Grid Generation and Inviscid Flow Computation About Aircraft Geometries

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Abstract

Grid generation and Euler flow about fighter aircraft are described. A fighter aircraft geometry is specified by an area ruled fuselage with an internal duct, cranked delta wing or strake/wing combinations, canard and/or horizontal tail surfaces, and vertical tail surfaces. The initial step before grid generation and flow computation is the determination of a suitable grid topology. The external grid topology that has been applied is called a dual-block topology which is a patched C^1 continuous multiple-block system where, inner blocks cover the highly-swept part of a cranked wing or strake, rearward inner-part of the wing, and tail components. Outer-blocks cover the remainder of the fuselage, outer-part of the wing, canards and extended to the far field boundaries. The grid generation is based on transfinite interpolation with Lagrangian blending functions. This procedure has been applied to the Langley experimental fighter configuration and a modified F-18 configuration. Supersonic flow between Mach 1.3 and 2.5 and angles of attack between 0° and 10° have been computed with associated Euler solvers based on the finite-volume approach. When coupling geometric details such as boundary layer diverter regions, duct regions with inlets and outlets, or slots with the general external grid, imposing C^1 continuity can be extremely tedious. The approach taken here is to patch blocks together at common interfaces where there is no grid continuity, but enforce conservation in the finite-volume solution. The key to this technique is how to obtain the information required for a conservative interface. We have used the **Ramshaw technique** which automates the computation of proportional areas of two overlapping grids on a planar surface and is suitable for coding. We have generated internal duct grids for the Langley experimental fighter configuration independent of the external grid topology, with a conservative interface at the **inlet** and **outlet**.

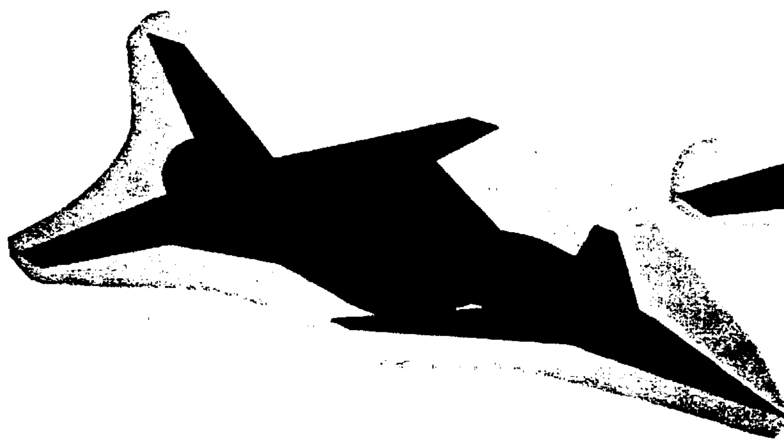
FEATURES

- MULTIPLE-BLOCK STRUCTURED GRIDS
- FINITE-VOLUME EULER SOLVERS
- CONSERVATIVE INTERFACE BETWEEN GRID BLOCKS

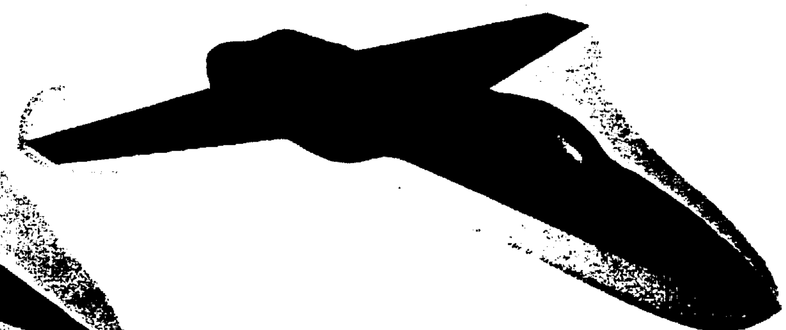
CONTENTS

- FIGHTER CONFIGURATIONS
- BOUNDARY GRIDS
- VOLUME GRID GENERATION
- CONSERVATIVE INTERFACING
- EULER FLOW SOFTWARE AND SOLUTIONS
- VIDEO DISPLAY
- CONCLUSIONS AND COMMENTS

FIGHTER CONFIGURATIONS



EXPERIMENTAL FIGHTER



MODIFIED F-18

BOUNDARY GRIDS

- CONFIGURATION SURFACE

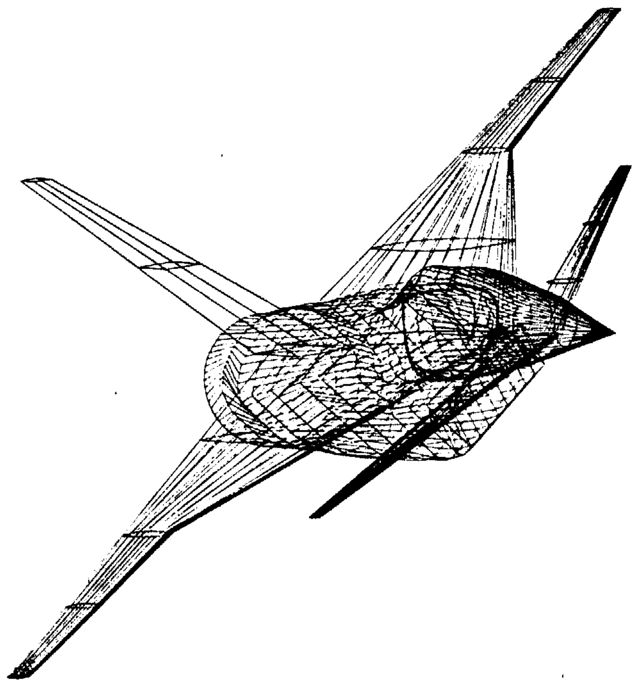
  1. Component Cross Sections
  2. Interpolation, Fitting and Smoothing
  3. Grid Point Distributions

- INTERMEDIATE BOUNDARY SURFACES

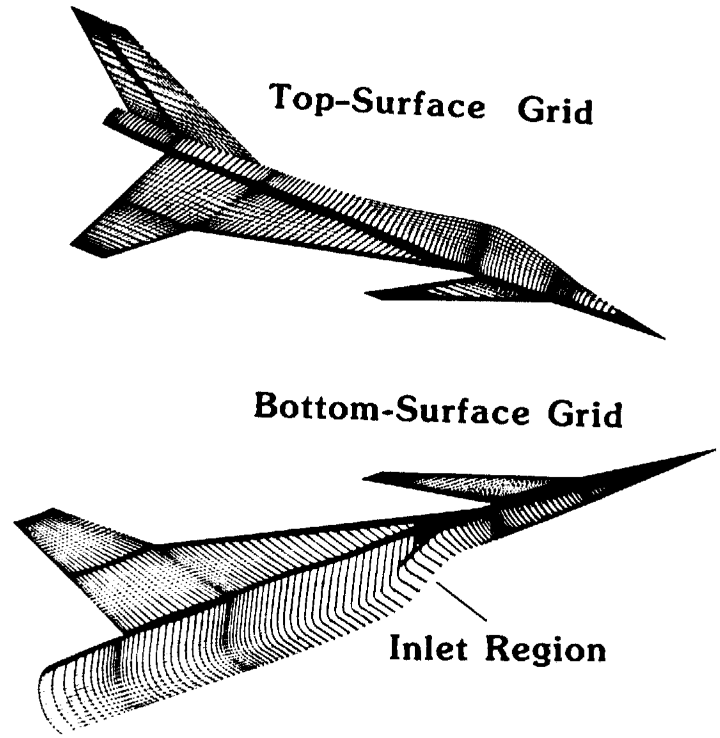
  1. Algebraic Functions
  2. Embedded Grid Point Distributions

- FAR FIELD BOUNDARY SURFACES

BOUNDARY-SURFACE GRIDS



Original Definition



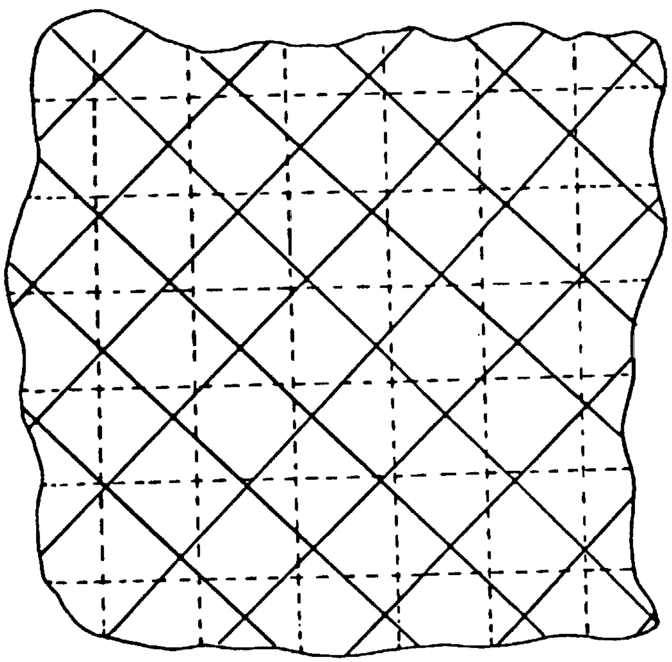
Grid-Surface Definition

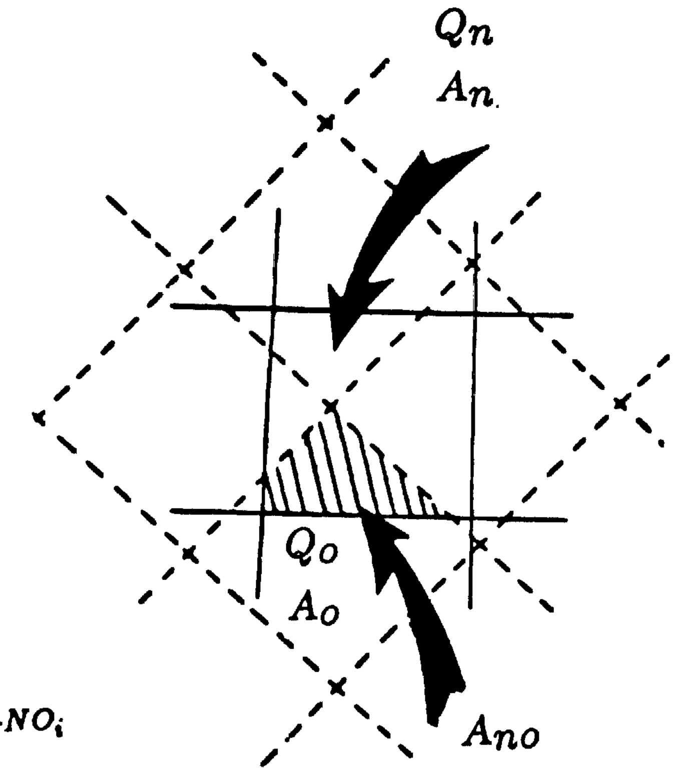
VOLUME GRID GENERATION

- GRID TOPOLOGY
  - * Block Location and Interfaces
- TRANSFINITE INTERPOLATION
  - *Various Interpolation Techniques
- GRID SPACING CONTROL
  - * Exponential Functions

CONSERVATIVE GRID INTERFACES

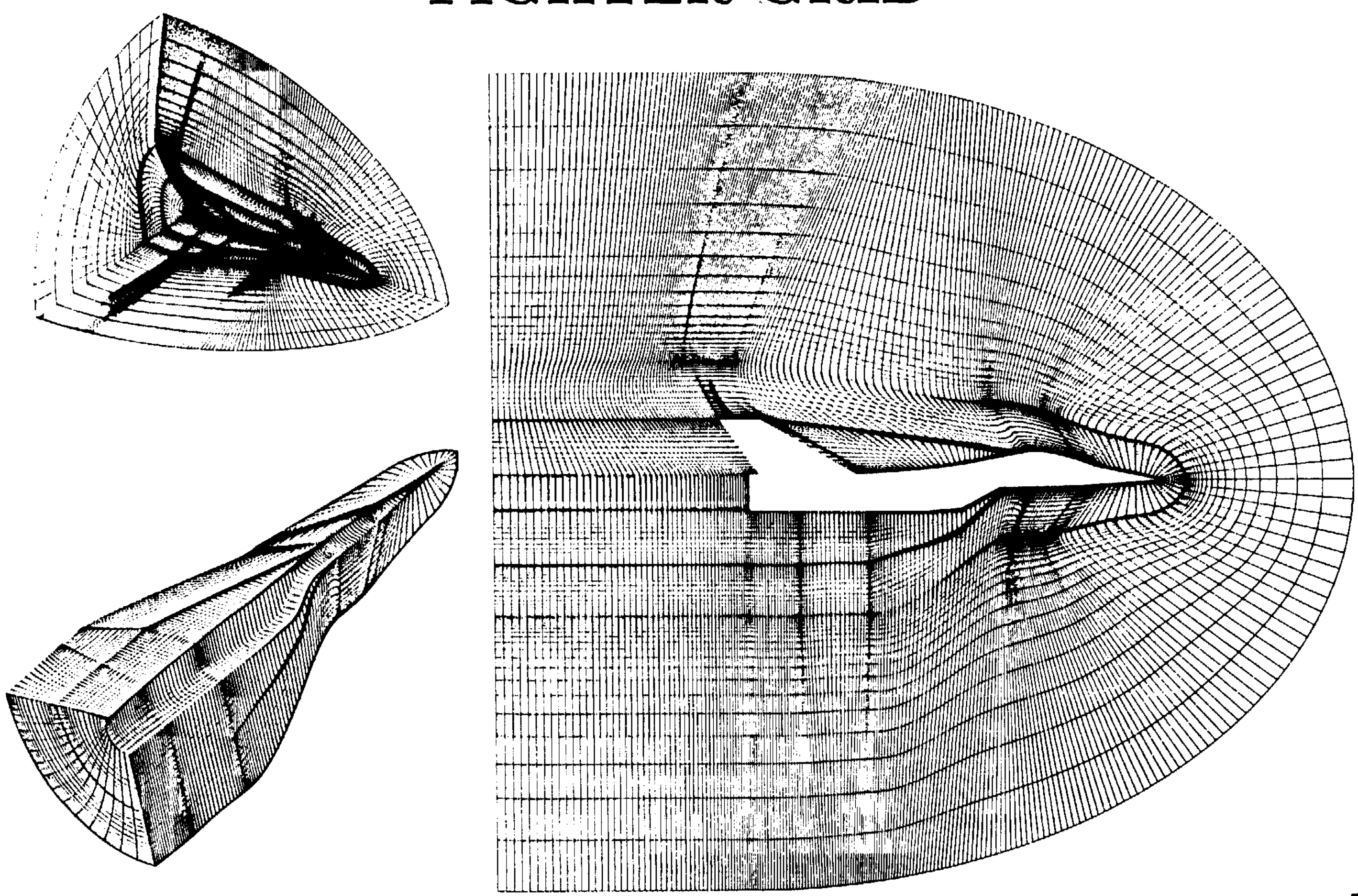
- Rai's Approach
- Ramshaw Redistribution





$$Q_N = \sum_{i=1}^{N_{NO}} Q_{O_i} \frac{A_{NO_i}}{A_{O_i}} = \sum_{i=1}^{N_{NO}} q_{O_i} A_{NO_i}$$

FIGHTER GRID

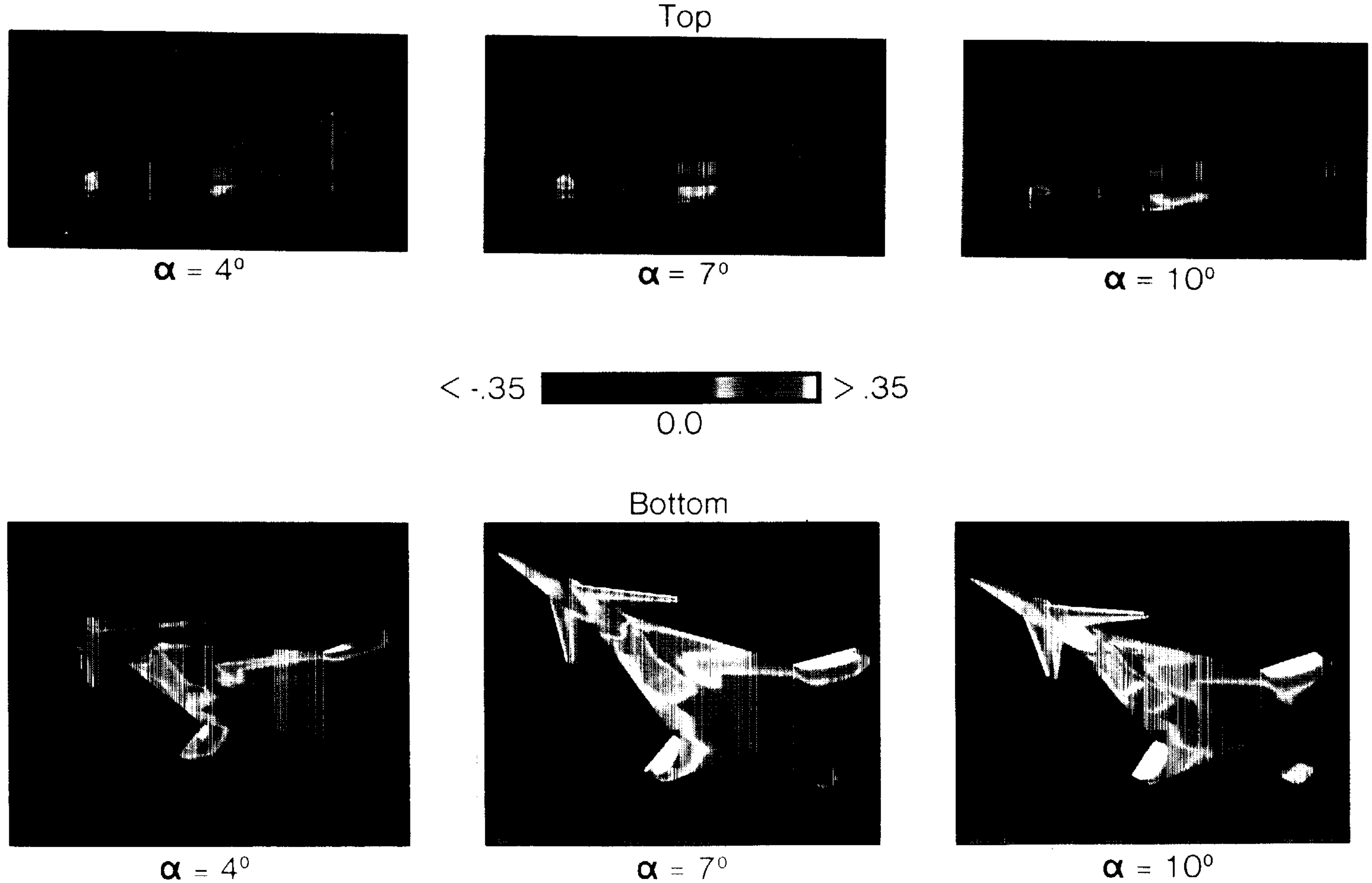


INVISCID-COMPRESSIBLE FLOW

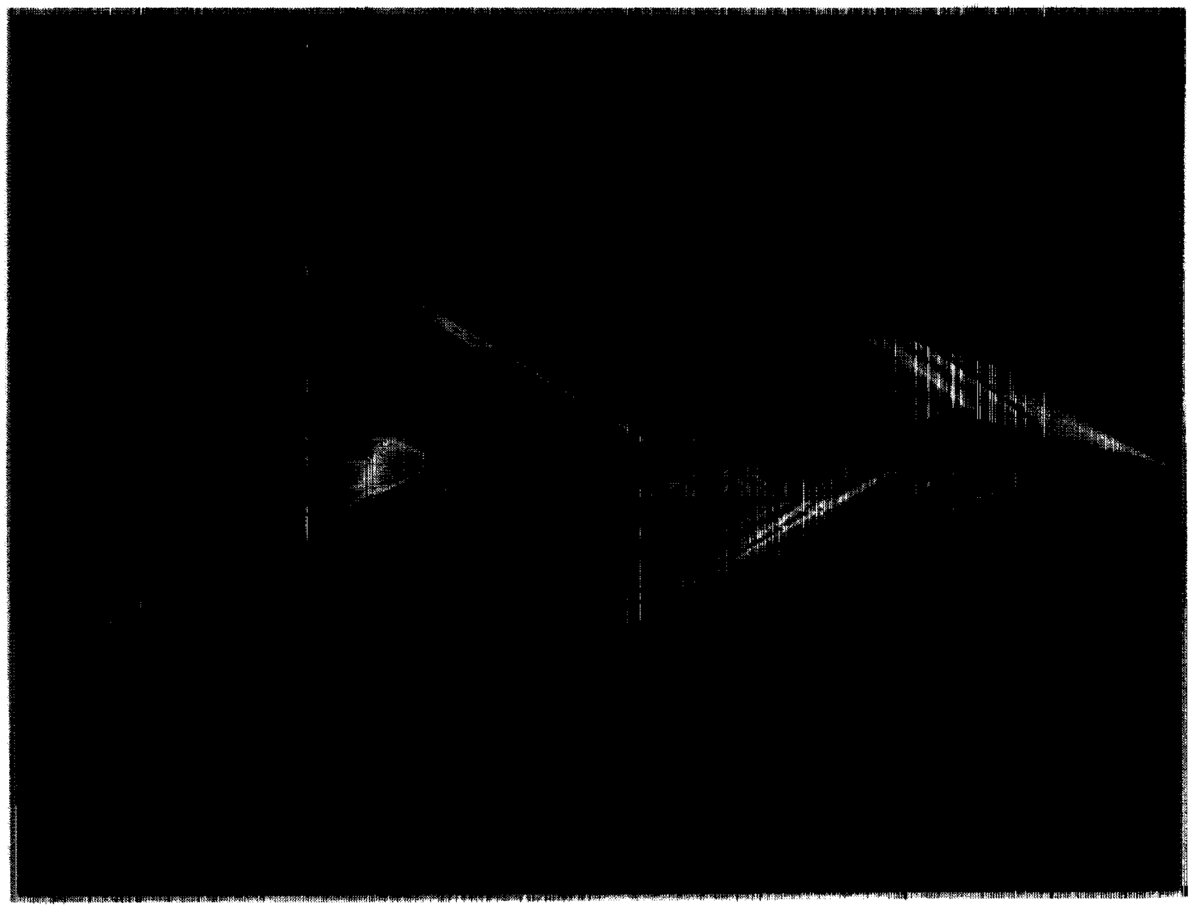
- FINITE-VOLUME METHODOLOGY
- CUSTOM EULER SOLVER
  - *CONTINUITY, MOMENTUM AND ENERGY
  - *3^{rd} ORDER RUNGE-KUTTA
- GENERAL MULTI-BLOCK EULER SOLVER
  - *CONTINUITY, MOMENTUM AND CONST. ENTHALPY
  - *4^{th} ORDER RUNGE-KUTTA

SUMMARY OF SOLUTIONS

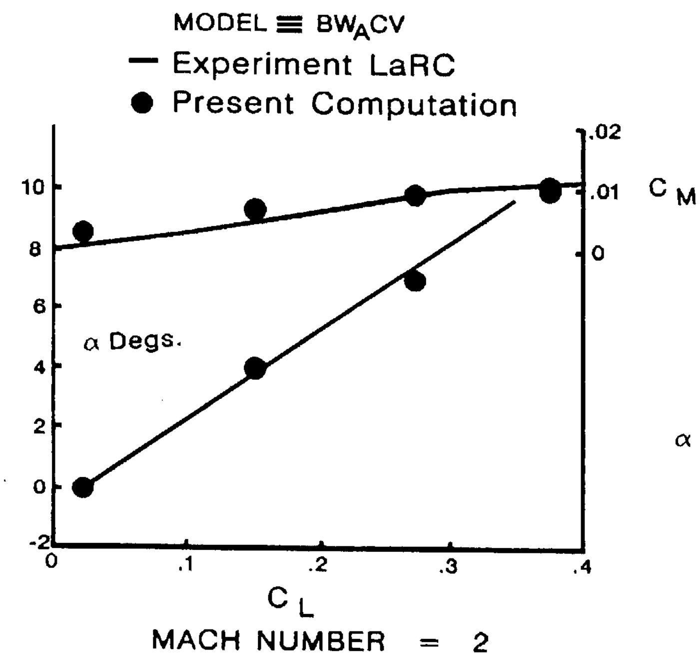
Mach Number = 2
Coefficient of pressure

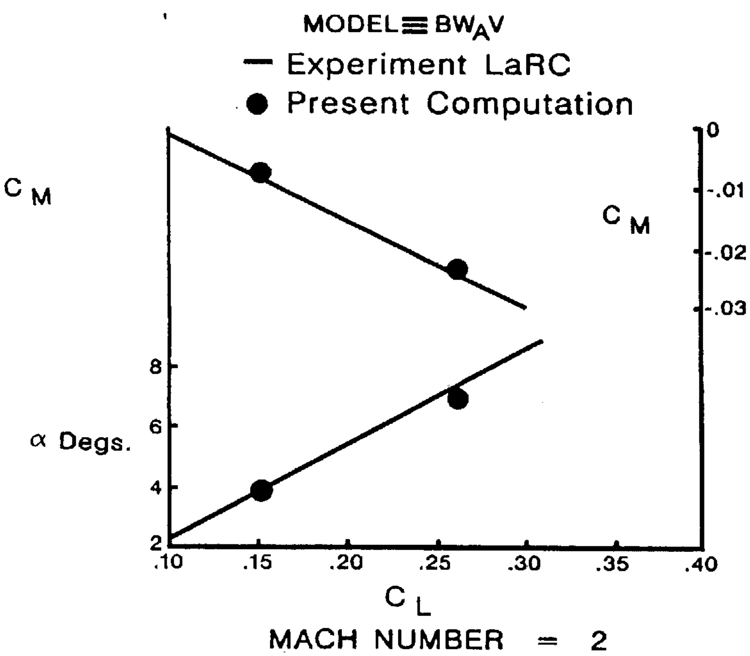


EXPERIMENTAL FIGHTER CONFIGURATION
CONTOURS OF PRESSURE COEFFICIENT
Mach number = 2 Angle of attack = 0°



AERODYNAMIC CHARACTERISTICS





CONCLUSIONS

- ALGEBRAIC GRID GENERATION FEASIBLE
- CONSERVATIVE BLOCK INTERFACES POSSIBLE
- FINITE-VOLUME EULER SOLVERS USED
- FLOW CHARACTERISTICS IN GOOD AGREEMENT
- VORTEX COMPUTATION NEEDS MORE STUDY