COMPUTATIONAL FLUID DYNAMICS RESEARCH AND APPLICATIONS AT NASA LANGLEY RESEARCH CENTER

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Research at Langley includes all aeronautics disciplines and selected space disciplines. Nearly all the aeronautics disciplines have a significant component of CFD research which complements wind-tunnel and flight experimental research; in space research, aerothermodynamics of planetary entry vehicles is heavily dependent on CFD as a research tool. Langley's CFD strategy contains four major thrusts: Focus efforts on critical CFD barriers; focus efforts on critical aerodynamics barriers; validate CFD codes; and transfer technology to United States users. The Langley presentations in this conference are representative of our strategy. They are grouped in six broad areas:

1. Direct Simulation of Transition and Turbulence
2. Hypervelocity Aerothermodynamics and Rarified Flows
3. Hypersonic External and Internal (scramjet) Flows
4. Unsteady Aerodynamics and Aeroelasticity Applications
5. Grid Generation and Applications for Complex Configurations
6. Supersonic and Transonic Wing Design Applications

Three examples of important work not shown in this conference are described in the conclusion of the presentation.

LANGLEY CFD STRATEGY

- FOCUS EFFORT ON CRITICAL CFD BARRIERS
  - GRIDS & ALGORITHMS FOR COMPLEX CONFIGURATIONS
  - TRANSITION & TURBULENCE MODELS FOR RANS CODES
  - NEW ALGORITHMS FOR MASSIVELY-PARALLEL PROCESSORS
  - ENABLE ROUTINE APPLICATIONS
- FOCUS EFFORT ON CRITICAL AERODYNAMICS BARRIERS
  - DIRECT SIMULATION OF TRANSITION AND TURBULENCE
  - SIMULATION/PREDICTION OF HIGH-ALPHA FLOWS
  - SIMULATION/PREDICTION OF HYPERSONIC PROPULSION

LANGLEY CFD STRATEGY
(Concluded)

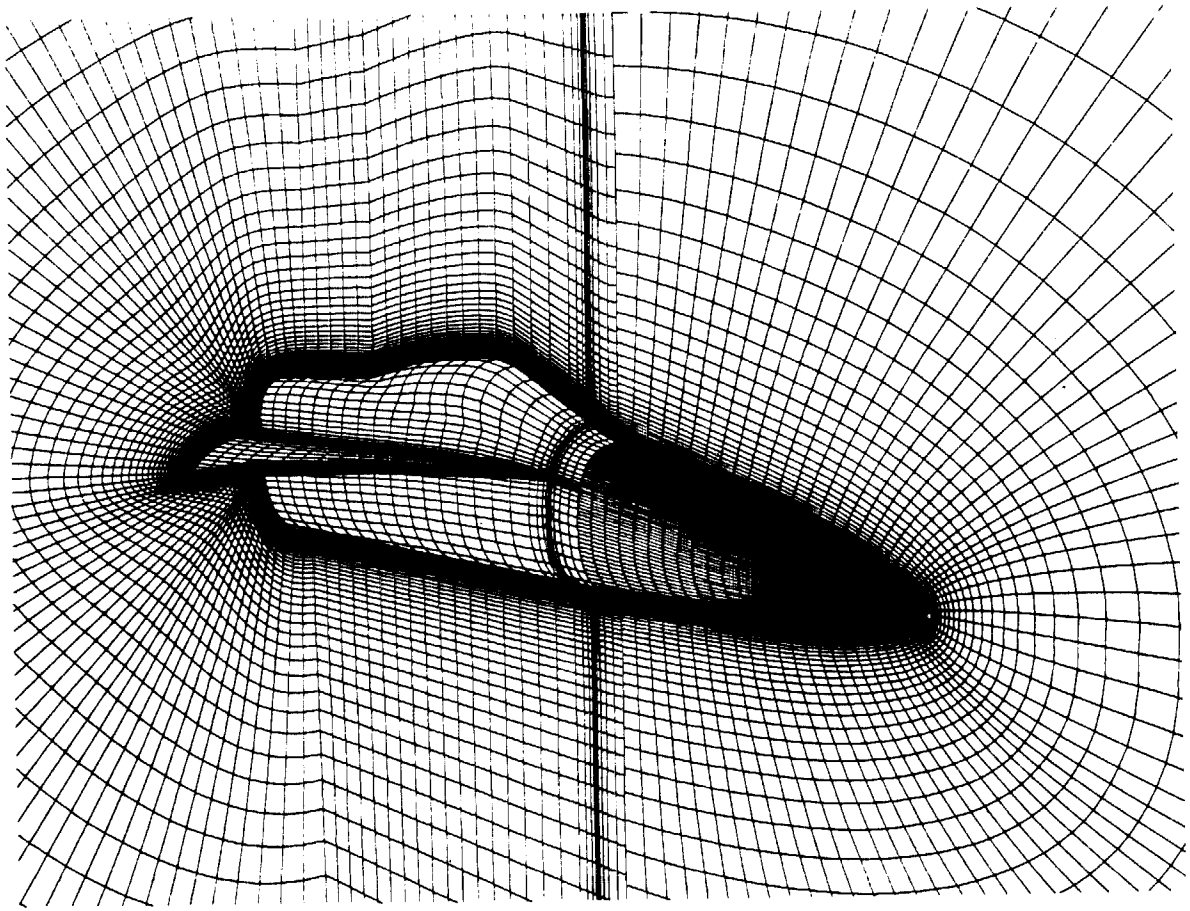
- VALIDATE CFD CODES
  - CODE-ON-CODE
  - CODE-ON-EXPERIMENT (GROUND & FLIGHT)
- TRANSFER TECHNOLOGY
  - RESEARCHER EXCHANGES (ARC ⟷ LaRC ⟷ LeRC
  - NAS NETWORK DATA/CODE EXCHANGES
  - TRAINING APPLICATIONS RESEARCHERS

CFD FIVE-YEAR PLAN

THRUST	YEAR					GOAL
	89	90	91	92	93	
CFD DEVELOPMENT	IMPROVE SPEED/ACCURACY N-S STOKES COMPLEX GEOMETRY/GRIDS PARALLEL PROCESSOR ALGORITHMS TRANSITION & TURBULENCE MODELS HIGH-SPEED REACTING FLOWS					PREDICTIVE CAPABILITY FOR COMPLEX 3D VISCOUS FLOWS FOR ADVANCED A/C MISSILES, & PROP. SYS.
FLOW PHYSICS	LOW SPEED-TRANSITION, TURB., & SEPARATION HIGH SPEED TRANSITION & TURB. TURBULENCE/CHEM. KINETICS INTERACTION					HIGHLY DETAILED DATA BASE TO EXTRACT UNDER-STANDING OF PHYSICS OF 2D & 3D FLOWS

3-BLOCK GRID TOPOLOGY

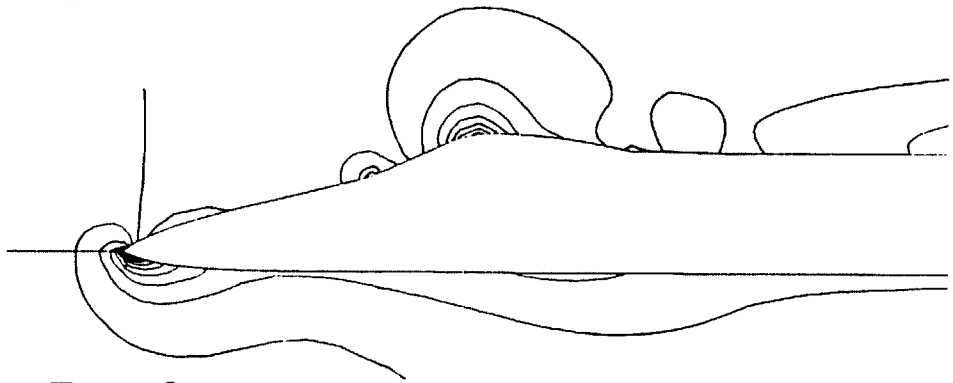
Nearfield view F-18 ; 300,000 points total



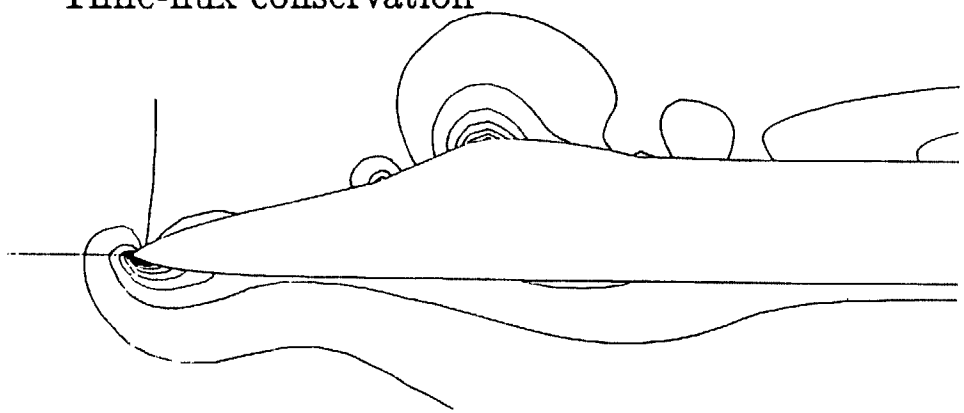
EFFECT OF PATCHING ALGORITHM

$M_\infty = .60 \quad \alpha = 20^\circ \quad R_{\bar{c}} = .8\ x\ 10^6$

Spatial-flux conservation



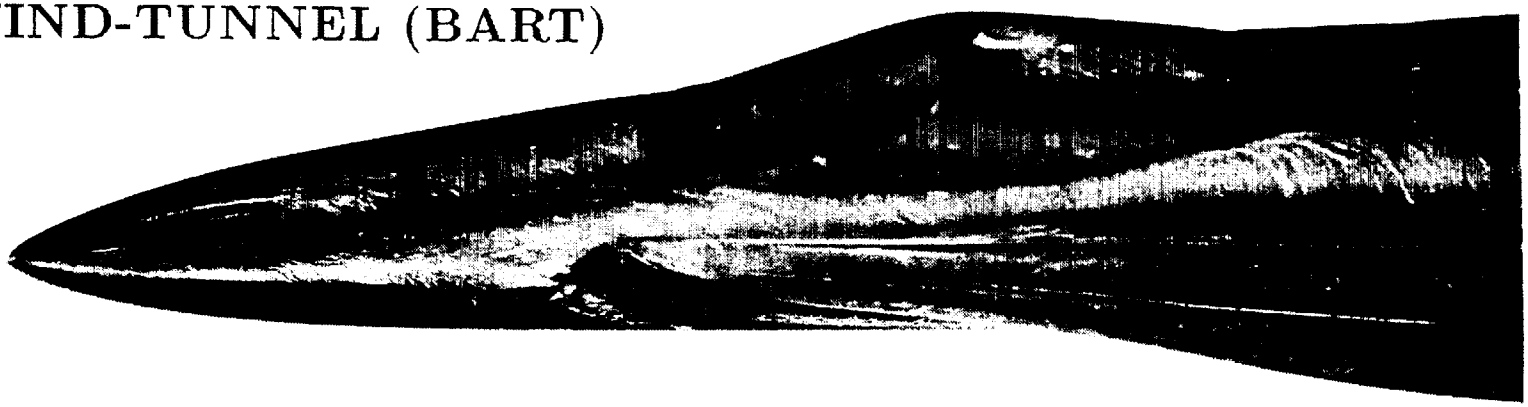
Time-flux conservation



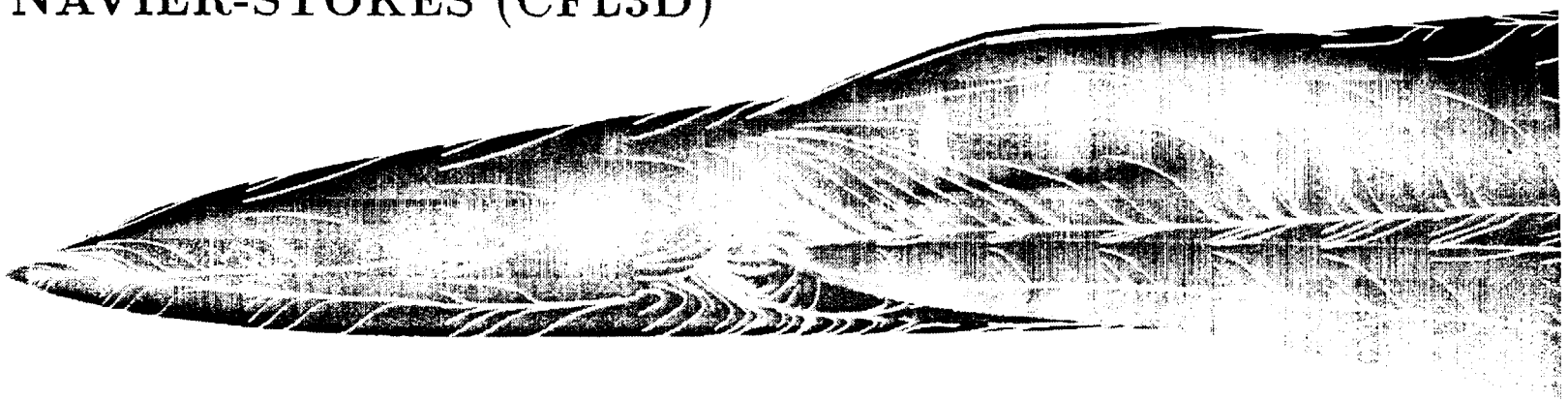
F-18 SURFACE FLOW

$\alpha = 30^\circ \quad R_{\bar{c}} = .2\text{-}.7 \times 10^6$

WIND-TUNNEL (BART)

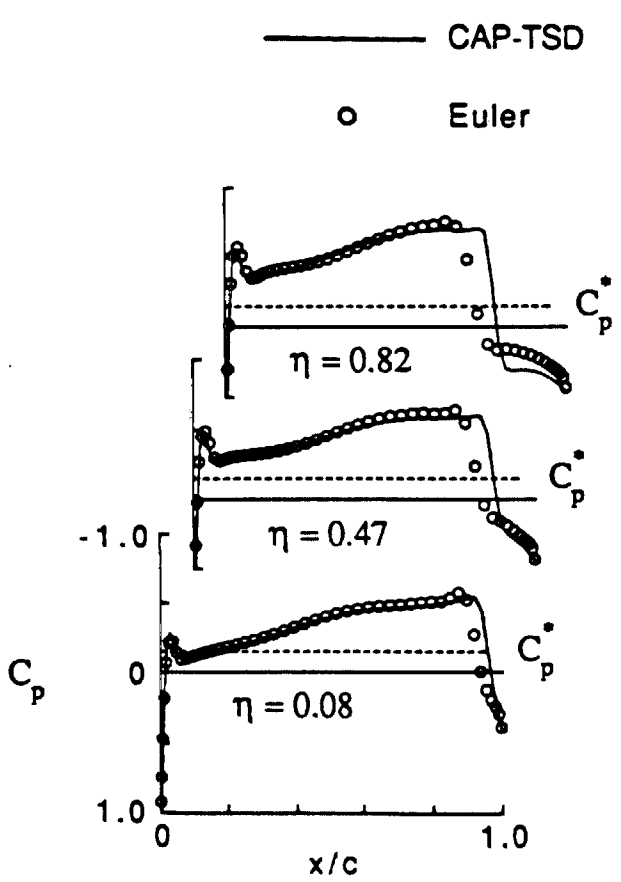


NAVIER-STOKES (CFL3D)

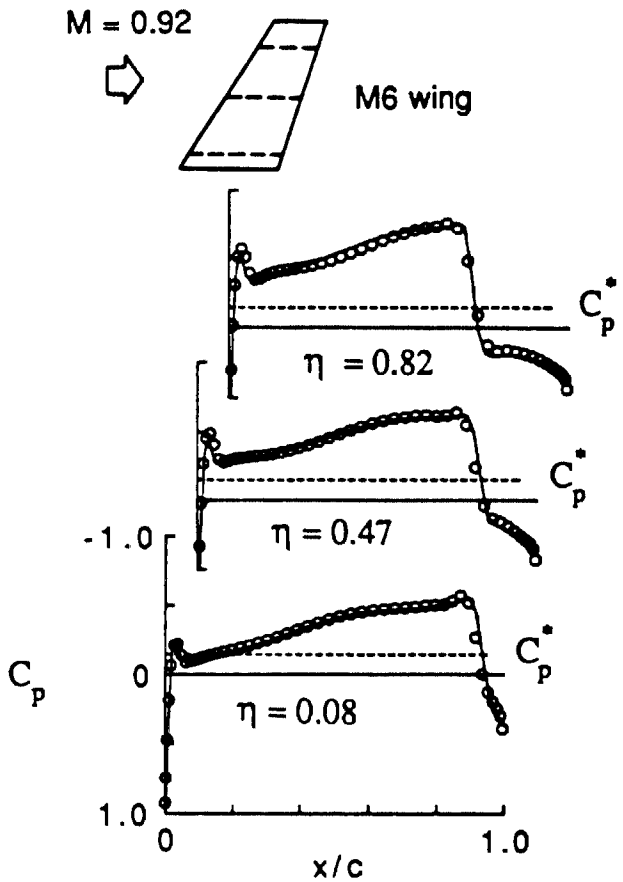


ENTROPY AND VORTICITY EFFECTS IMPROVE ACCURACY OF UNSTEADY TRANSONIC SMALL-DISTURBANCE (TSD) THEORY

- UNMODIFIED THEORY GIVES INACCURATE SHOCK PREDICTION

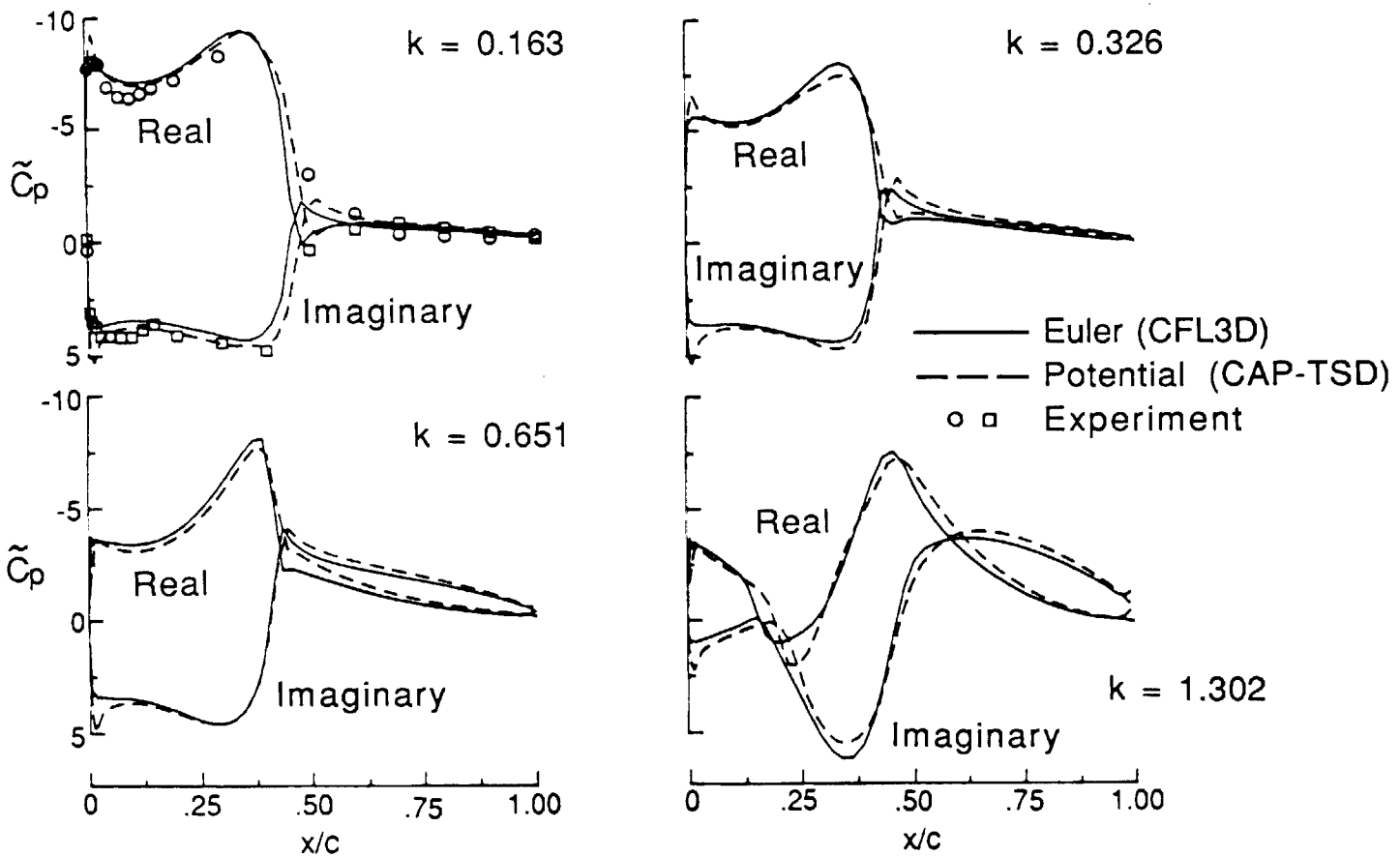


- ENTROPY AND VORTICITY CORRECTIONS YIELD EULER-LIKE RESULTS

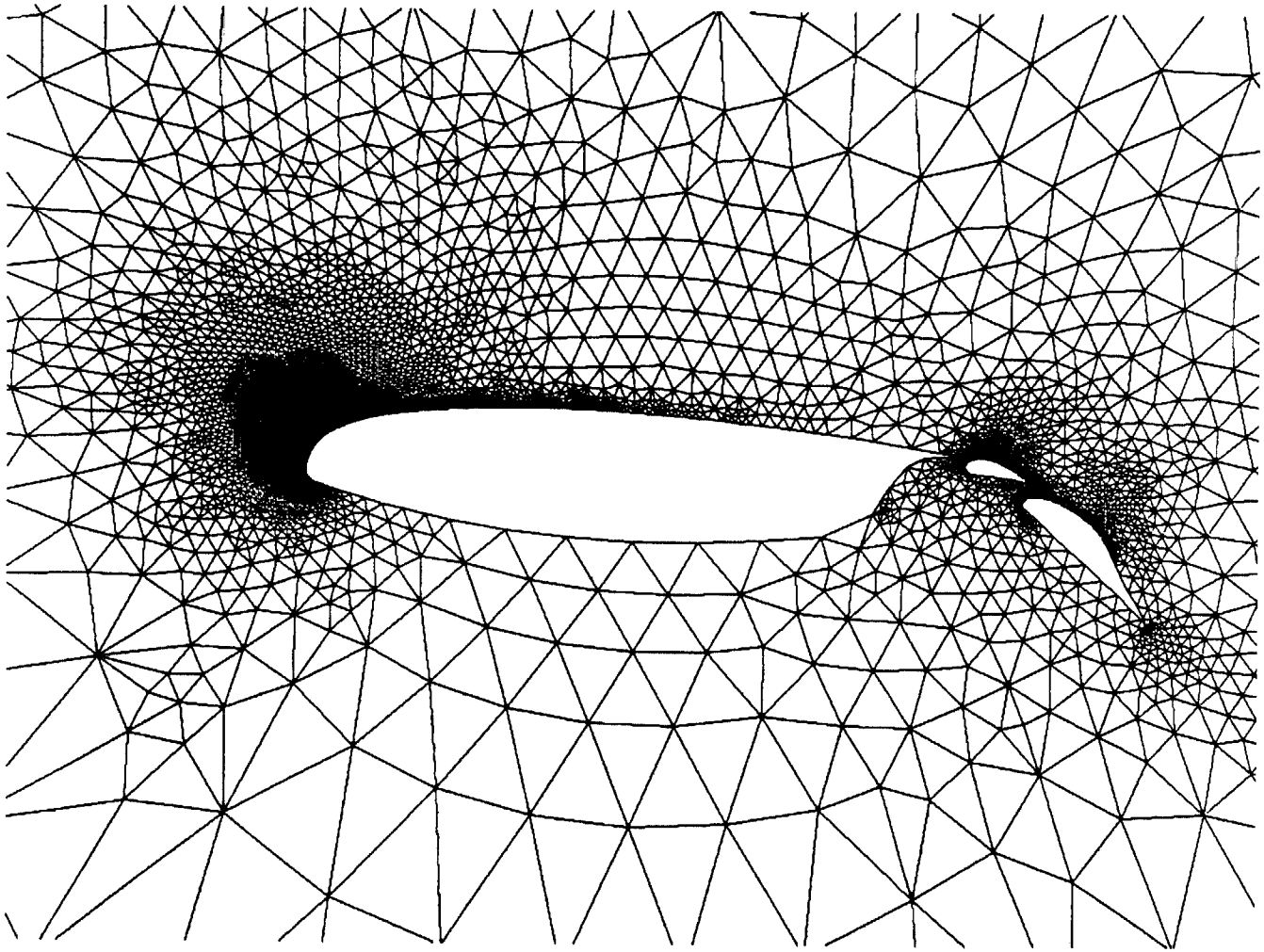


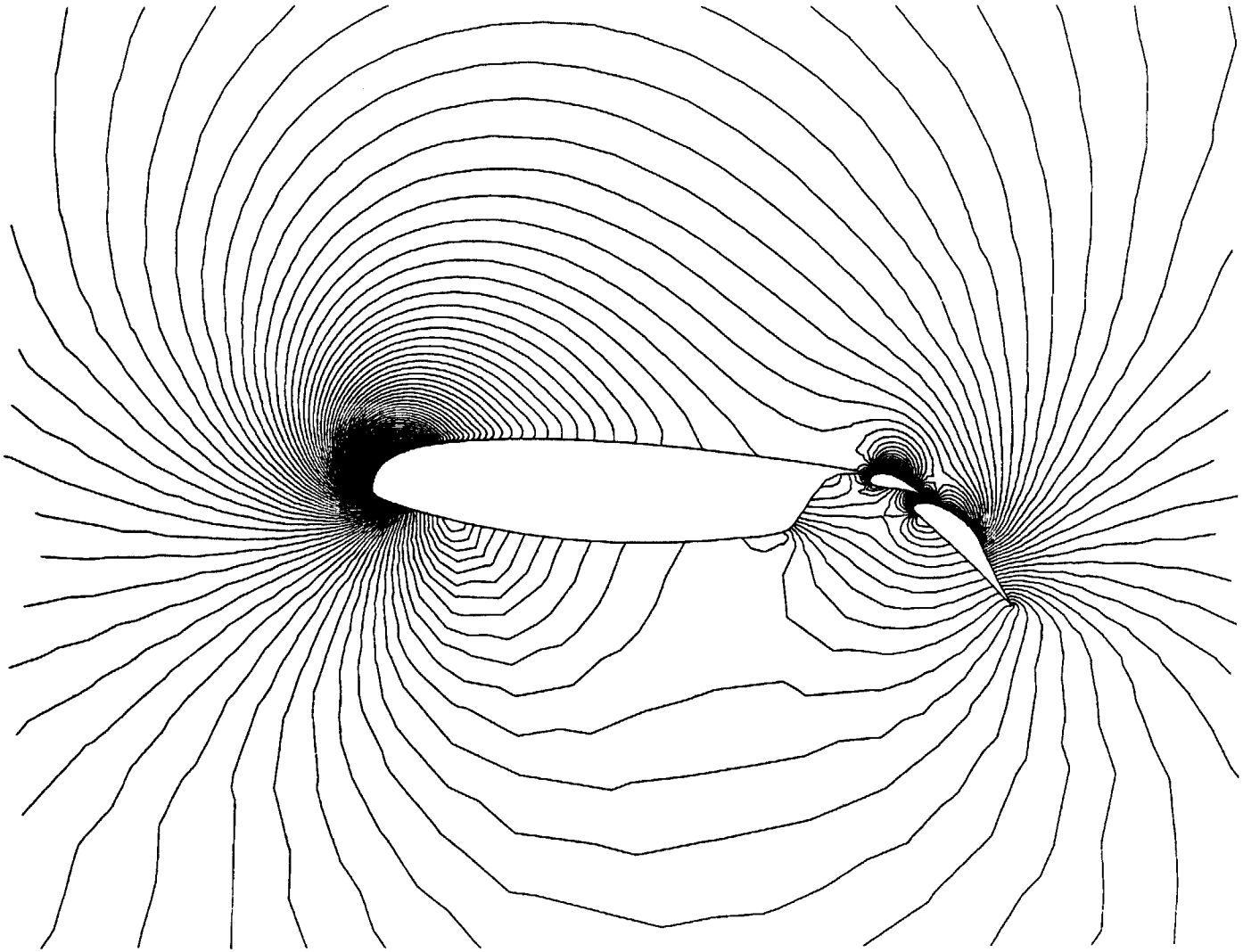
EFFECTS OF REDUCED FREQUENCY ON FIRST HARMONIC COMPONENTS OF UNSTEADY PRESSURES DUE TO AIRFOIL PITCHING

- **NACA 0012 airfoil at $M_\infty = 0.755$, $\alpha_o = 0.016°$, $\alpha_1 = 2.51°$**

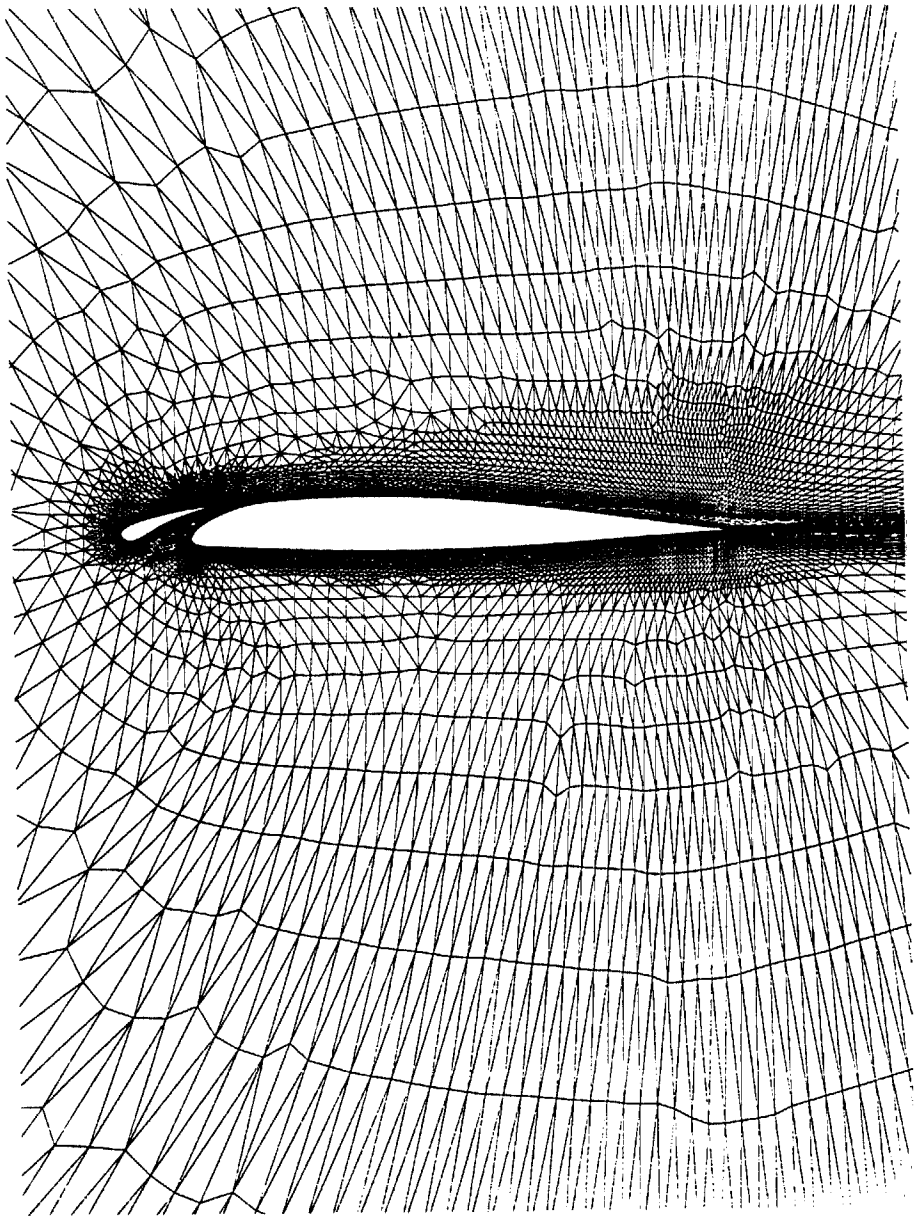


UNSTRUCTURED ADAPTIVE GRID FOR INVISCID SOLUTION
FOR 3-ELEMENT AIRFOIL (MAVRIPLIS, ICASE)

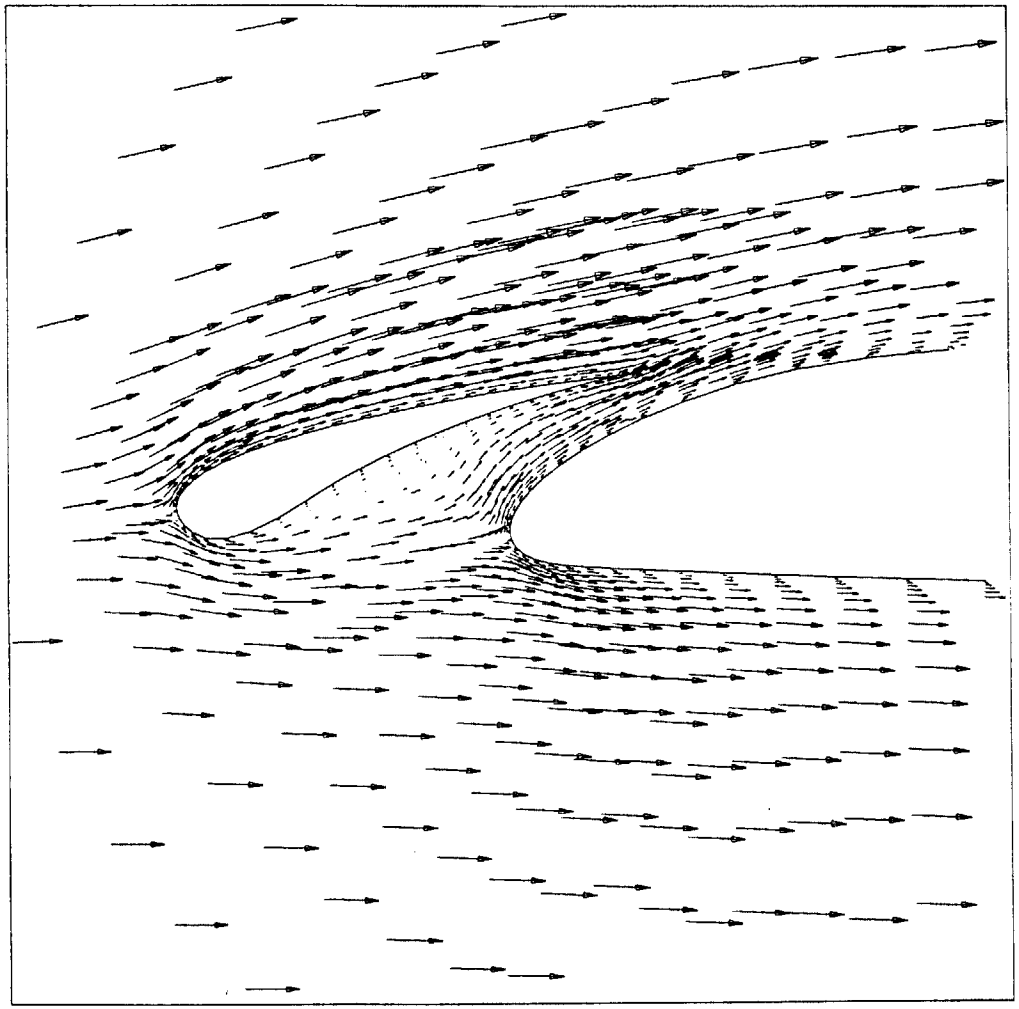




FINITE-VOLUME EULER SOLUTION FOR 3-ELEMENT AIRFOIL (MAVRIPLIS, ICASE)



UNSTRUCTURED GRID FOR AIRFOIL WITH SLAT. HIGHLY-STRETCHED TRIANGLES TO RESOLVE LAMINAR BOUNDARY LAYER.
(MAVRIPLIS, ICASE)



LAMINAR NAVIER-STOKES CALCULATIONS ON UNSTRUCTURED MESH IN SLAT REGION (MAVRIPLIS, ICASE)