PRELIMINARY EFFORTS TOWARD DEVELOPMENT OF DATA HANDLING AND ANALYSIS SOFTWARE FOR UNSTEADY FLOW MEASUREMENTS: AN APPLICATION FOR AEROELASTIC TRANSONIC FLOW CONFIGURATIONS

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by

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A few years ago the Structural Dynamics Division at LaRC started ambitious experimental research efforts known as the Benchmark Models Program. The primary objective of this program was to provide experimental data that may serve as a calibration source for CFD efforts that deals with aeroelastic unsteady flow configuration. It also focuses on the understanding of complex flow phenomenon associated with unsteady flow developments. The overall plan for the program has been described by Bennett, et al. (1991), including a presentation of initial test results of flutter of a rigid wing mounted on flexible supports. Figure (1), shows an example of a test model employed to measure the dynamic response along with corresponding pressure distributions. This model incorporates eighty pressure transducers distributed along two spanwise stations. In addition, the models are equipped with four accelerometers and two strain gages. Additional results of testing on this model are reported by Rivera, et al. (1991).

Comments on the Flow Problem

The complexity of unsteady flow developments and the large associated parameter space imposes severe limitations on most research efforts. As sketched in Figure (2), unsteady aeroelastic flow configurations may encounter a wide range of complex flow developments such as boundary layer separation and transition, vortex developments & interaction, and shock wave formations & oscillations. The recent research efforts and limitations are reviewed by Edward and Malone (1991). In addition to the complexity of flow developments, the large parameter space of the flow problem limited even ambitious research programs to spot investigations. The efforts of the Benchmark Models Program are aimed toward minimizing these limitations by performing quantitative and qualitative parametric studies. However, this type of experimentation leads to acquiring large data sets that demand development of a specialized data handling and analysis system. The purpose of such a system is to provide a reliable tool designed specifically for data gathering, reduction, storing, and analysis for unsteady flow measurements. The development of such a system is essential in providing an adequate environment for performing parametric analysis that surveys the dependence of the main parameters of the flow problem.

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Present Effort and Sample Results

The data handling system for the Benchmark Model Program is currently under development. As a part of these efforts, a preliminary effort toward the development of such a system was conducted. Several interactive computer routines designed for user interface, dynamic memory allocation, unsteady flow measurements data extraction, and further data processing were developed. As shown in Figure (3), based on a specified user input, a main driver can activate several utilities designed to extract experimental measurements and perform requested analysis. These utilities were written in the C programming language for the UNIX environment. Two-dimensional and three-dimensional Fortran plotting routines, developed initially by Bland (1992), were modified and integrated into the developed package.

The developed software was tested by using several data files for the 0012 Benchmark model. To present a few examples of measured data, the unsteady pressure distributions and the wing model dynamic response were plotted. Figure (4) shows a three-dimensional plot of streamwise unsteady pressure distributions along with a two-dimensional plot showing a movie frame of instantaneous pressure. In Figure (5), the pressures were subtracted from the mean pressure distribution and plotted. Figure (6) shows an example of maximum, minimum, and mean pressure distributions over the wing model upper surface. Figure (7) shows an example of wing vertical and angular amplitudes and their corresponding phase plots. This data was obtained by strain gages that measure the bending and torsion of the flexible apparatus that holds the wing model. It is hoped that this initial effort will be extended to develop the needed interactive software for efficient pre and post data processing and analysis system. This system is a key element to accomplish the objectives of the Benchmark Models Program.

REFERENCES

1. Edwards, J.W., and Malone, J.B., "Current Status of Computational Methods for Transonic Unsteady Aerodynamics and Aeroelastic Applications", NASA TM 104191, January, 1992.

2. Bland, S., Personal Communications, NASA Langley Research Center, July, 1992.

3. Finaish, F., and Johnston, A.P., "Dynamic Response of an Elastically Supported Wing Model in Steady Flow: Numerical Experiments for Undergraduates", International Journal of Mechanical Engineering Education, Vol. 20, No. 1, 1992.

4. Bennett, R.M., Eckstorm, C.V., Rivera, J.A., Jr., Dansberry, B.E., Farmer, M.G. and Durham, H.M., "The Benchmark Aeroelastic Models Program-Description and Highlights of Initial Results", Paper No. 25, AGARD Specialists Meeting on Transonic Unsteady Aerodynamics and Aeroelasticity, San Diego, CA, 1991.

5. Rivera, J.A., Jr., Dansberry, B.E., Farmer, M.G., Eckstorm, C. V., Seidel, D.A., and Bennet, R.M., "Experimental Flutter Boundaries with Unsteady Pressure Distributions for the NACA 0012 Benchmark Model", AIAA Paper No. 91-1010, April 1991.

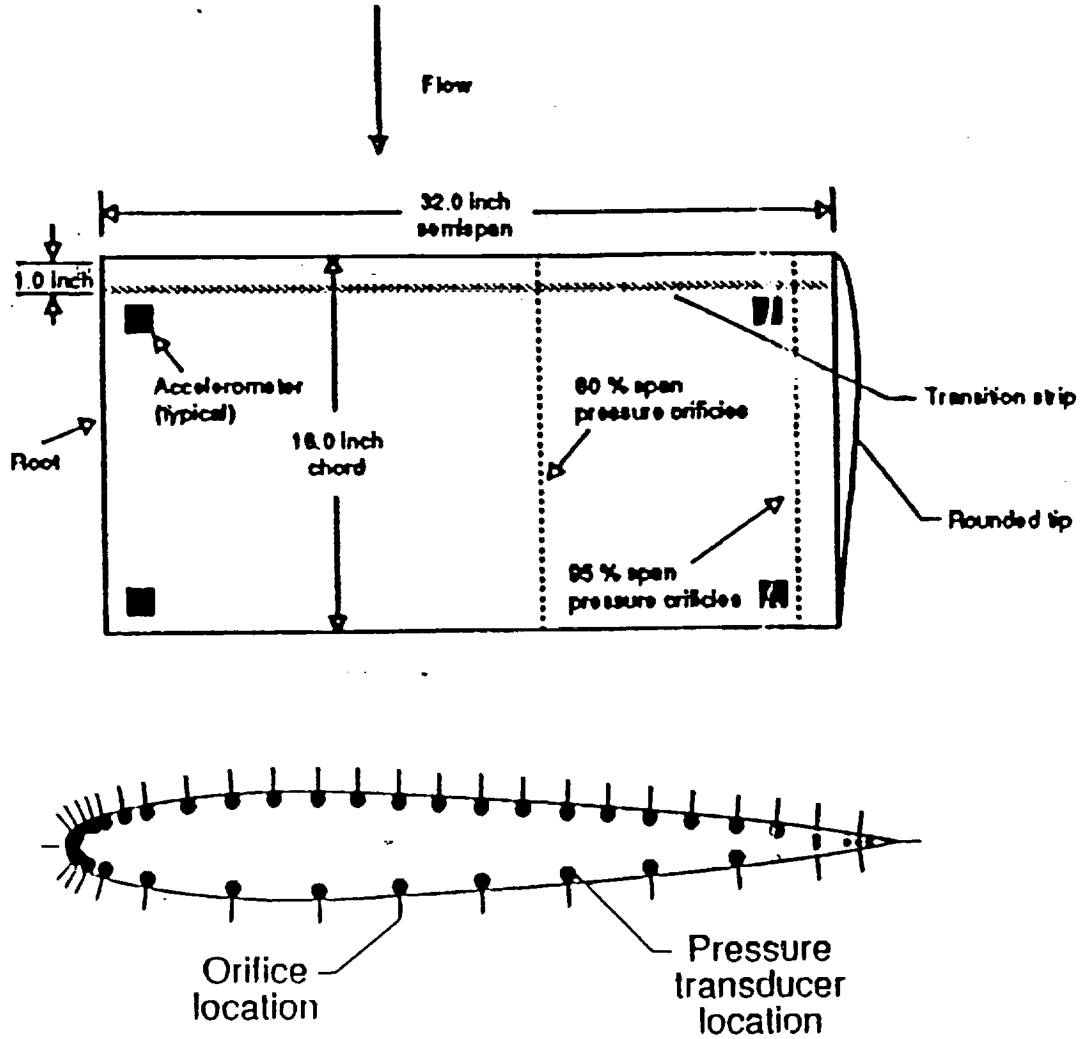

Figure 1. An example of a test model used in the Benchmark Models Program. (Taken from Ref. 4)

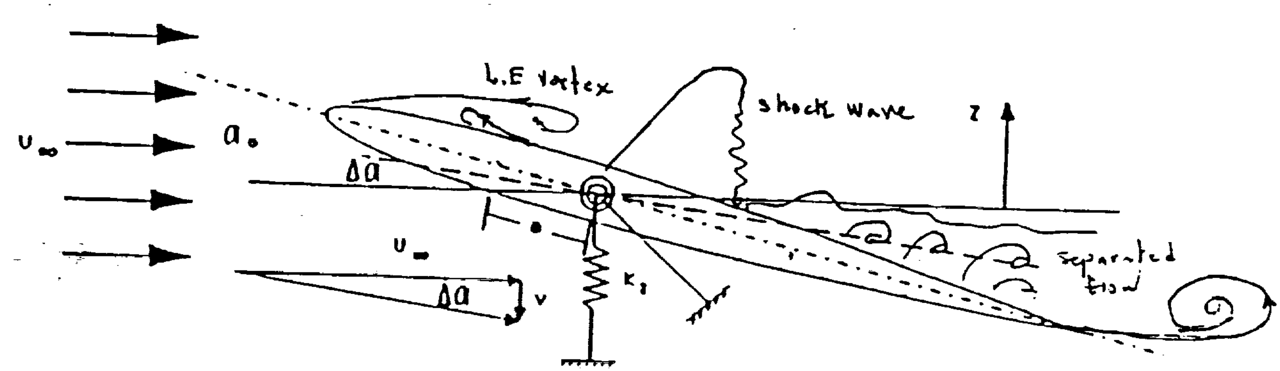

Figure 2. Schmatic of a wing model mounted on elastic supports (Taken from Ref. 3)

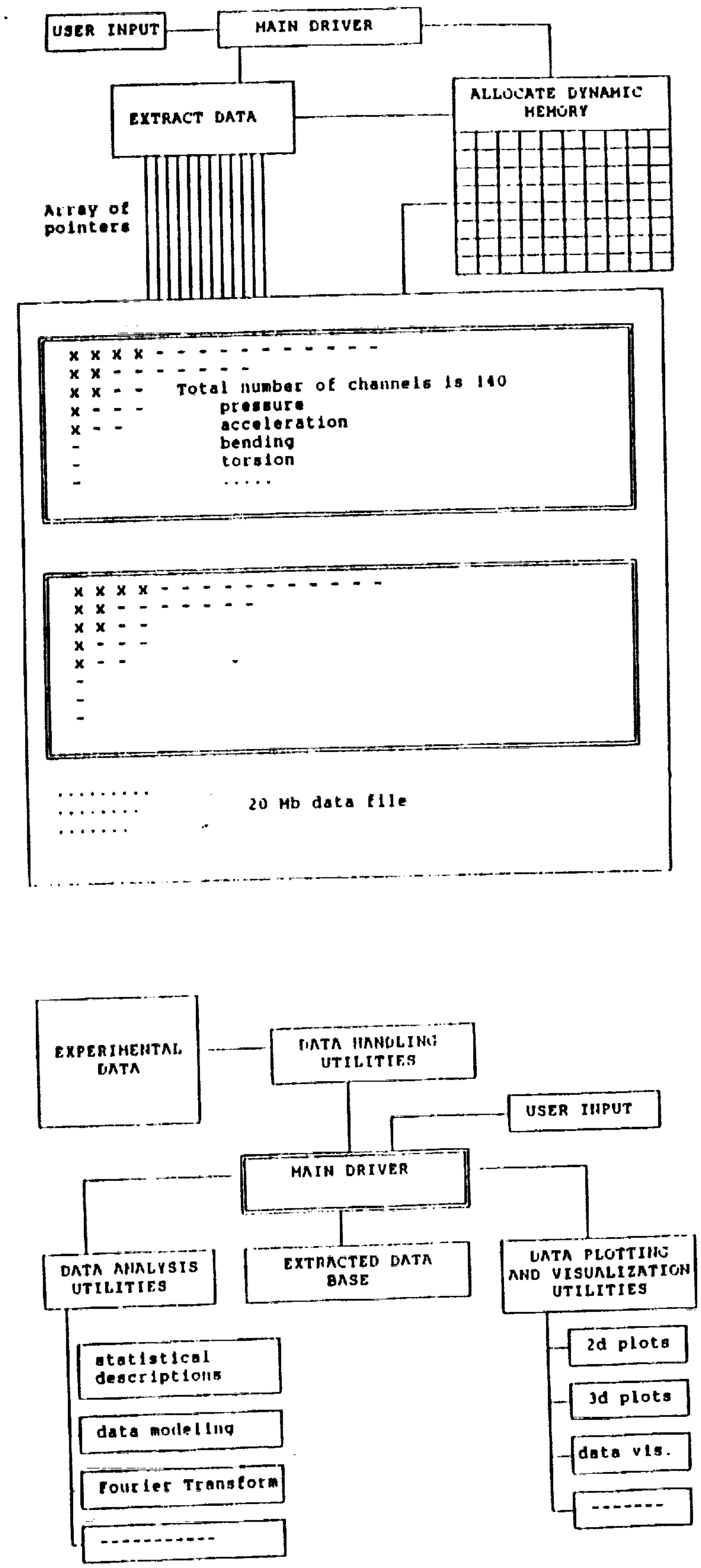

Figure 3. A schematic of developed data handling and analysis setup

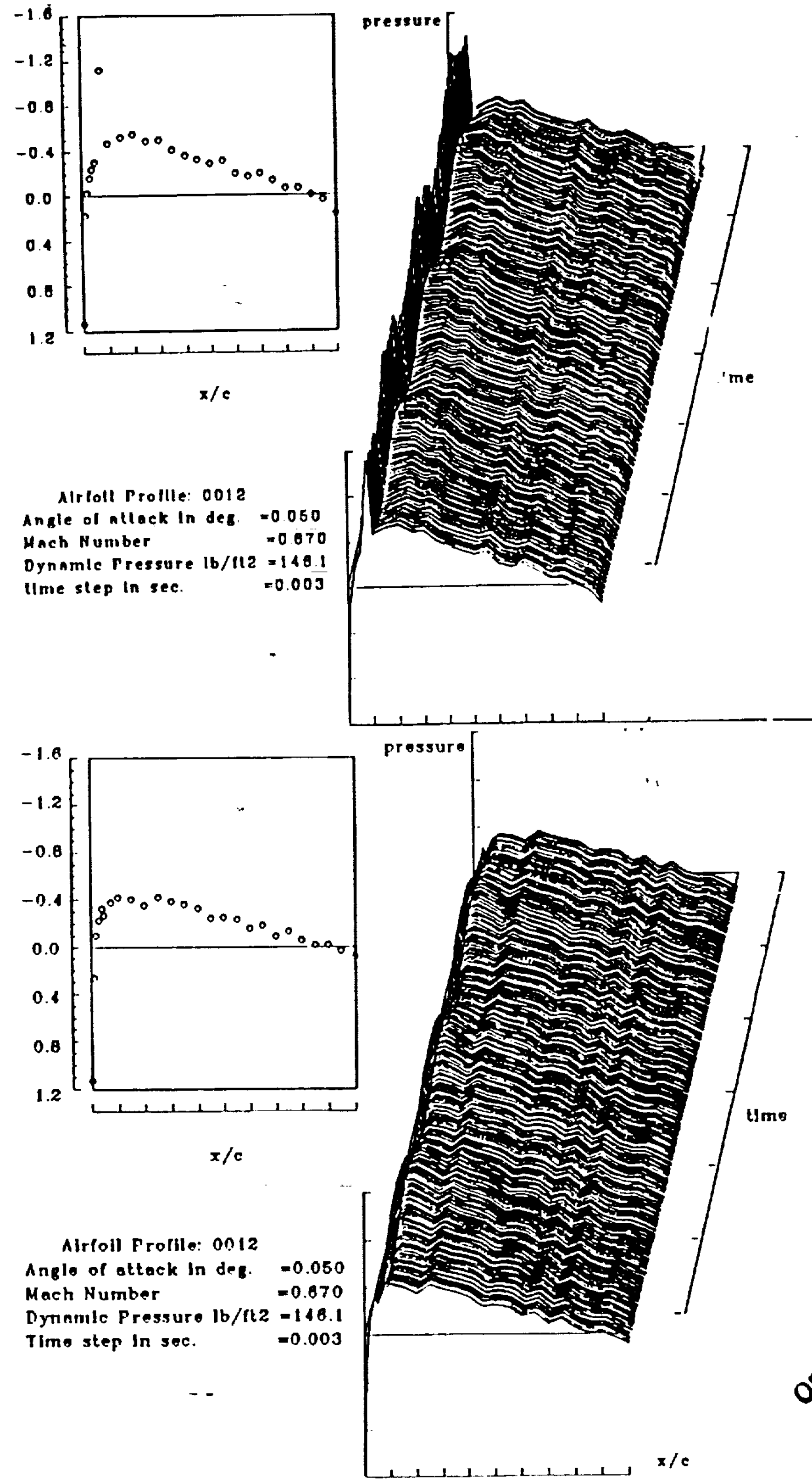

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Figure 4. An example of streamwise unsteady pressure distribution over the wing model upper surface.
(Top: along 60% span, Bottom: along 95% span)

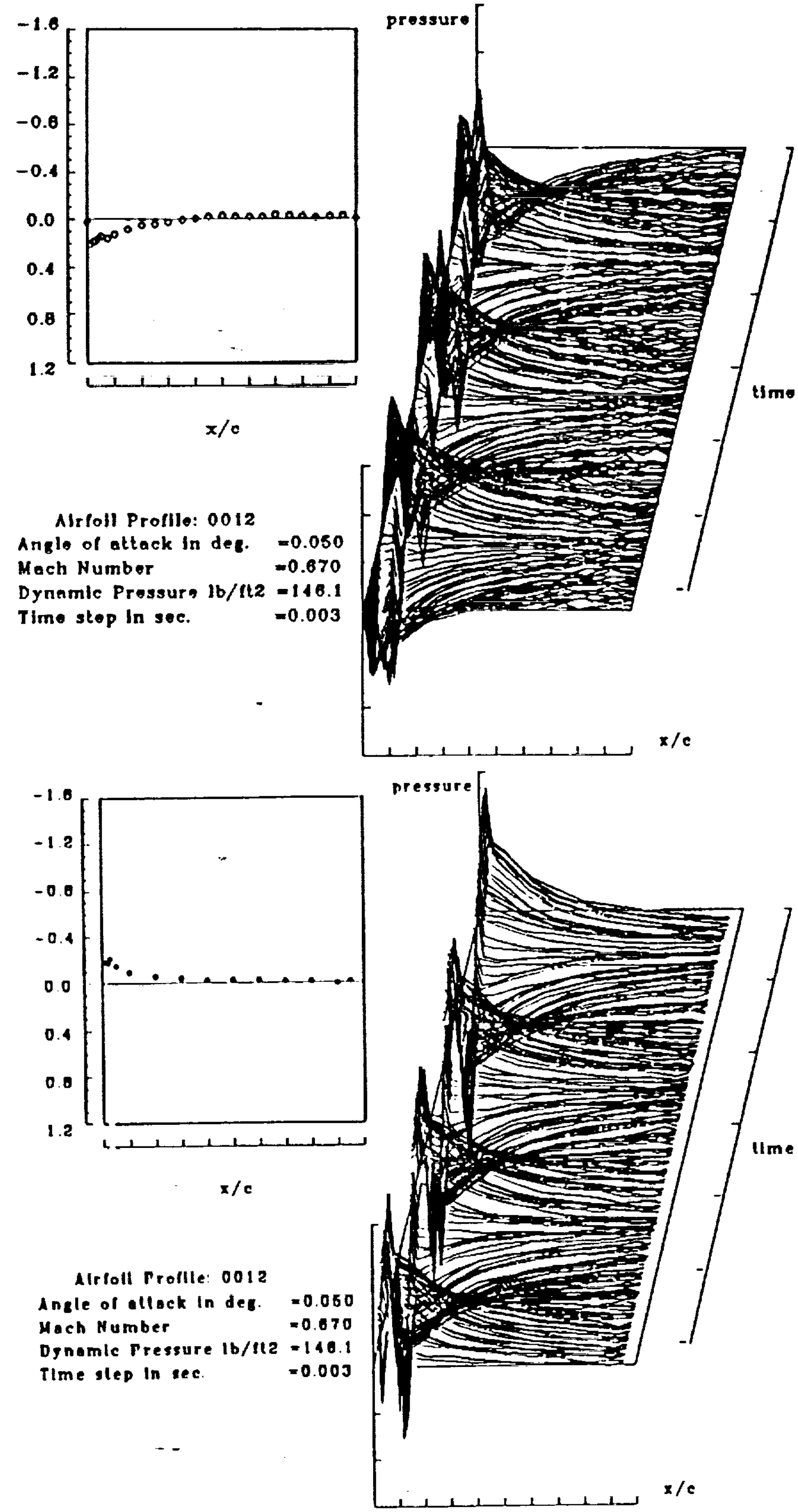
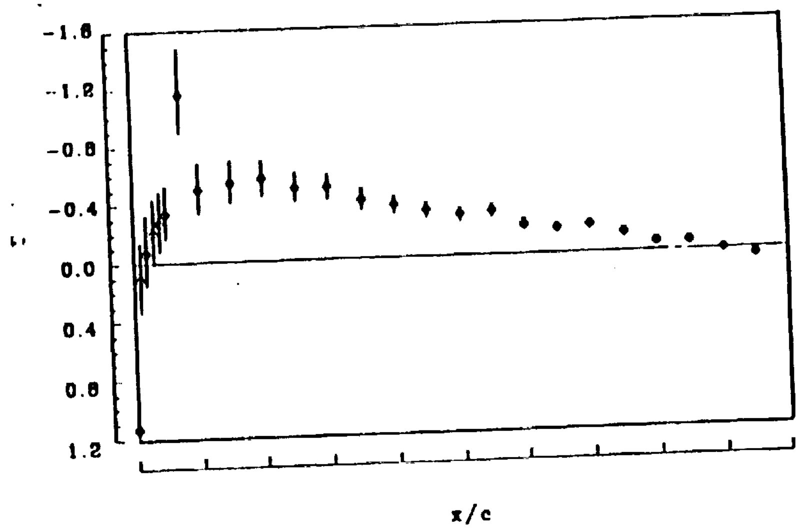
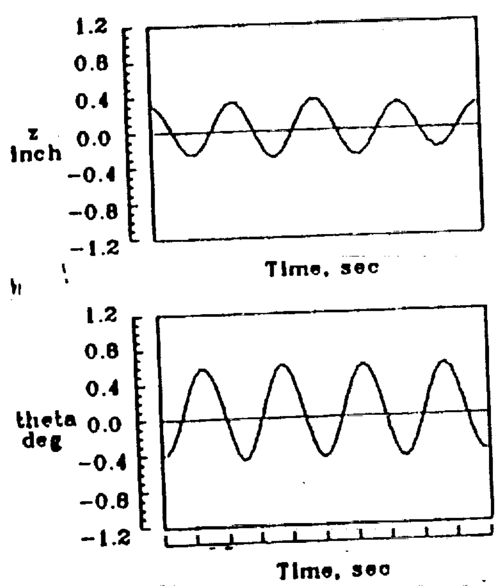


Figure 5. An example shows pressure distribution subtracted from mean pressure
(Top:upper surface, Bottom:lower surface)



Airfoil Profile: 0012
Angle of attack in deg. =0.050
Mach Number =0.670
Dynamic Pressure lb/ft2 =146.1
Time step in sec. =0.003

Figure 6. An example shows maximum, minimum, and mean pressure distribution over the wing model upper surface.



Angle of attack in deg. =0.050
Mach Number =0.824
Dynamic Pressure lb/ft2 =159.5
Time step in sec. =0.003

Figure 7. An example shows wing model vertical and angular response