STATUS OF VGRID/USM3D AERO ANALYSIS SYSTEM

NEAL T. FRINK
NASA LANGLEY RESEARCH CENTER

PARESH PARIKH
ViGYAN

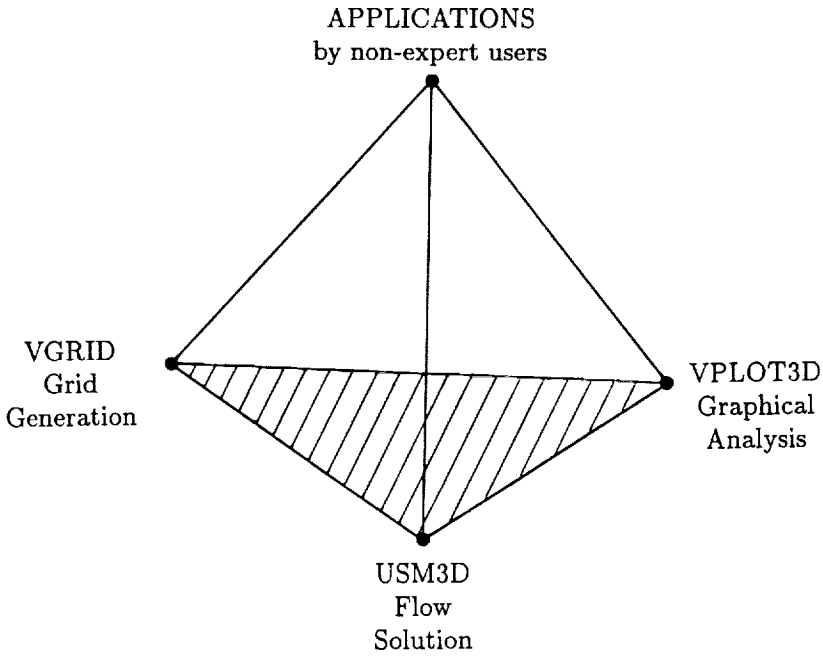
SHAHYAR PIRZADEH
ViGYAN

Outline

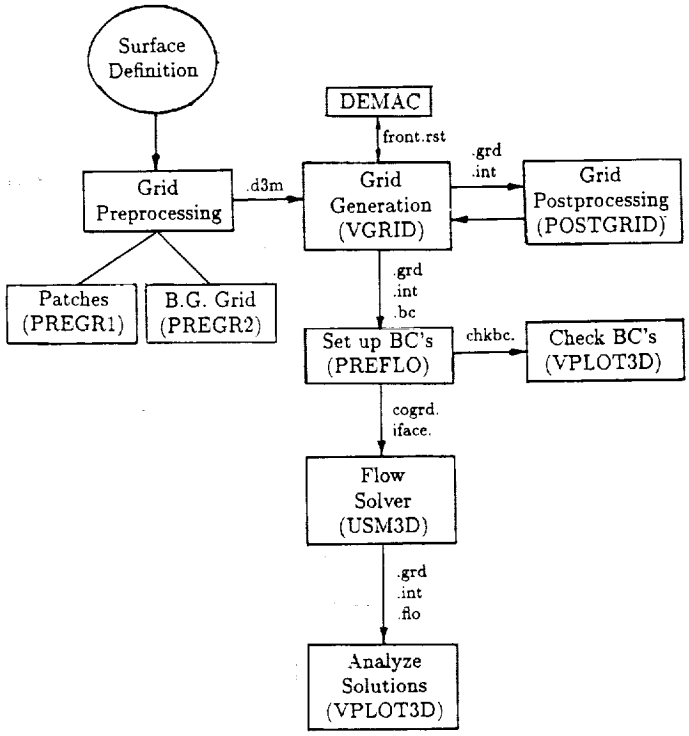
- Introductory Remarks
- General Capabilities
  - Grid generation
  - Flow solver
  - Graphic Postprocessing
- Dissemination
- Customer Applications
- Plans
- Closing Remarks

The Structure Behind Our Unstructured Work

- An Application-Oriented Development Program -



Flowchart for Unstructured Codes



Unstructured Grid Generation, VGRID

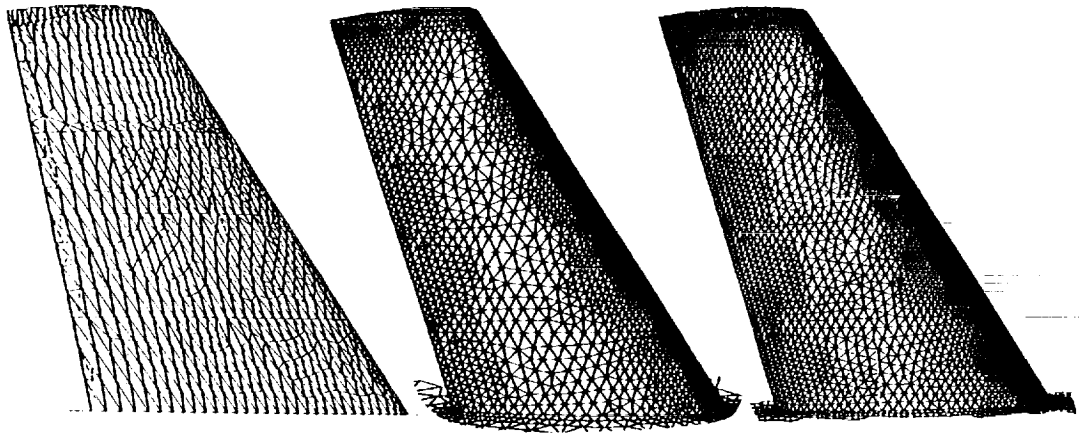
- A program for generation of unstructured tetrahedral grids around complex configurations using the Advancing Front Method.
  - Base code developed under SBIR with ViGYAN
  - Considerable extentions made in TAB to improve:
    - robustness
    - grid quality
    - reduced grid generation time
  - Viscous grid generation effort well underway

- Additional enhancements made by GEOLAB/CSC
  - Surface projection/correction
  - New graphic interface tool under development
    - Enhanced surface patches
    - Improved surface grid generation

Unstructured Euler Solver, USM3D

- Finite-volume approach with cell-centered, tetrahedral elements
- Upwind-biased, flux-difference splitting (Roe's Scheme)
- Fast higher-order differencing formula
- Three-stage Runge-Kutta time stepping to advance to steady state
- Acceleration techniques:
  - Local time stepping
  - Implicit residual smoothing
- Efficient data structure:
  - CPU time: 17.5 μ-sec/cell/cycle on Cray Y-MP
  - Memory usage: 45 words/cell

Upper Surface Grid
OM6 Wing

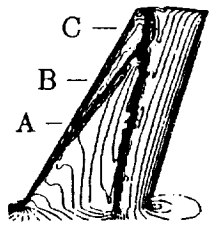


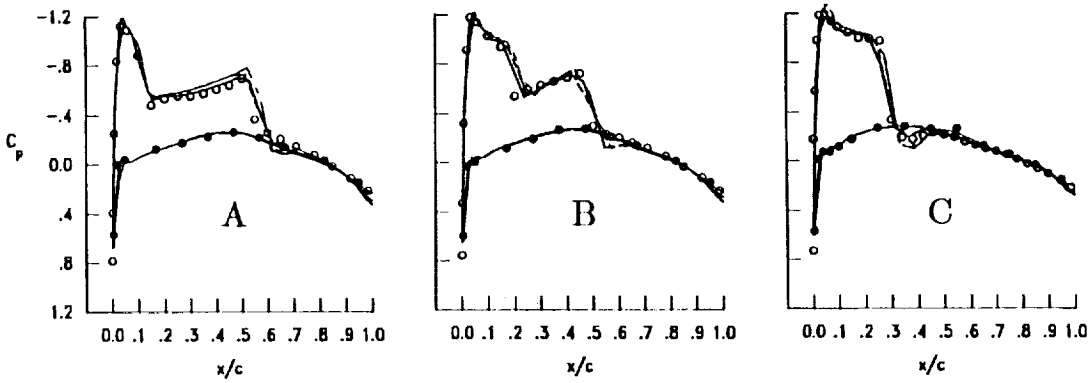
	Stretch	Coarse	"Workshop" Fine
No. Cells	= 35008	= 108755	= 231507
No. Nodes	= 6910	= 20412	= 42410

Effect of Grid on Chordwise Surface Pressure Distributions

USM3D, $M_\infty = 0.84$, $\alpha = 3.06°$

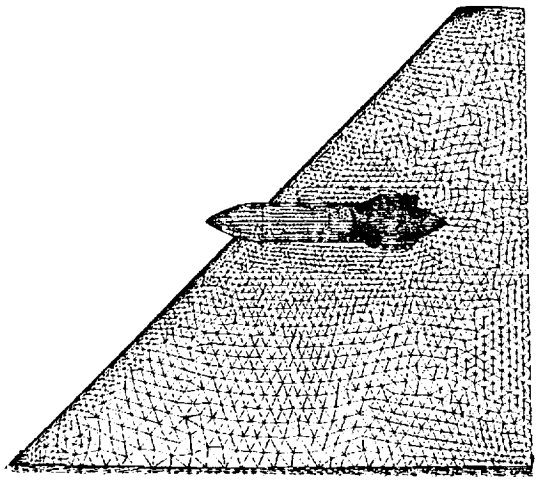
		Memory	CRAY2S Run time
o •	Data		
———	Stretch,	2.3MW,	11.5 min
- - - - - - -	Coarse,	7.0MW,	1 hr 29 min
—— - - ——	Fine,	14.9MW,	3 hr 23 min



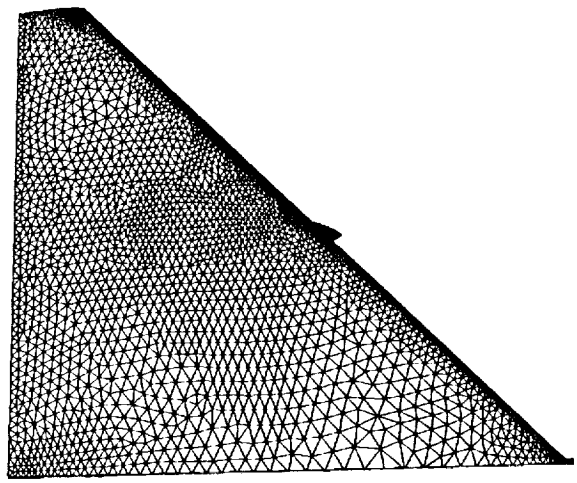


SURFACE GRID ON THE CONFIGURATION

13,256 Points
27,044 Faces

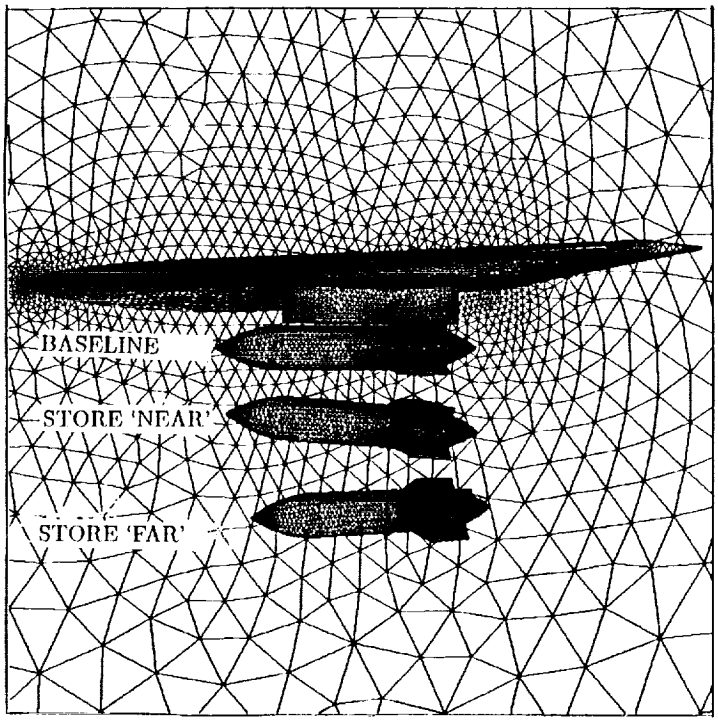


Lower Surface

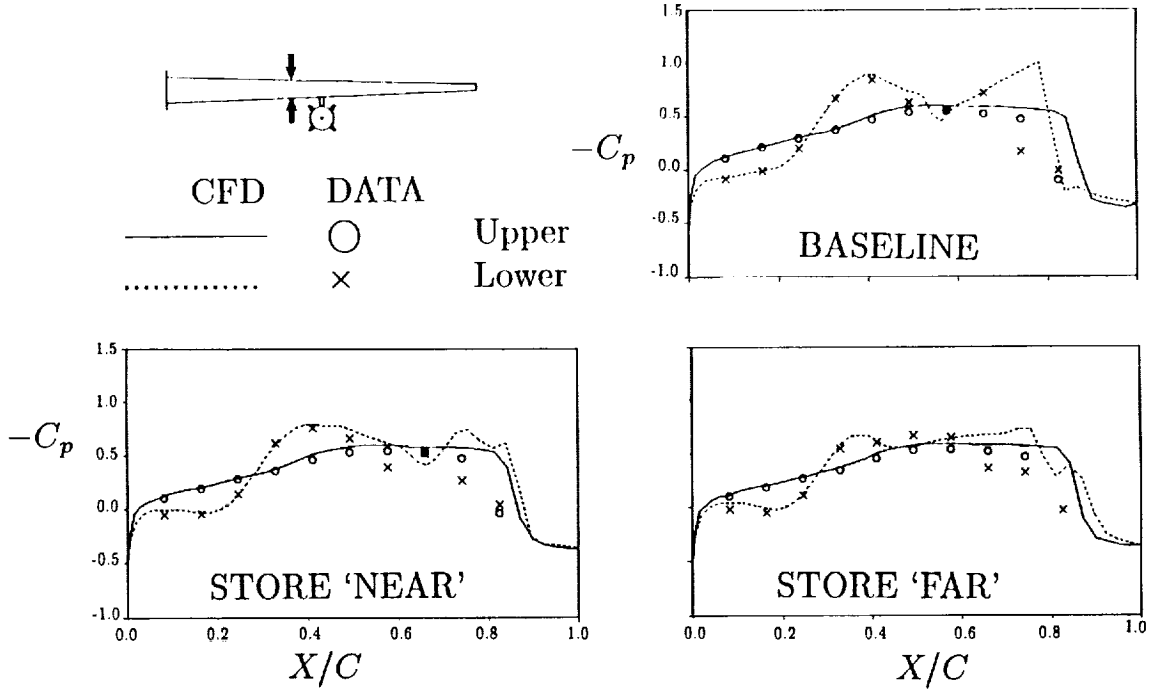


Upper Surface

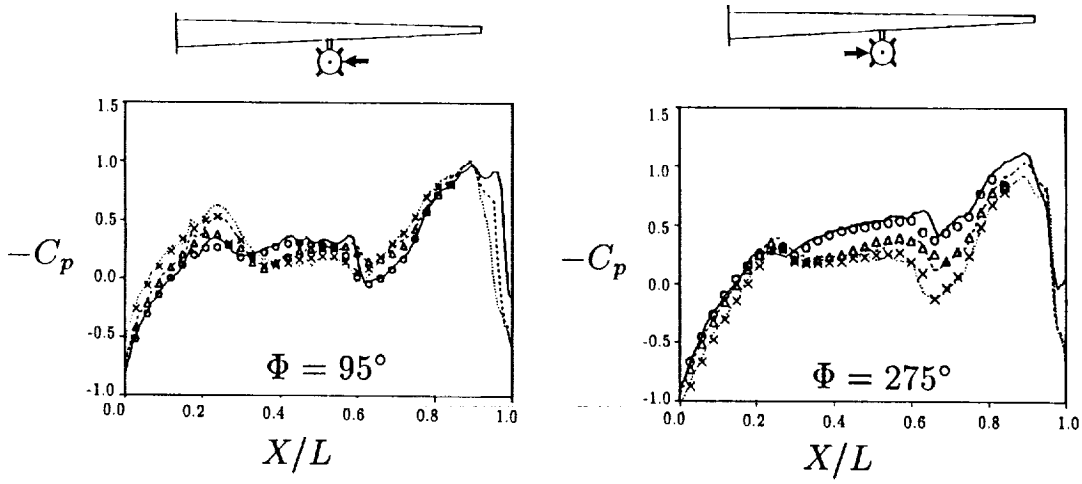
REPRESENTATIVE STORE LOCATIONS



PRESSURE COMPARISON ON THE WING, $M_\infty = 0.95$
Location: 1.2 Store Diameter Inboard



SURFACE PRESSURE COMPARISON ON THE STORE
$M_\infty = 0.95$

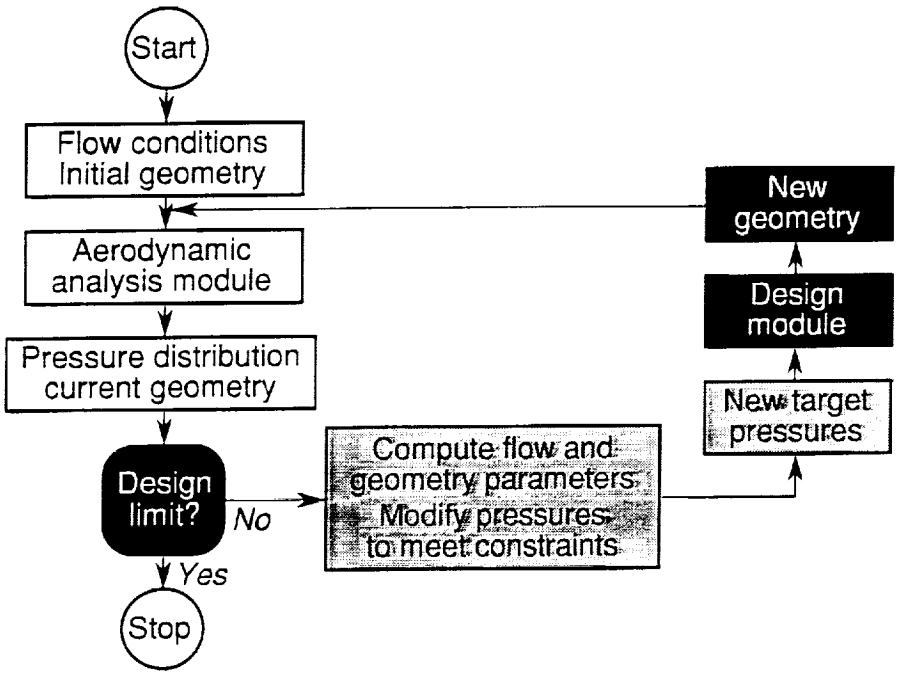


CFD	DATA	
———	○	BASELINE
- - - - - -	△	STORE 'NEAR'
.....	×	STORE 'FAR'

Recent Improvements to USM3D

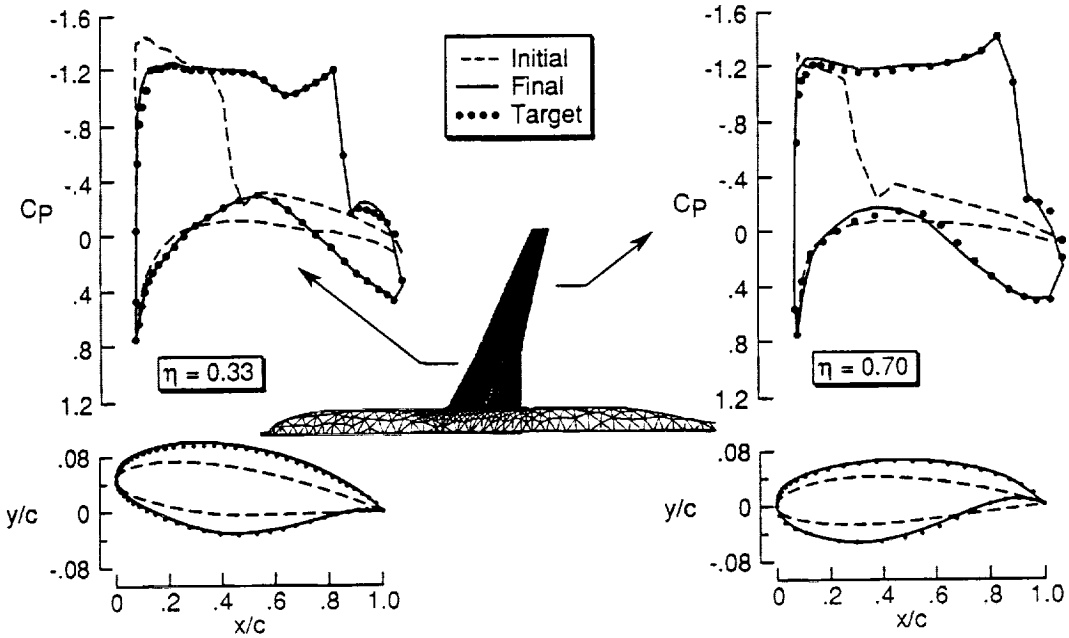
- Implemented 2nd-order nodal averaging technique
  - higher-order boundary condtions
- Improved data structure through face coloring
- Teamed with Dr. Kyle Anderson, CAB/FlMD, to install his implicit time integration algorithm and FVS
- Iterative design capability installed by L. A. Smith, TAB/AAD

CONSTRAINED DIRECT ITERATIVE SURFACE CURVATURE (CDISC) DESIGN METHOD



TRANSONIC WING DESIGN USING THE DISC DESIGN METHOD AND USM3D

M = .77



Dissemination of VGRID/USM3D Developmental Codes

- Academia - 4 universities
- Government
  - 3 NASA research centers
  - 3 Air Force research laboratories
  - 2 Naval air research/development centers
  - National Institute of Standards and Technology
- Industry - 11 companies, including 4 major aircraft companies
- Total of 30 outside requests
- Provided hands-on training to 48 users

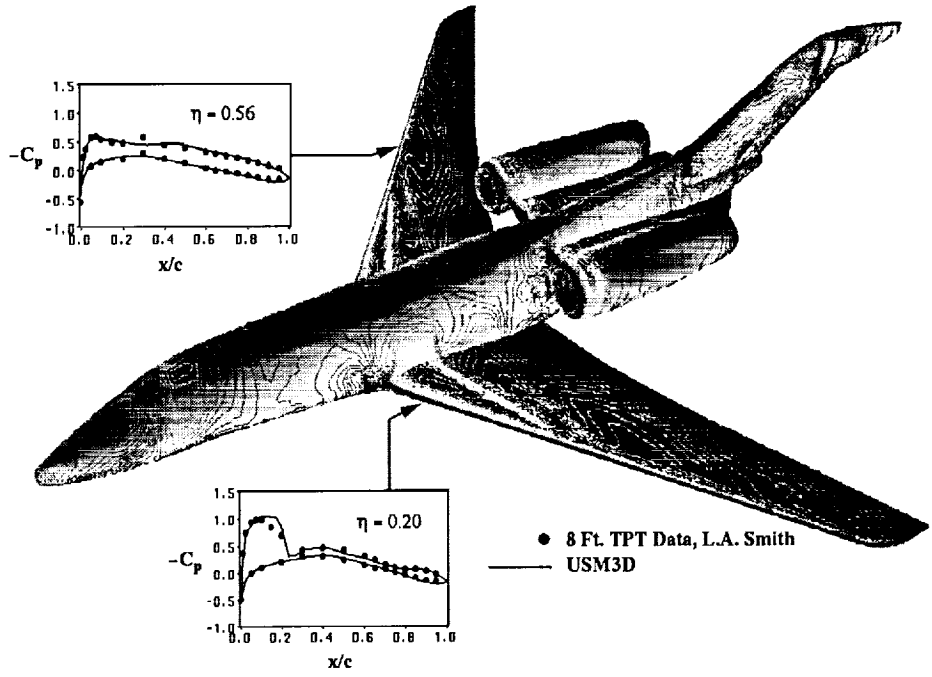
Selected Customer Applications

- Subsonic Aircraft
  - Cessna Citation - (Cessna/Parikh)
  - MD-11 - (Douglas/NASA)
  - B737 - (SAB, S. Dodbele)
  - C-17 - (HRNAB, J.Alsaadi)
  - T-39 - (WPAFB, J. Slavey)
- High-Speed Civil Transport
  - Generic HSR Configuration - (SAB K. Kjerstad)
  - Cranked wing LEVF - (SAB, K. Kjerstad)
  - HSCT - (Boeing, J. Wai)
  - Sonic Boom research - (VIB, K. Fouladi)
- High-Performance Military Aircraft
  - Fighter - (Boeing, J. Wai)
  - Joined wing - (Boeing, J. Wai)
  - MTVI - (TAB, F. Ghaffari)
- Other
  - Cavities - (TAB Cavity Flow Team)
  - Internal flow - (NASA LeRC, O.J. Kwon)

Comparison of C_p Distributions on Cessna Citation 10

Mach = 0.82, $\alpha = 1.11^{\circ}$

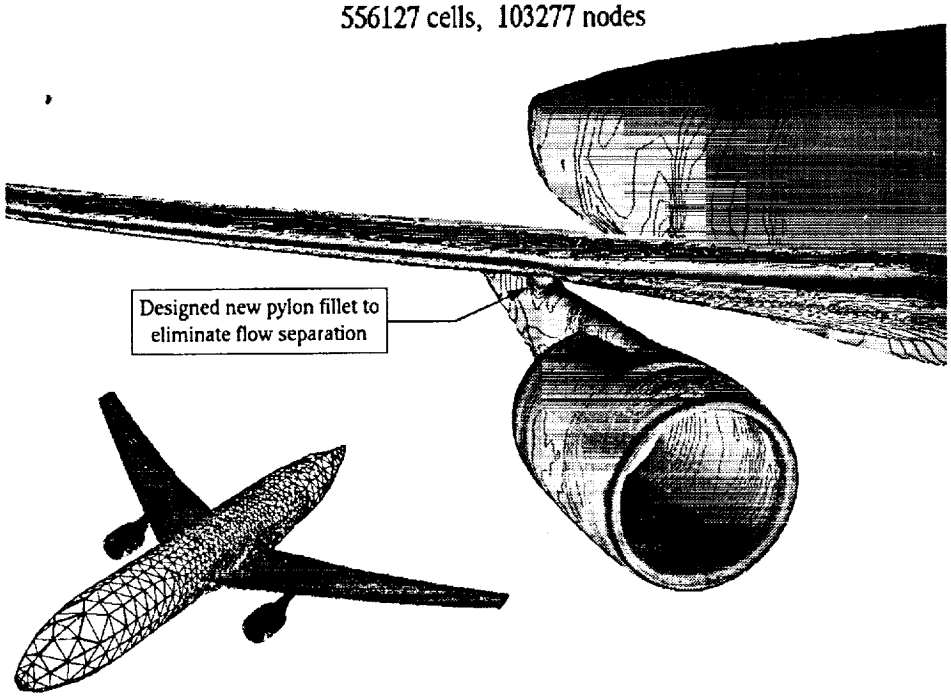
762553 cells, 137742 nodes

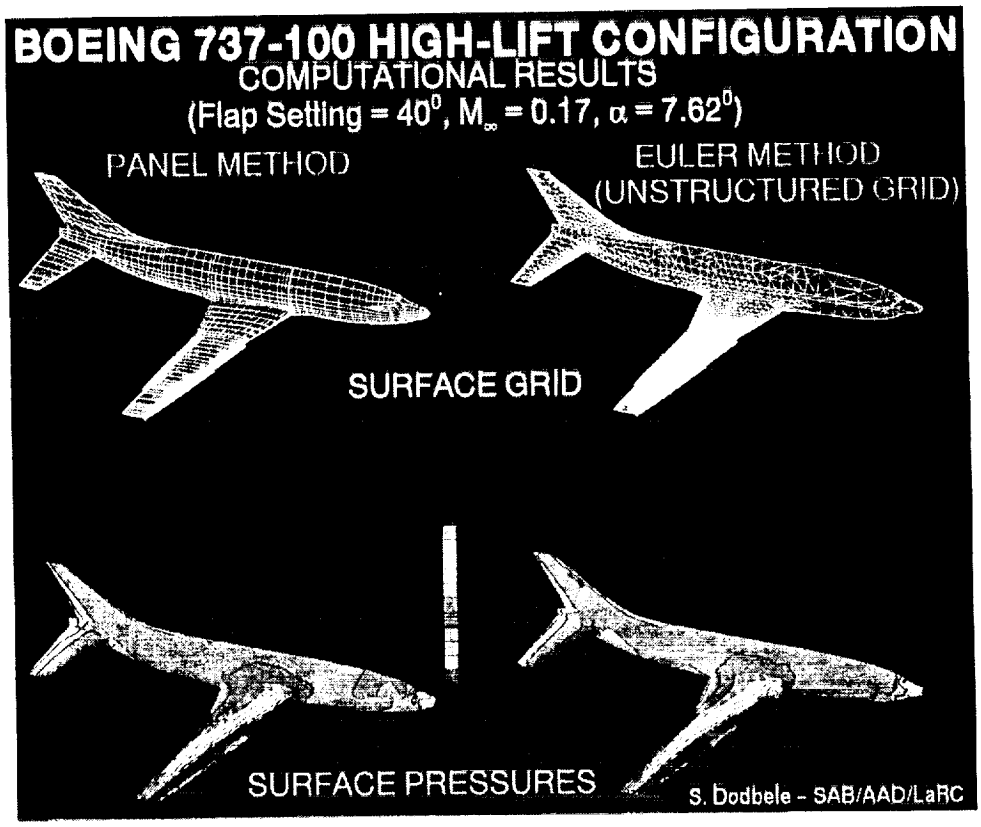


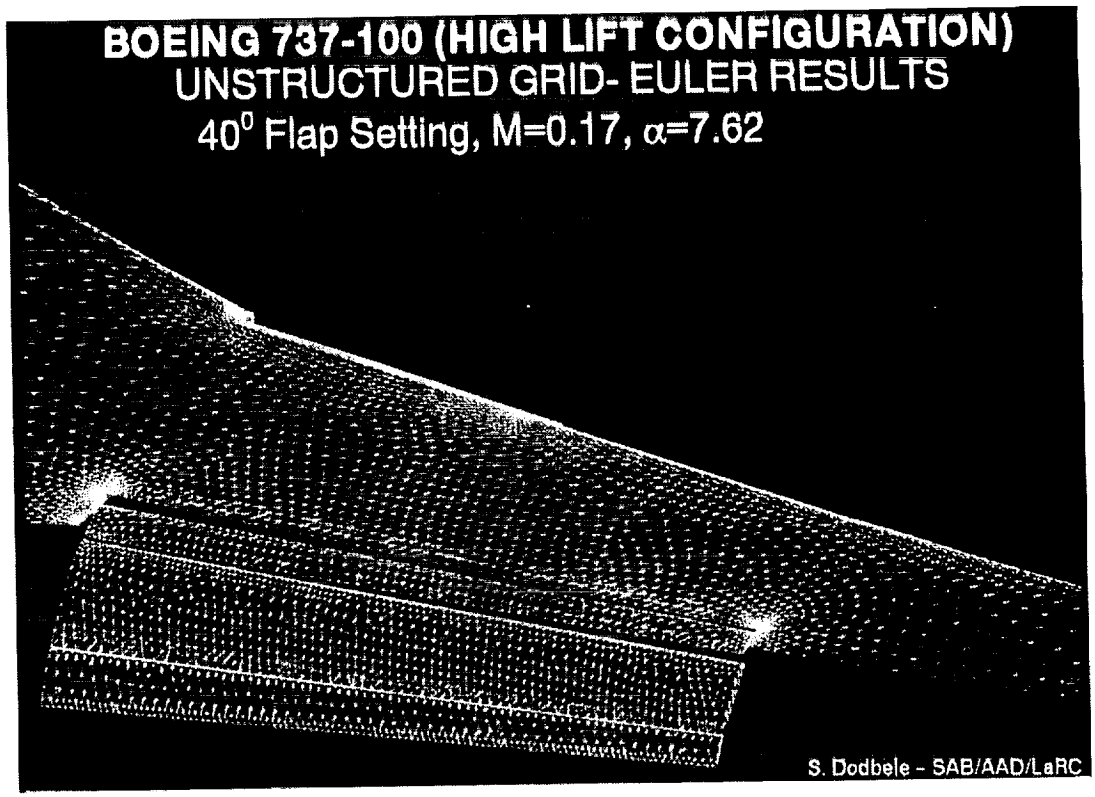
Wing–Pylon Fillet Design Using USG Methodology

MD–11 Configuration, Mach=0.83, $\alpha = 2.35^{\circ}$

556127 cells, 103277 nodes

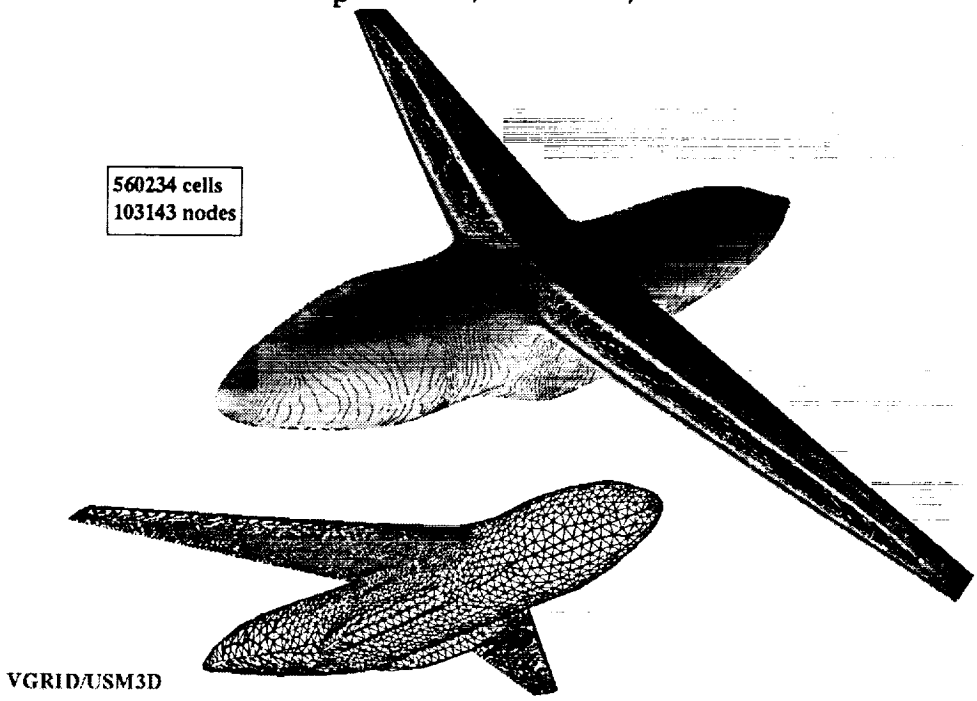



BOEING 737-100 HIGH-LIFT CONFIGURATION
COMPUTATIONAL RESULTS
(Flap Setting = 40°, M∞ = 0.17, α = 7.62°)
PANEL METHOD
EULER METHOD
(UNSTRUCTURED GRID)
SURFACE GRID
SURFACE PRESSURES
S. Dodbele - SAB/AAD/LaRC


BOEING 737-100 (HIGH LIFT CONFIGURATION)
UNSTRUCTURED GRID- EULER RESULTS
40° Flap Setting, M=0.17, α=7.62
S. Dodbele - SAB/AAD/LaRC

High–Wing Transport Configuration

C_p Contours, Mach=0.77, $\alpha = 1.6^{\circ}$

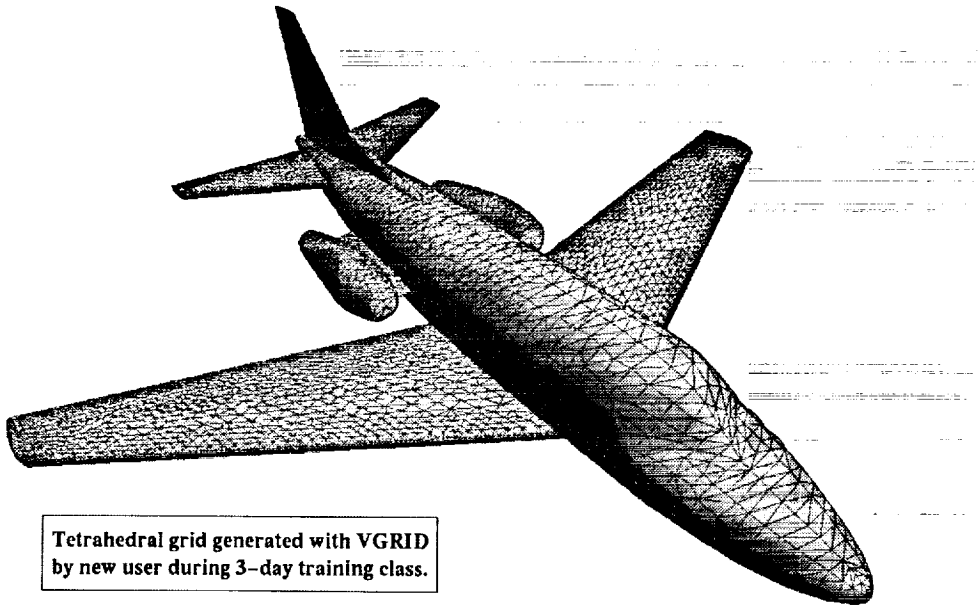


560234 cells
103143 nodes

VGRID/USM3D

Unstructured Grid for T–39 Aircraft

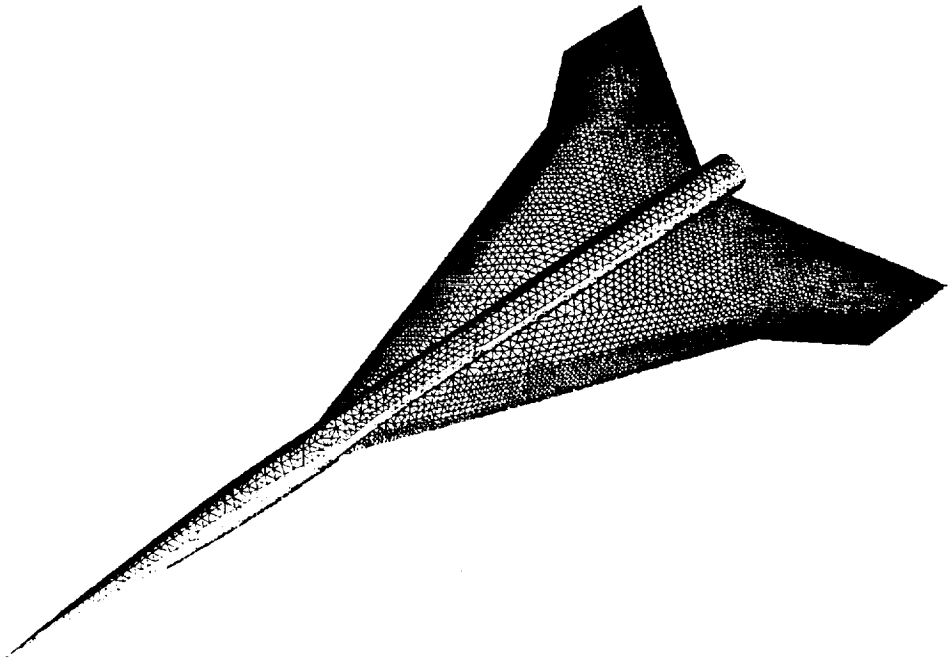
244156 cells, 46050 nodes

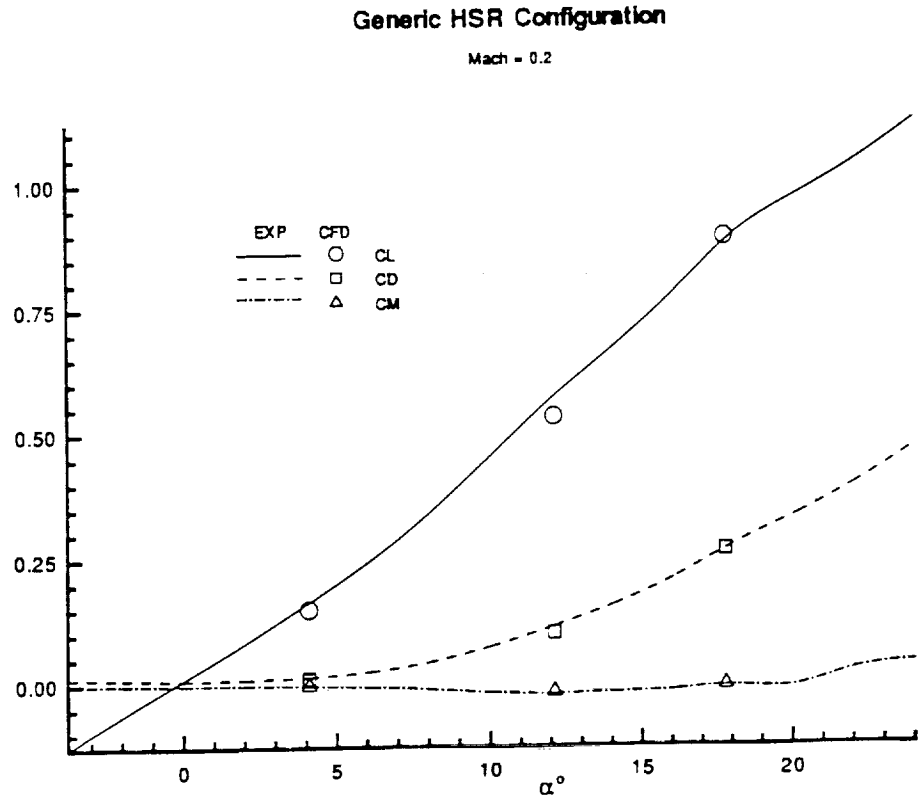


Tetrahedral grid generated with VGRID by new user during 3–day training class.

Generic HSR Configuration

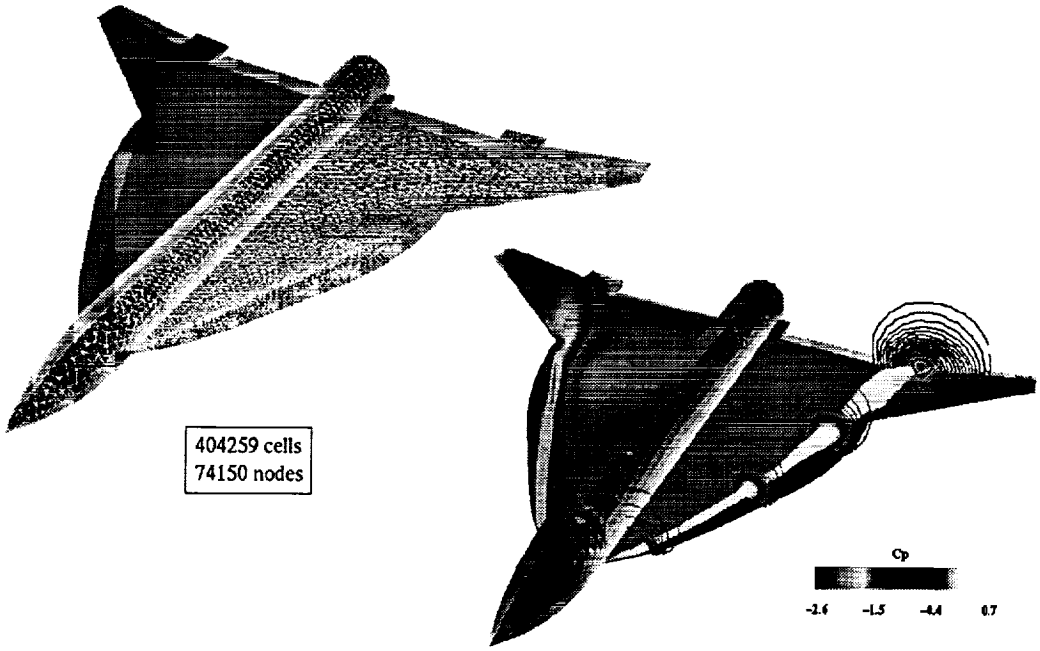
Unstructured Grid





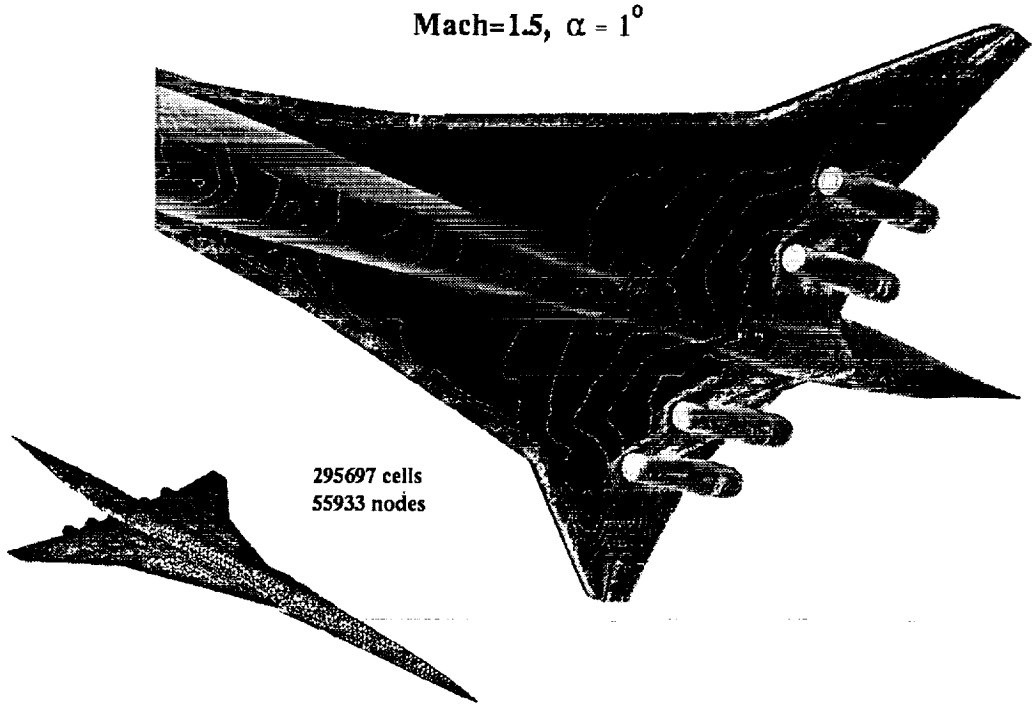
HSR Planform Study (VGRID/USM3D)

68/48 planform with $\delta_{vf} = 30^{\circ}$, $\delta_{te} = 15^{\circ}$, Mach=0.22, $\alpha = 12^{\circ}$

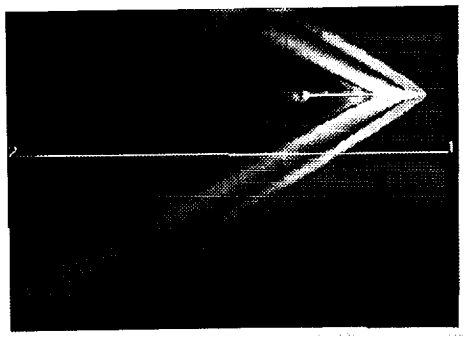


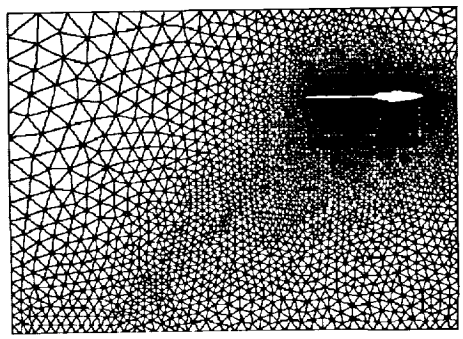
HSR C_p Distribution Using USM3D

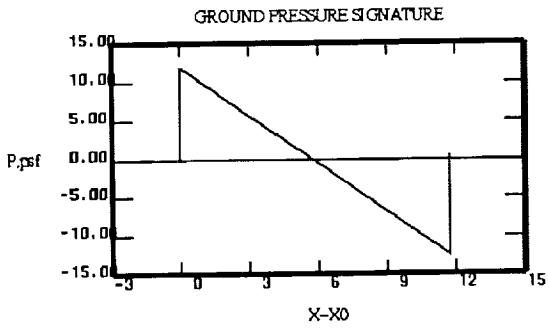
Mach=1.5, $\alpha = 1^{\circ}$

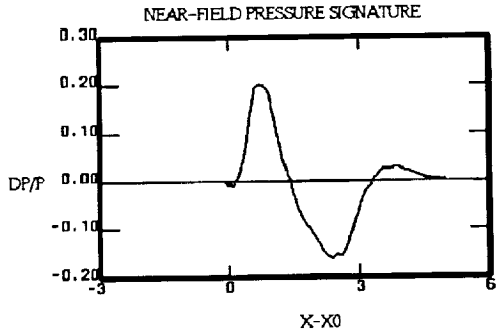


SONIC BOOM ANALYSIS OF A BODY OF REVOLUTION





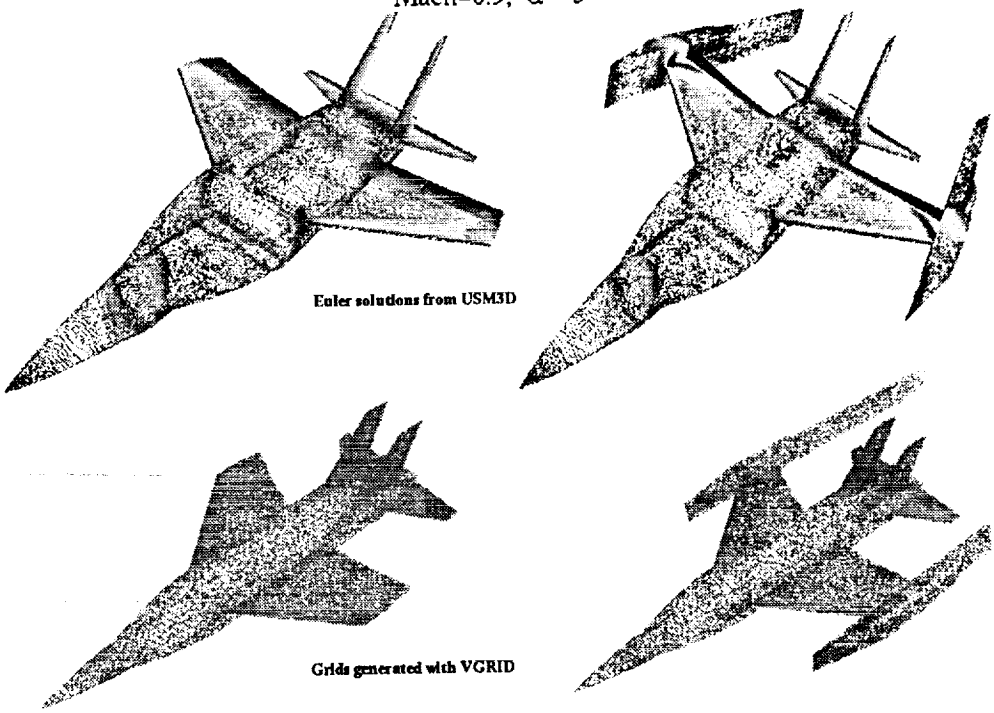




Boeing Multirole Fighter Configuration

Assessment of Tunnel Installation Interference

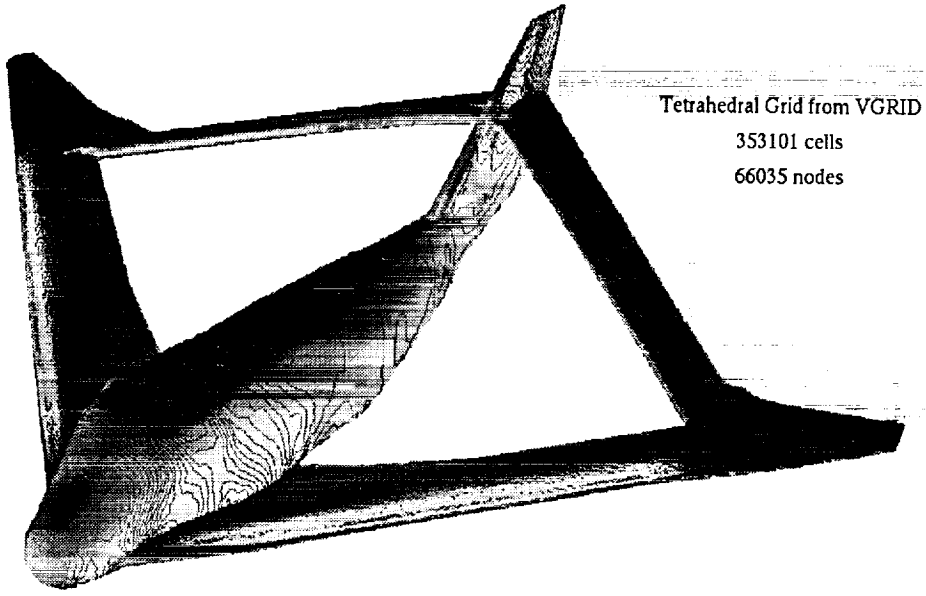
Mach=0.9, α = 3°



Boeing Joined–Wing Configuration

Cp Distribution from USM3D

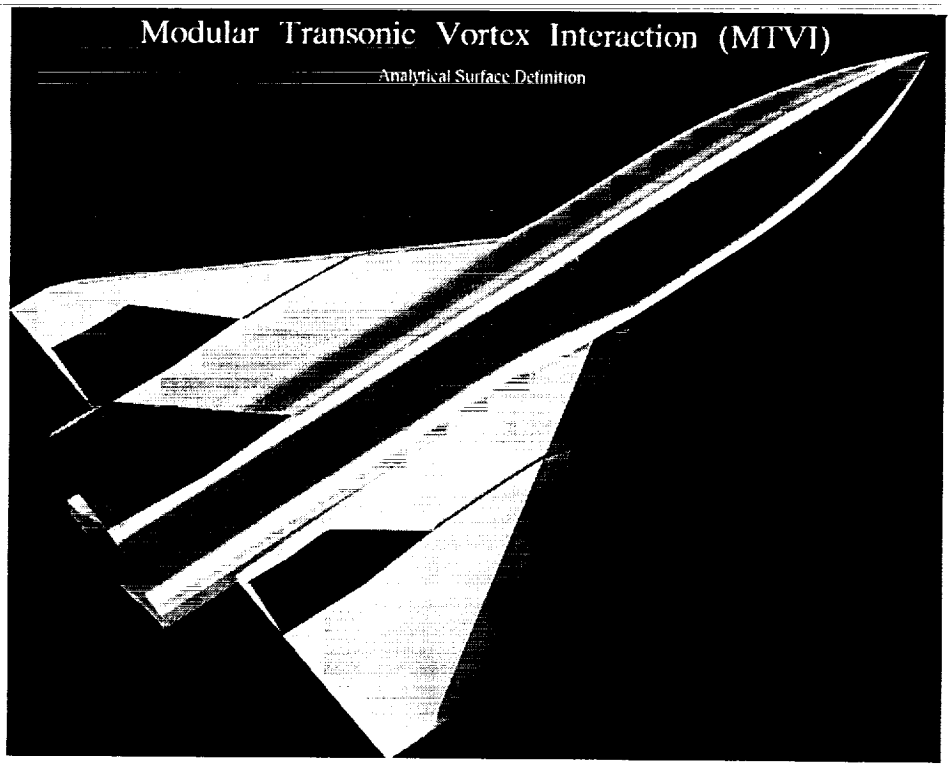
Mach=.38, $\alpha = 4^{o}$



Tetrahedral Grid from VGRID

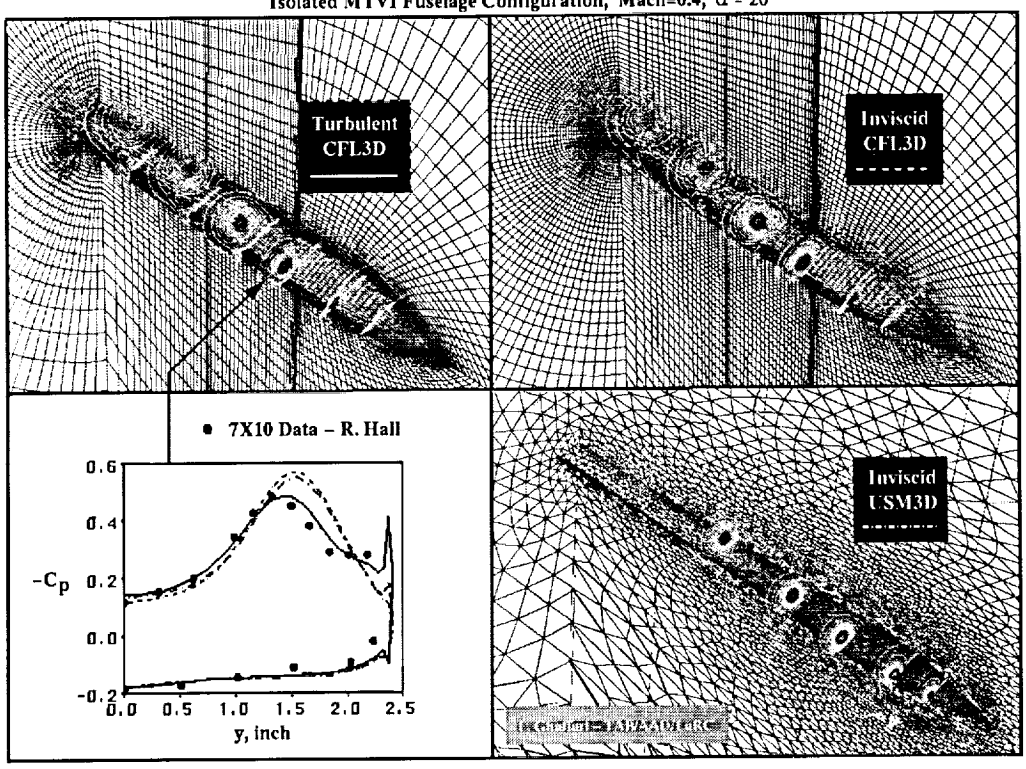
353101 cells

66035 nodes



Structured/Unstructured Code Validation Study

Isolated MTVI Fuselage Configuration, Mach=0.4, $\alpha = 20^{o}$



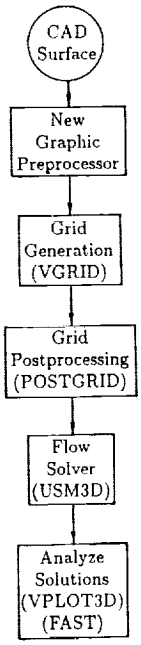
Planned Capabilities
(work underway)

- One-day turnaround for inviscid problems
- Viscous grid generation (2D and 3D)
- 3-D viscous flow solver
- Solution adaptive grids
- Dynamic moving grids (ODU contribution)

User Related Plans

- Establishment of VGRID/USM3D local user's group
- Release/training for VGRID Version 2.5 on June 1, 1993
  - New graphic interface with consolidated preprocessing functions
  - More generalized surface patches with T-intersection feature
- VGRID Version 3.0 to be released later in Summer 1993
  - Direct surface triangulation with n-sided patches
  - More consolidation entire flow analysis process
  - Use of more standardized file formats

Flowchart for Version 3.0 USG System
Release in late Summer 1993



Note: All codes to be interfaced with common file formats

Closing Remarks

- Assembled an integrated aerodynamic analysis and design capability using state-of-the-art three-dimensional USG technology
- Ongoing application-oriented development program dependent on feedback from wide user base
- Grid generation time for complex geometries now measured in days for experienced users
- Made significant advances in overall technology through teaming