HYPERCSONIC CFD APPLICATIONS AT NASA LANGLEY

USING CFL3D AND CFL3DE

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CFL3D/CFL3DE

- Time-dependent conservation law form of compressible Euler and Navier-Stokes equations
- Upwind-biased spatial differencing (Flux Vector Splitting - FVS and Flux Difference Splitting - FDS)
- Thin-layer, finite-volume implementation with algebraic turbulence model
- Zonal grids - longitudinally patched (for hypersonic flows)

  - CFL3D
    - 3-factor implicit time advancement algorithm
    - Thin-layer viscous in 3 directions - two wall corner model
  
  - CFL3DE
    - Streamwise-relaxation crossflow-AF, space-marching Euler or PNS, first or second order
    - Perfect gas or equilibrium air
INDUSTRY USE STATUS OF CODES

  - Production code for NASP for McDonnell Aircraft Company
  - Some use at General Dynamics

● Other industry use
  - Boeing
  - Northrup
  - United Technologies Research Center

● University use
  - Iowa State University

● Other government use
  - Naval Surface Warfare Center
SR71 - GEOMETRY DEFINITION

FOUR ZONES:
51X51X23
71X51X8
71X51X7
91X51X4

$M_{\infty} = 3.0 \quad \alpha = 0^\circ$

$\rho_{\infty} = 0.038 \text{kg/m}^3 \quad P_{\infty} = 5460 \text{N/m}^2$
HYPERSOニック LIFTING BODY

AOA=0

M=19.2

Re=30000/in
PRESSURE COMPARISONS

M = 12.55  
Re = 2.7 million/ft.  
Zero degrees angle of attack

[Graphs showing pressure comparisons for upper and lower surface centerlines with open and closed symbols.]
HEAT TRANSFER COMPARISONS

M = 12.55
Re = 2.7 million/ft.
Zero degrees angle of attack

Upper Surface Centerline

Lower Surface Centerline

Open symbols - upper surface
Closed symbols - lower surface
AERODYNAMIC COEFFICIENTS COMPARISON MCDONNELL BLENDED WING BODY CFD AND EXPERIMENT

\[ M = 12.4, \alpha = 6^\circ, Re/L = 930,000/ft \]

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DENSITY

GENERIC NOZZLE AFTERBODY

COMPUTATIONAL METHODS BRANCH NASA LANGLY

CONTOUR LEVELS

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<th>MACH</th>
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<td>ALPHA</td>
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<tr>
<td>Re</td>
<td>2.34x10^5</td>
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TEMPERATURE

GENERIC OPTION #2 : 2-D INLET MODEL

COMPUTATIONAL METHODS BRANCH NASA LANGLEY

CONTour LEVELS

12.500 MACH
0.00 DEG ALPHA
9.40x10**4 Re
1.0 TIME
95x30x51 GRID
**MACH NUMBER**

30 DEG SLEET  MACH 3.5 INLET

COMPUTATIONAL METHODS BRANCH NASA LANGLEY

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<th>Contour Levels</th>
<th>Mach</th>
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<td>31 x 72 x 15</td>
<td>Grid 3</td>
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FUTURE PLANS RELATED TO THE NATIONAL AERO-SPACE PLANE PROGRAM

- Continue to expand the envelope of capabilities for the code to include calculations of an entire NASP-like configuration

- Improved zonal capabilities for inlets with sweep and combustors

- Addition of non-equilibrium chemistry for combustor and nozzle/afterbody calculations

- All capabilities scheduled for production code by 1/90 (NASP Technology Maturation Program)