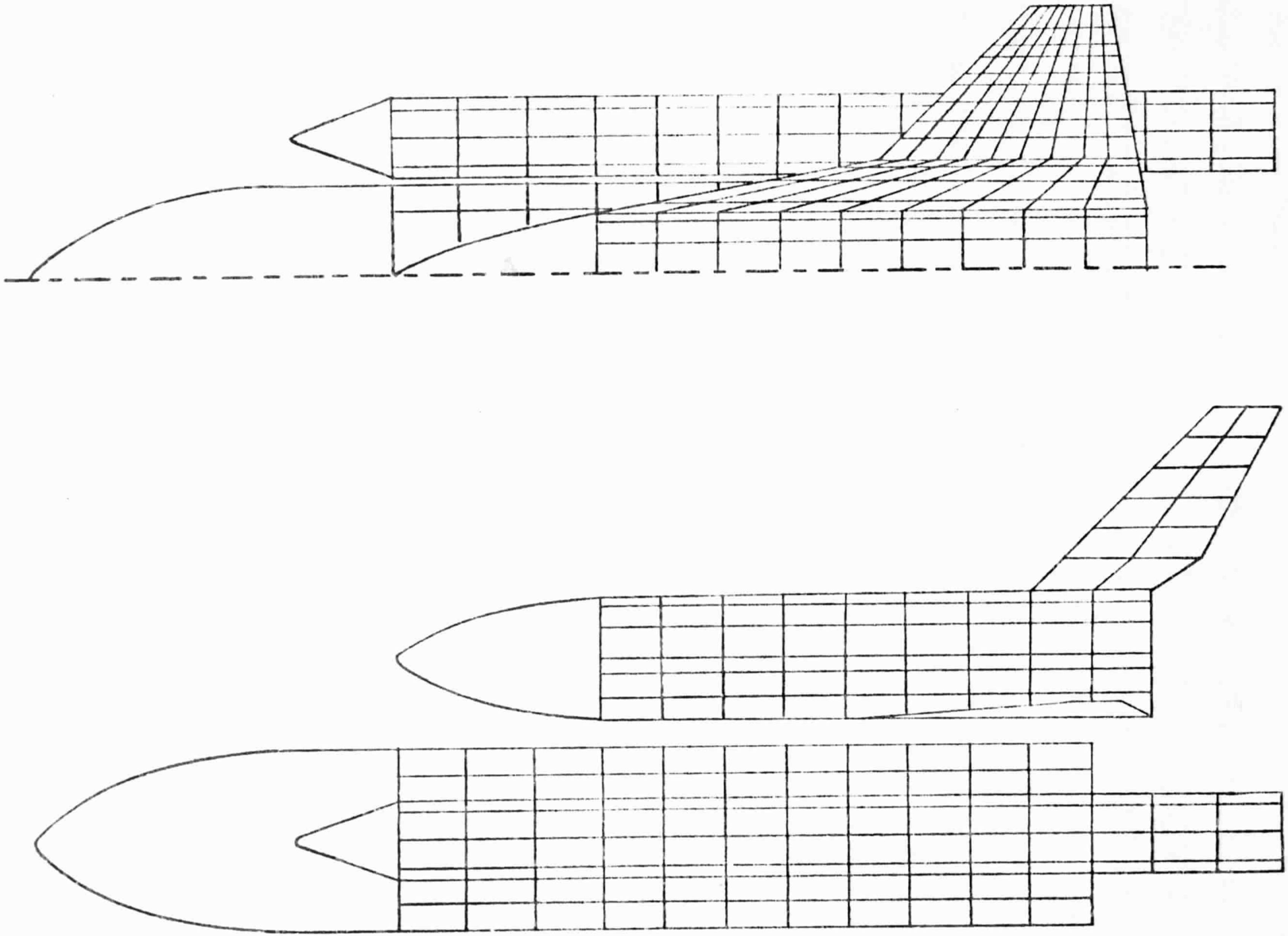
2. Parks, W.C., and Riley, T.V.: Stability and Control Report for BQM-34E, Supersonic Aerial Drone, Report No. TRA 16654-1C, August 18, 1970.

3. The Boeing Company: ATLAS - An Integrated Structural Analysis and Design System, Users Manual 3.0, Document No. D6-25400-0003 TN, January 1975.



(a) Wind tunnel model

Figure 1. Space shuttle configuration.



(b) FLEXSTAB analytical model

Figure 1. Continued.

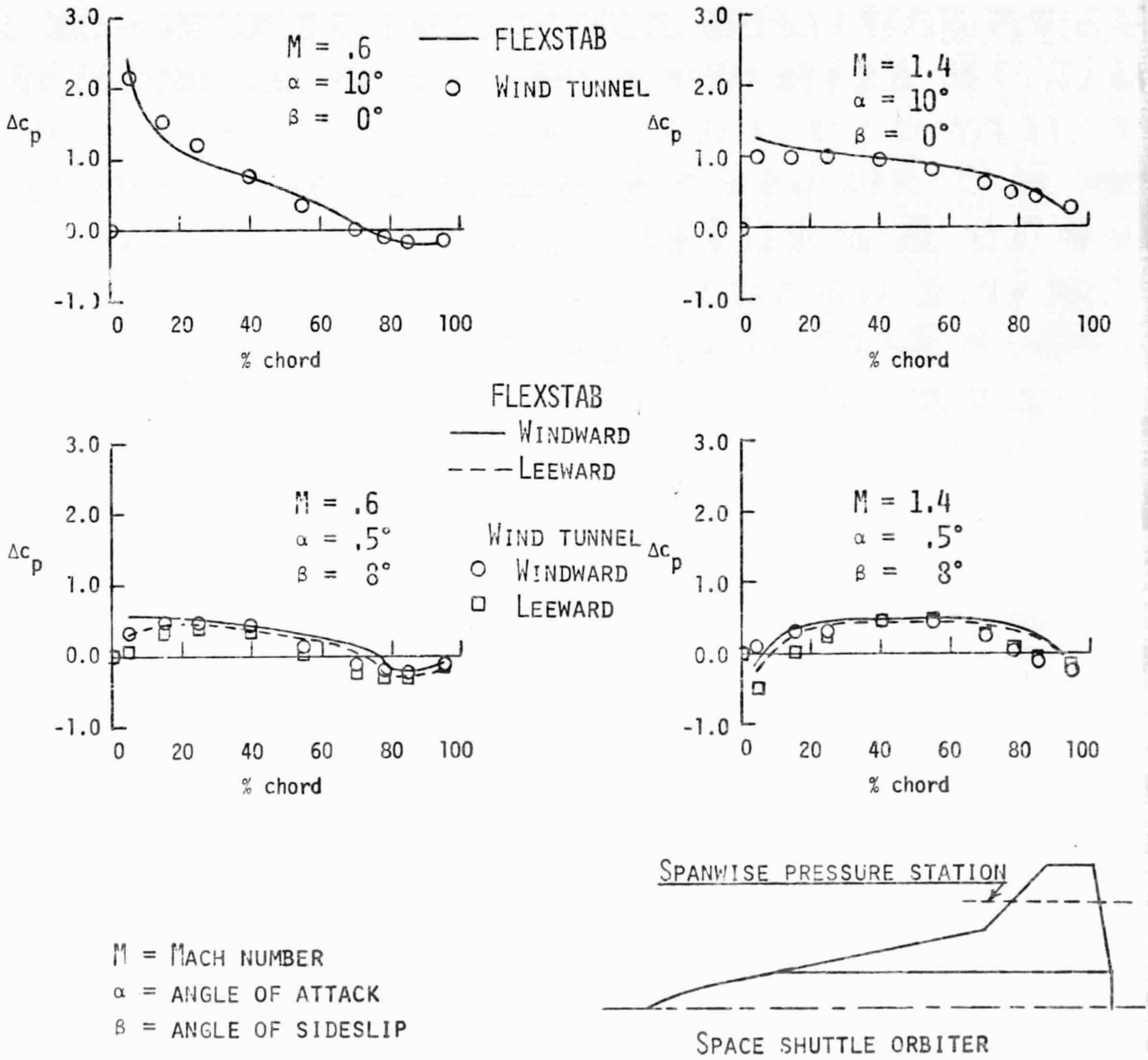
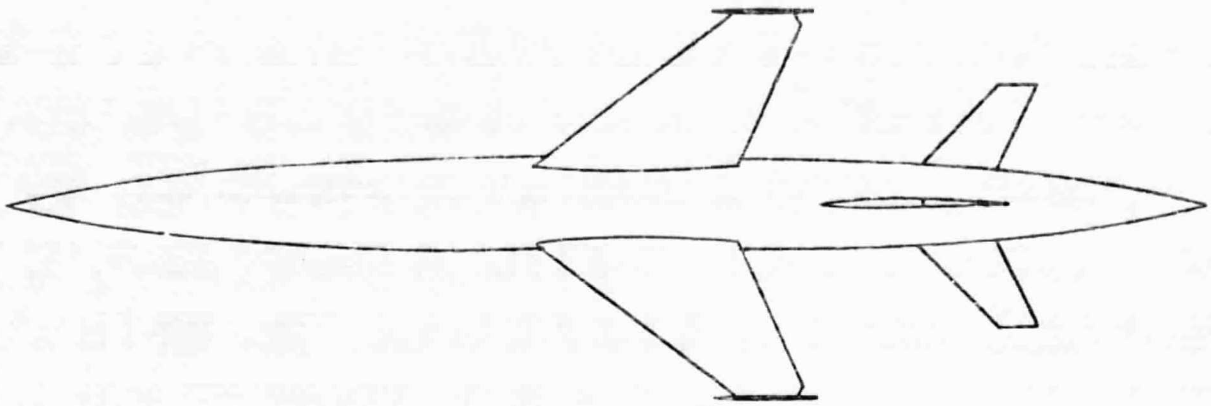
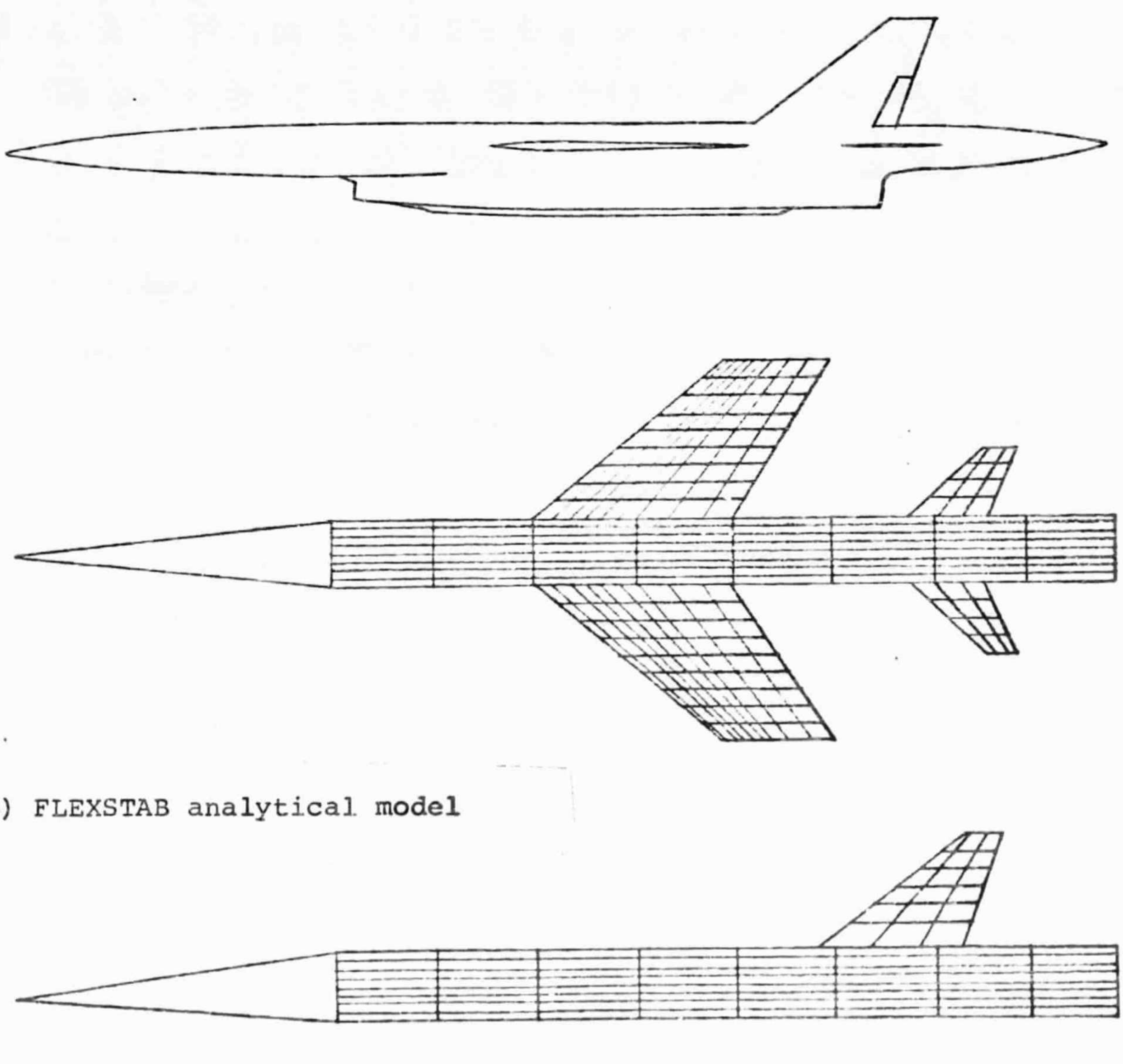


Figure 2. Comparison of FLEXSTAB predictions and wind tunnel measurements of space shuttle orbiter pressure distributions.

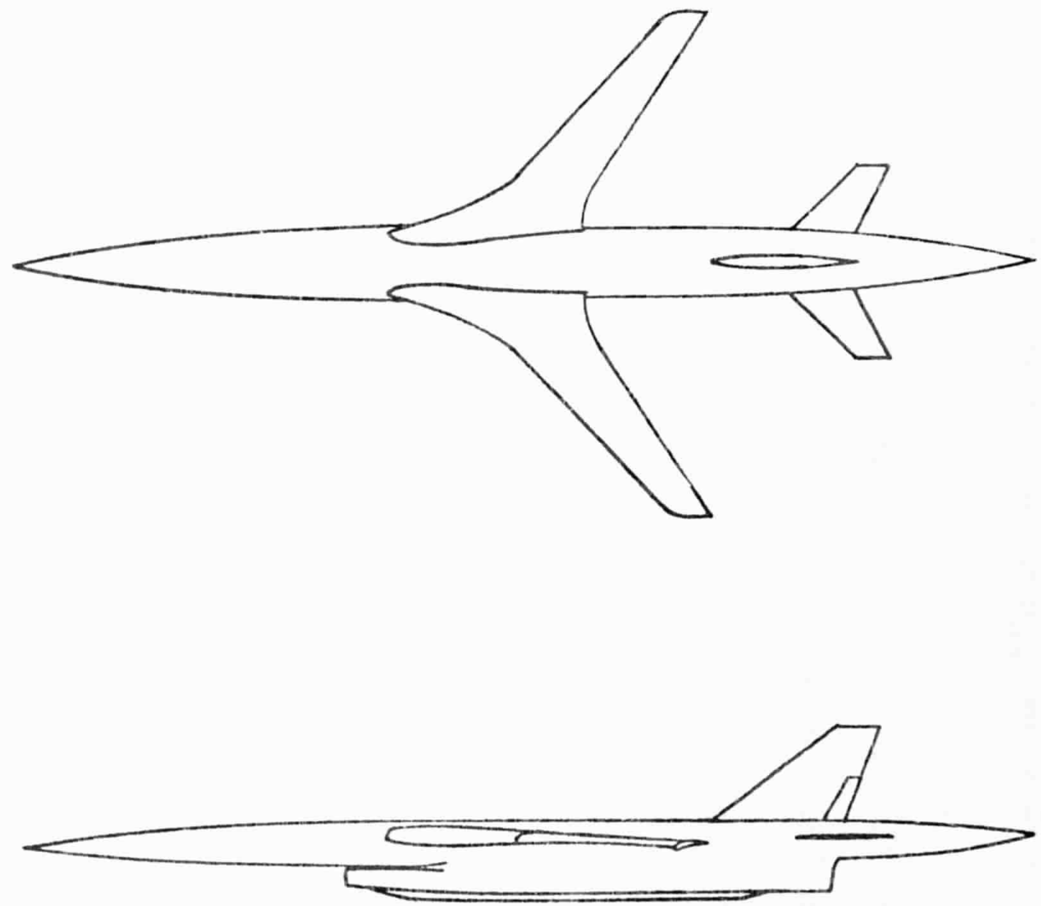


(a) Drone flight vehicle with low aspect ratio swept wing



(b) FLEXSTAB analytical model

Figure 3. Drone flight and analytical configurations.



(c) Drone flight vehicle with supercritical research wing

Figure 3. Continued.

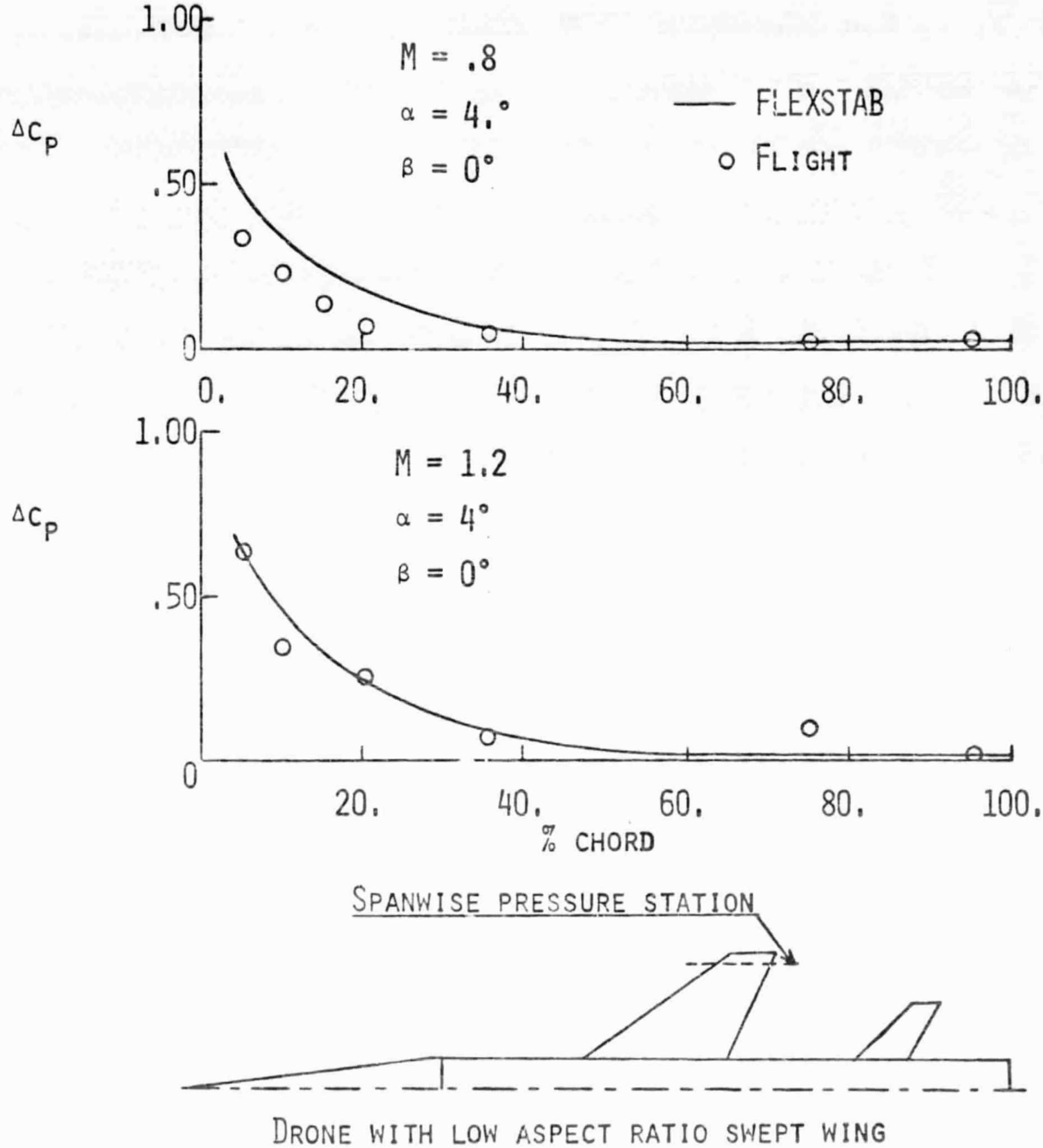


Figure 4. FLEXSTAB predictions compared with measured drone flight vehicle pressure distributions.

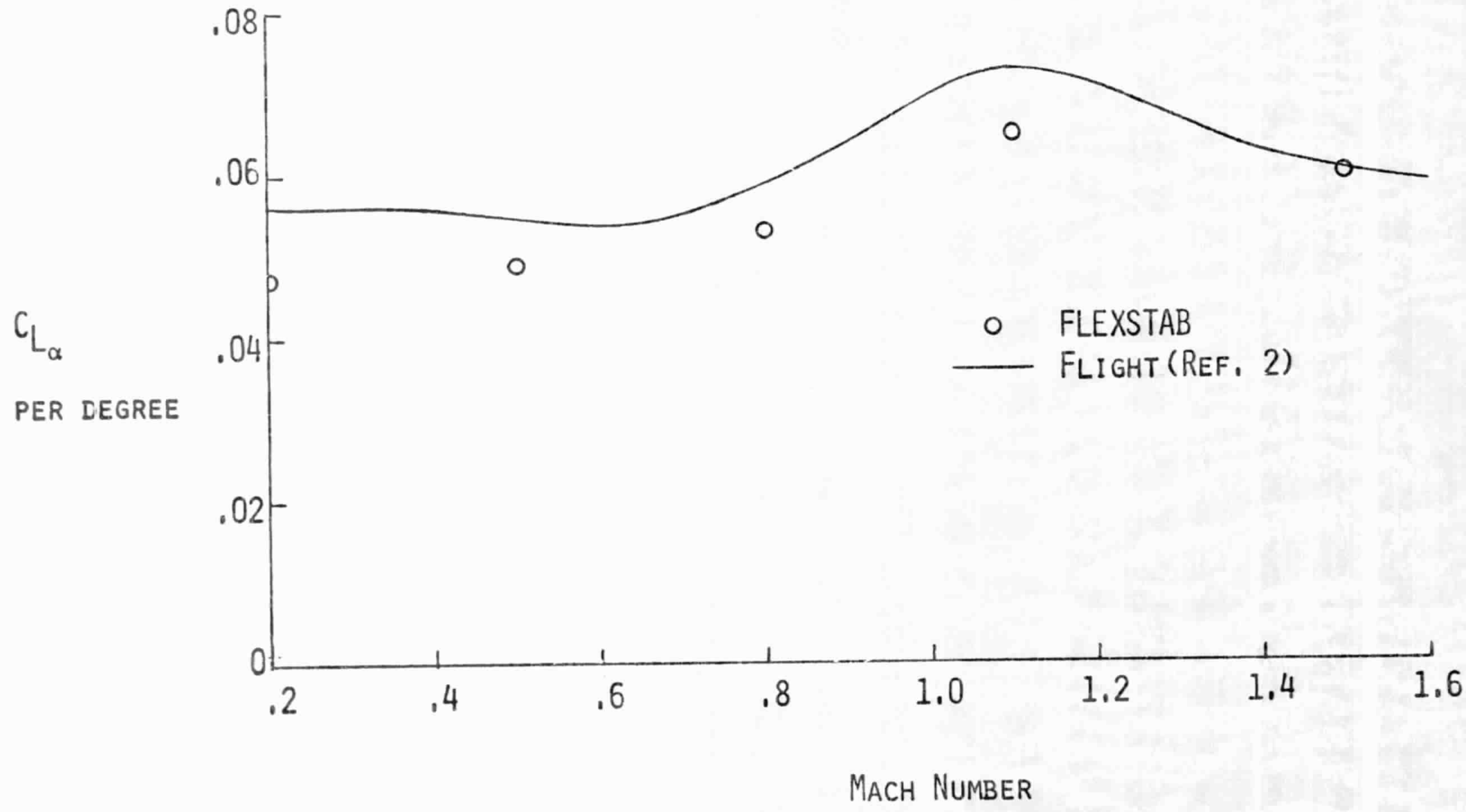


Figure 5. FLEXSTAB predictions compared with measured drone flight vehicle stability derivative (C_{L_α}).