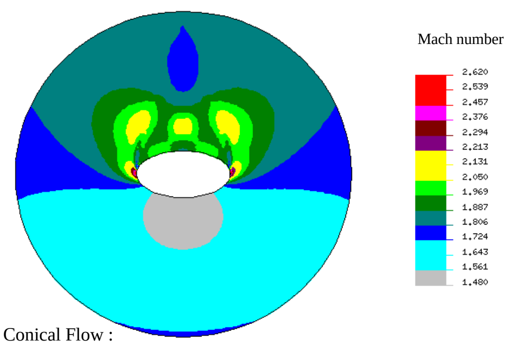
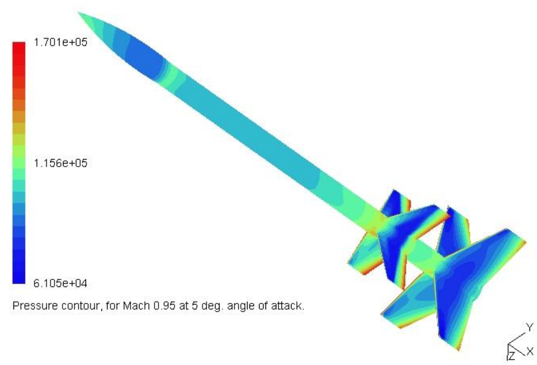
FluSol™

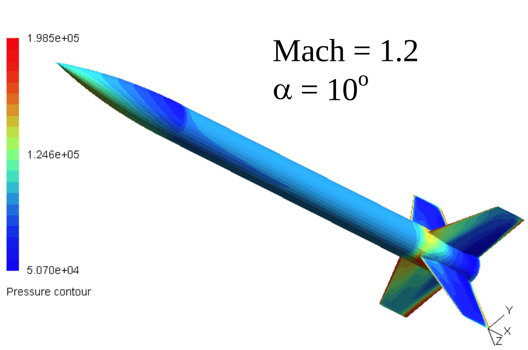
A Finite Element Method Based CFD Program For Aerospace Industry

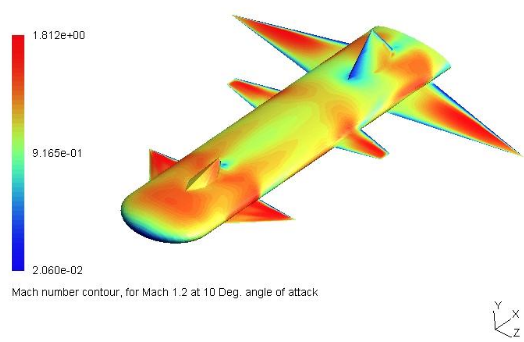


Conical Flow :

Cross sectional Mach number contour for Mach 1.8 flow past a 5:2.5 degrees of ellipse at 20º of angle of attack.







FluSol-CFD, LLC

Contact: cfd-rocket@gmail.com

FluSol

A Finite Element Code for the Defense and the Aerospace Design Engineering

GEOMETRY AND MESH CAPABILITIES

- Generation of mesh, initial and boundary conditions
- Triangle and quadrilateral elements for 2D computational domain
- Hexahedral, prismatic, pyramidal and tetrahedral elements for 3D computational domain.
- Convert any 2D quadrilateral mesh into all triangles
- Convert any 3D hexahedral mesh into all prisms or pyramids or tetrahedral elements
- Sweeping 2D axisymmetric mesh around the axis line to create hybrid 3D mesh and corresponding initial and boundary conditions

UNSTEADY STATE COMPRESSIBLE FLOW GOVERNING EQUATIONS SOLVED

- Navier-Stokes equations plus species mass equations with or without chemical reaction
- Gas properties for chemical reacting flow are calculated by CHEMKIN package
- Navier Stokes equations
- Euler equations
- Navier-Stokes and Euler equations under conical coordinate
- Navier-Stokes or Euler equations plus particular mass, momentum and energy equations under Eulerian coordinate for two phase flow problems
- Navier-Stokes or Euler equations plus particular mass, momentum and energy equations under Lagrangian coordinate for two phase flow problems

NUMERICS

- Totally unstructured grid: Structured/Unstructured/Hybrid
- Steady state time integration with local time step technique
- Choice of first order upwind or 2nd order TVD schemes
- Second order time accuracy for transient flow simulation
- Explicit scheme no matrix operations

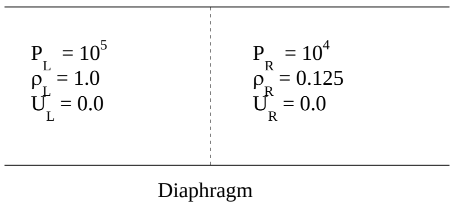
APPLICATIONS

- 1D, planar, cylindrical and spherical flows
- 2D planar flow
- 2D axisymmetric flow
- 3D flow
- Subsonic, transonic, supersonic and hypersonic flows with/without chemical reactions
- Particles + gas two phase flow

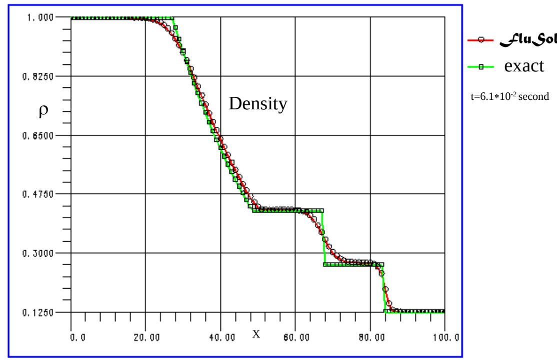
Problem: Transient Solution at 6.1 μ Second for The Sod's Shock Tube

* 1D planar flow
* Exact Riemann solution

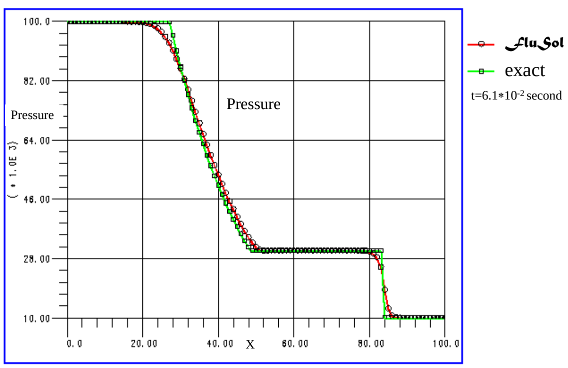
* Shock tube problem
* Transient solution



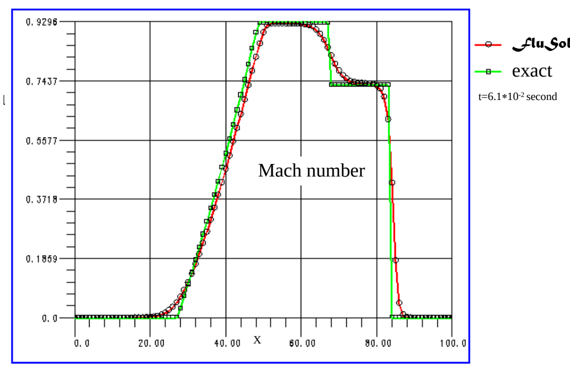
Computational domain for one dimensional shock tube problem.



Density distribution at $6.1*10^{-2}$ second after the diaphragm was broken.



Pressure distribution at $6.1*10^{-2}$ second after the d iaphragm was broken.

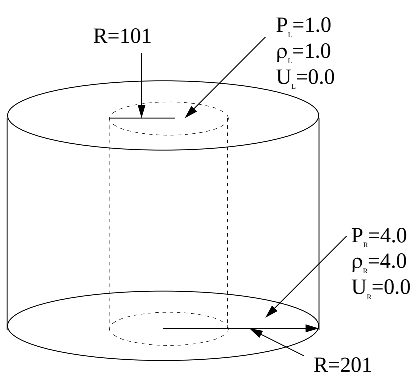


Mach number distribution at $6.1*10^{-2}$ second after the diaphragm was broken.

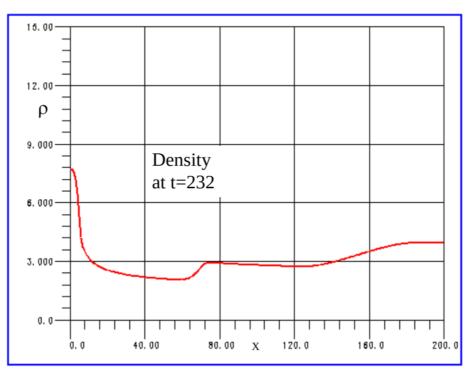
Problem: Reflection of a Cylindrical Convergent Shock Wave

* 1D cylindrical flow
* Transient solution

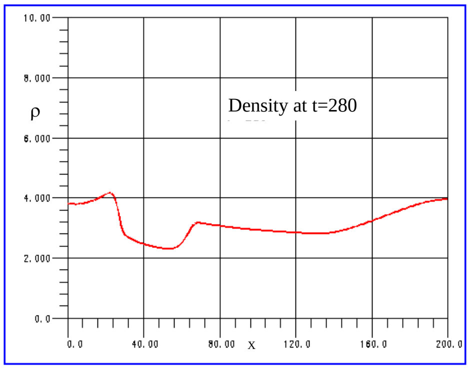
* Cylindrical shock tube problem



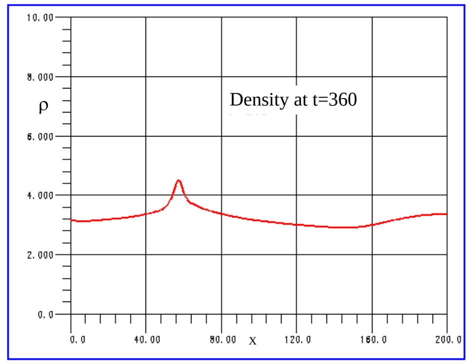
Computational domain for converging and reflecting cylindrical shock wave .



Density distribution at 232 time steps after the diaphragm was broken.



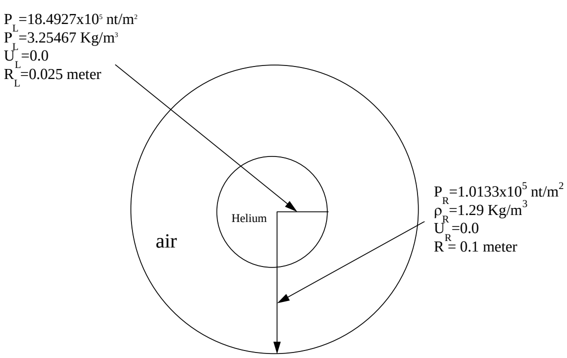
Density distribution at 280 time steps after the diaphragm was broken.



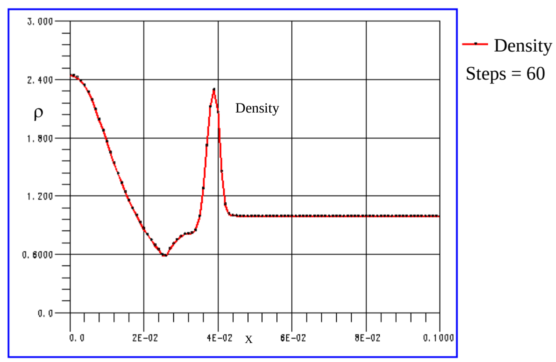
Density distribution at 360 time steps after the diaphragm was broken.

Problem: Helium Exploded Into Surrounded Air

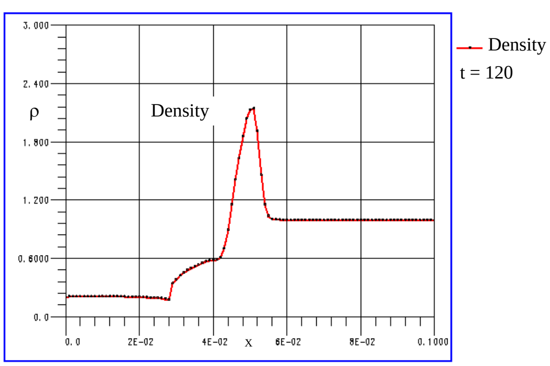
* 1D spherical flow
* Spherical shock wave
* Transient solution



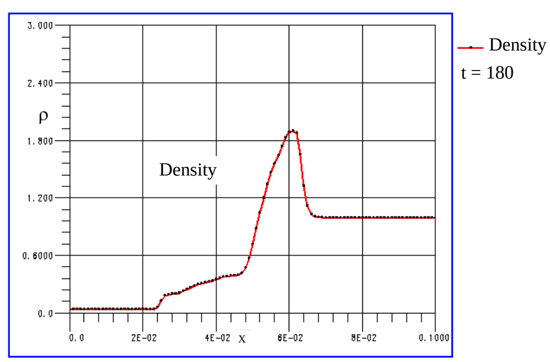
Computational doamin for Helium spherically exploded into surrender air.



Density distribution at 60 time steps after the Helium sphere was broken.

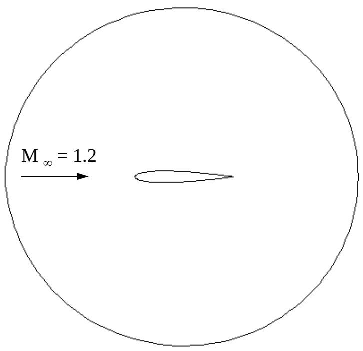


Density distribution at 120 time steps after the Helium sphere was broken.

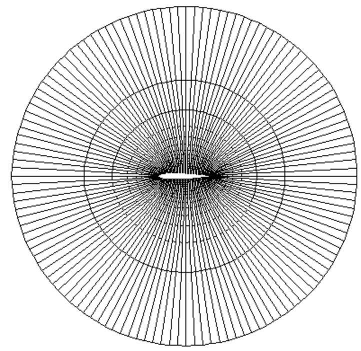


Density distribution at 180 time steps after the Helium sphere was broken.

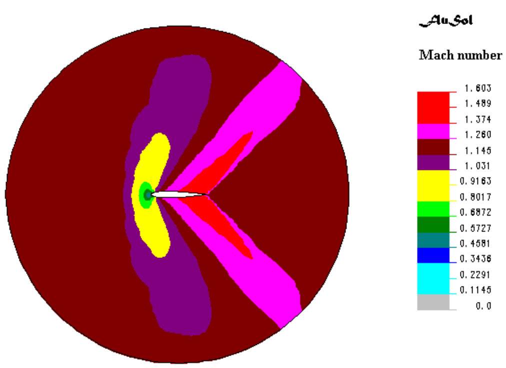
Problem: Mach 1.2 flow past a NACA0012 airfoil at 0^o angle of attack



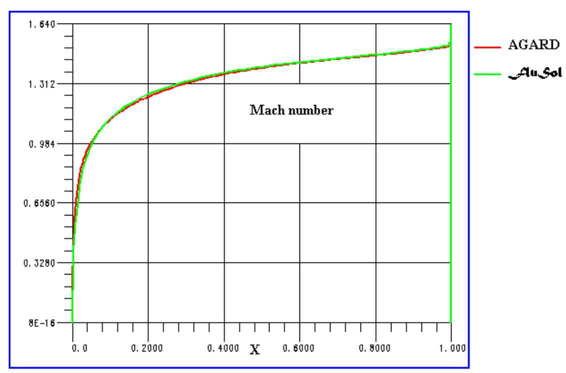
Problem : Mach 1.2 flow past a NACA0012 airfoil at α = 0^o.



Finite element mesh for flow past NACA0012 airfoil.

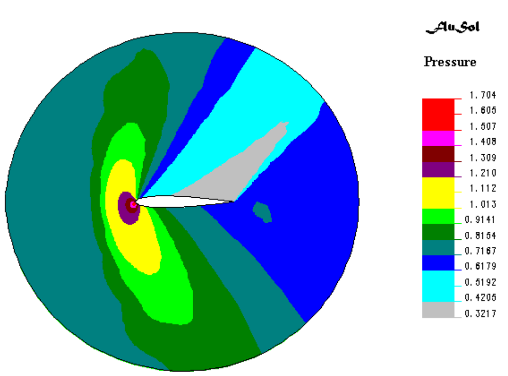


Mach number contour for Mach 1.2 flow past a NACA0012 airfoil at zero degree of angle of attack.

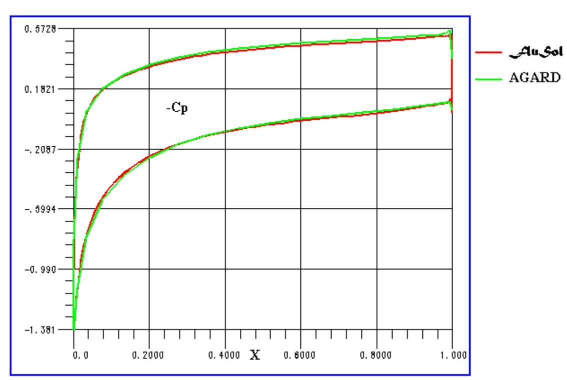


Mach number distribution along the naca0012 airfoil surface.

Problem: Mach 1.2 flow past a NACA0012 airfoil at 7^o angle of attack



Pressure contour for Mach 1.2 flow past a NACA0012 airfoil at 7^o degrees of angle of attack.

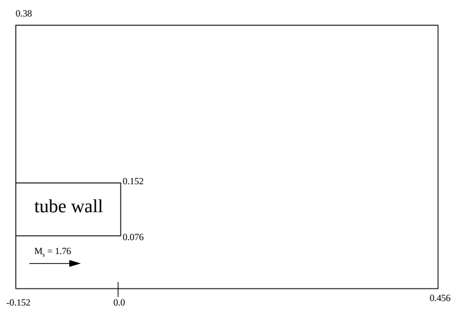


-Cp distribution along solid wall for Mach 1.2 flow past a naca0012 airfoil at 7 degrees of angle of attack.

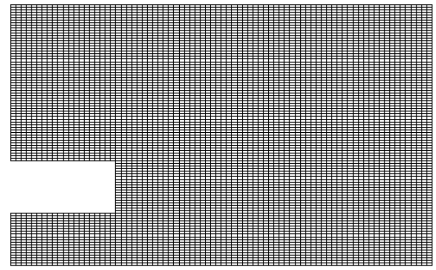
Problem: Mach 1.76 shock wave out of a cylindrical tube

* Transient simulation

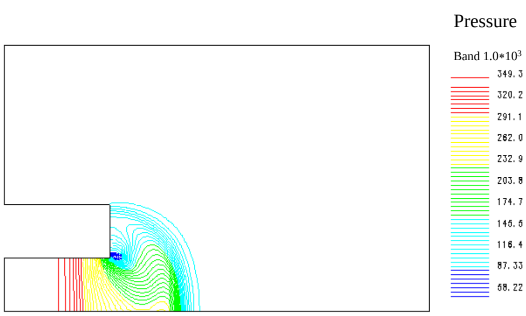
* Inviscid flow



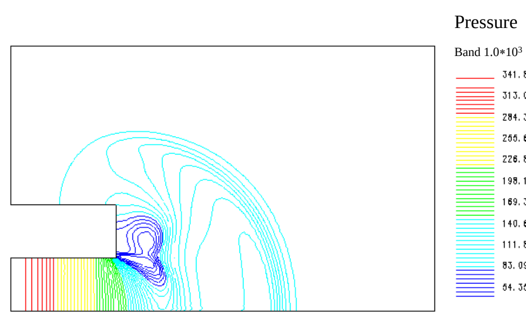
Computational domain for Mach 1.76 shock wave moves out a cylindrical tube.



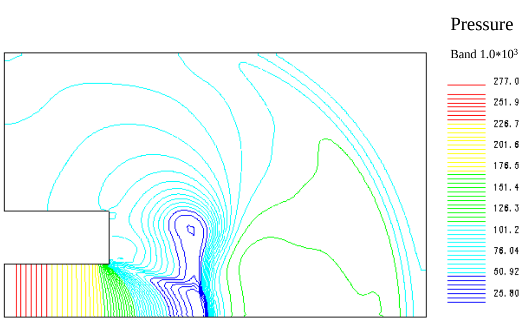
Finite element mesh for shock wave moves outa cylindrical tube.



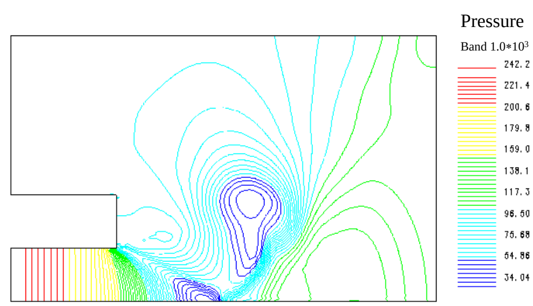
Pressure contour line at 200 µ seconds after shock wave moves out the tube.



Pressure contour line at 500 µ seconds after shock wave moves out the tube.



Pressure contour line at 1000 µ seconds after shock wave moves out the tube.

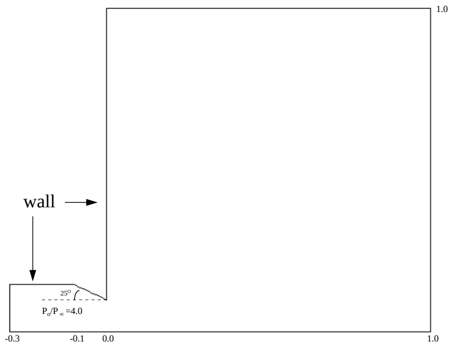


Pressure contour line at 1500 µ seconds after shock wave moves out the tube.

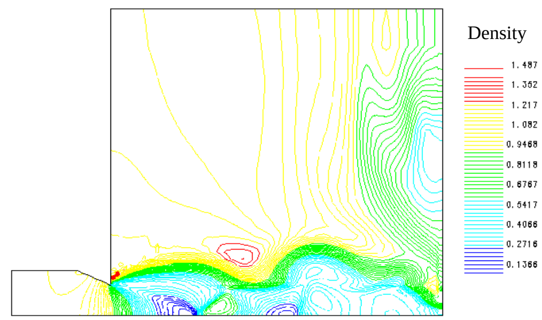
Problem: Flow discharges from a 25° or 45° convergent nozzles with P/P∞ = 4.0

* Convergent nozzle

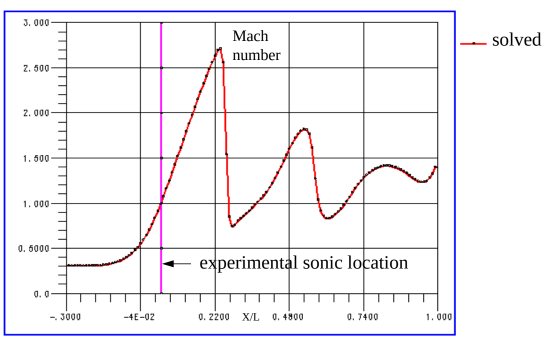
* Inviscid flow



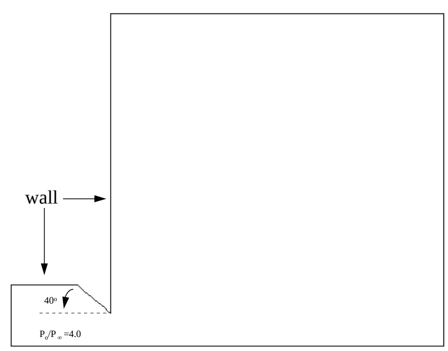
Computational domain for flow dischares from a 25° conical nozzle.



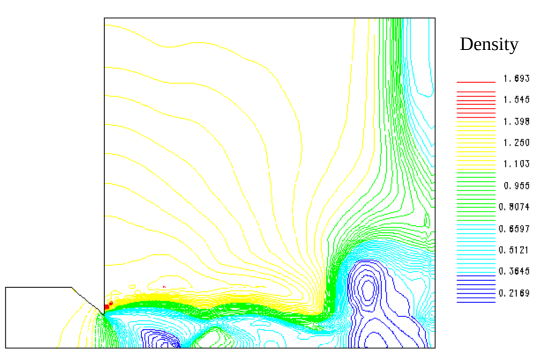
Density contour lines for flow discharges from a 25° conical nozzle with P_o/P_∞ =4.0.



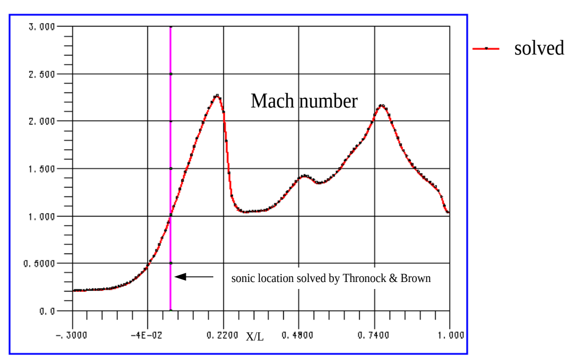
Mach number distribution along the axis line for flow discharges from a 25° conical nozzle.



Computational domain for flow dischares from a 40° conical nozzle.



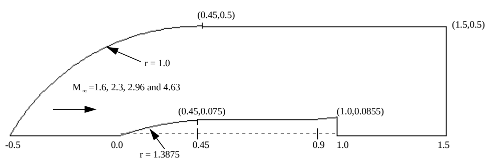
Density contour lines for flow discharges from a 40° conical nozzle with P_o/P_∞ =4.0.

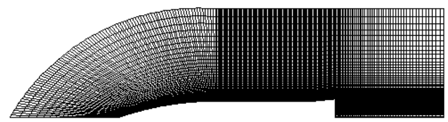


Mach number distribution along the axis line for flow discharges from a 40° conical nozzle.

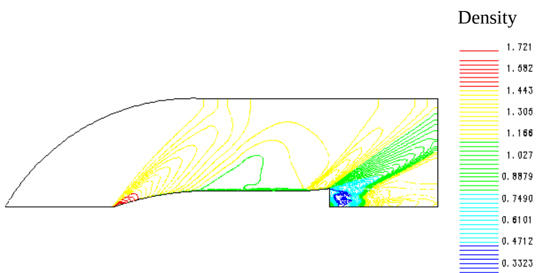
Problem: Mach 1.6, 2.3, 4.63 flow past an circular-arc-cylinder-flare projectile with Reynolds number equal to 6.6x10^6. NASA-TMX-3558

* Supersonic viscous flow
* Finite element unstructured grid
* Circular-arc-cylinder-flare projectile

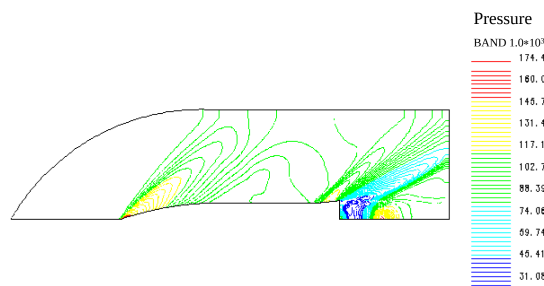




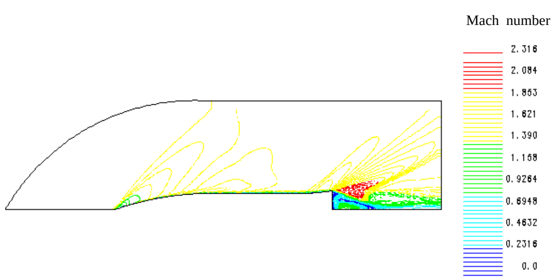
Supersonic flow past a circular-arc-cylinder-flare projectile.



Density contour line for Mach 1.6 flow past a circular-arc -cylinder-flare projectile with Re = 6.6x10^6.



Pressure contour line for Mach 1.6 flow past a circular -arc-cylinder-flare projectile with Re = 6.6x10^6.



Mach number contour line for Mach 1.6 flow past a circular-arc -cylinder-flare projectile with Re = 6.6x10^6.

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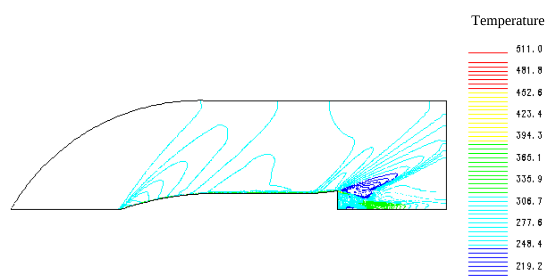
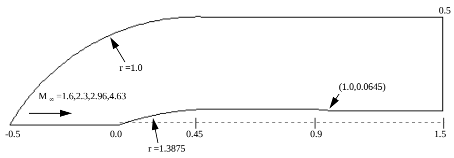


Temperature contour line for Mach 1.6 flow past a circular-arc-cylinder-flare projectile with Reynolds number equal to 6.6x10^6.

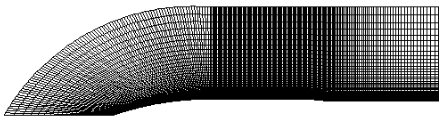
Problem: Mach 1.6, 2.3, 4.63 flow past an circular-arc-cylinder-boattail projectile with Reynolds number equal to $6.6x10^6$. NASA-TMX-3558

* Supersonic viscous flow
* Finite element

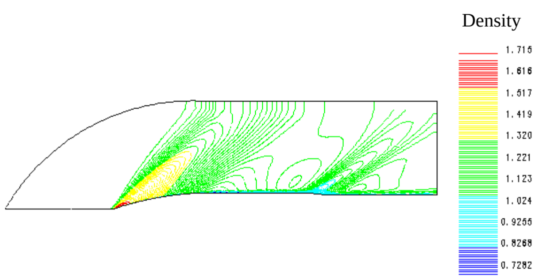
* Circular-arc-cylinder-boattail projectile
* Unstructured grid



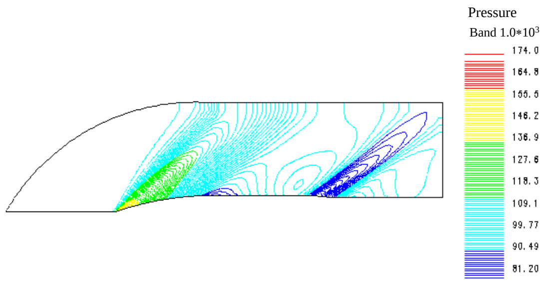
Mach 1.6 flow past a circular-arc-cylinder-boattail projectile with Reynolds number equal to $6.6x10^6$.



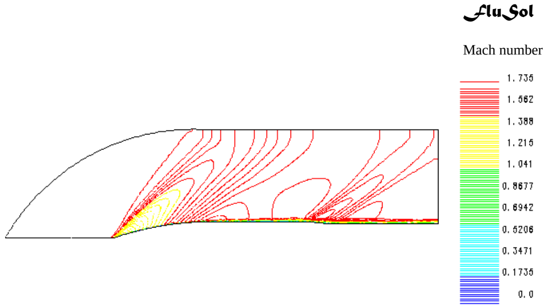
Finite element mesh for flow past a circular-arc-cylinder -boattail projectile.



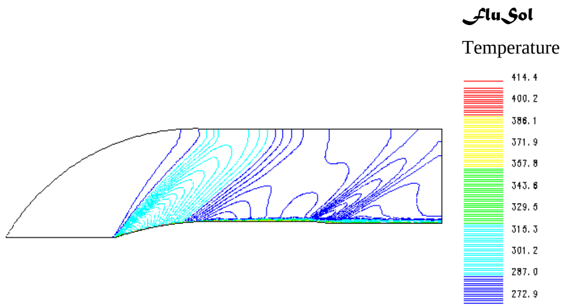
Density contour lines for Mach 1.6 flow past a circular-arc -cylinder-boattail projectile with $Re=6.6x10^6$.



Pressure contour lines for Mach 1.6 flow past a circular-arc -cylinder-boattail projectile with $Re=6.6x10^6$.



Mach number contour lines for Mach 1.6 flow past a circular-arc-cylinder-boattail projectile with Reynolds number equal to $6.6x10^6$.

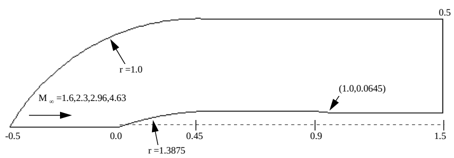


Temperature contour lines for Mach 1.6 flow past a circular-arc-cylinder-boattail projectile with Reynolds number equal to $6.6x10^6$.

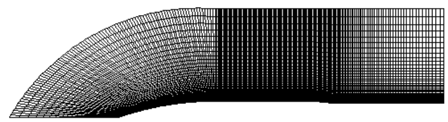
Problem: Mach 1.6, 2.3, 4.63 flow past an circular-arc-cylinder-boattail projectile with Reynolds number equal to $6.6x10^6$. NASA-TMX-3558

* Supersonic viscous flow
* Finite element

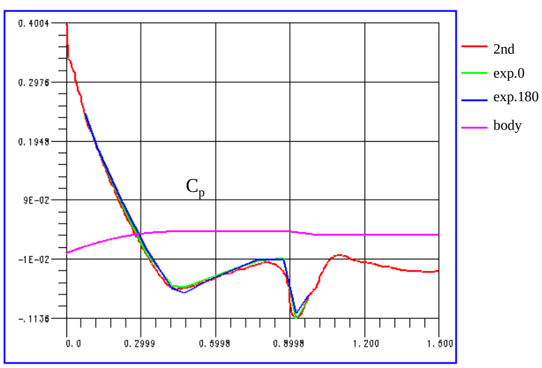
* Circular-arc-cylinder-boattail projectile
* Unstructured grid



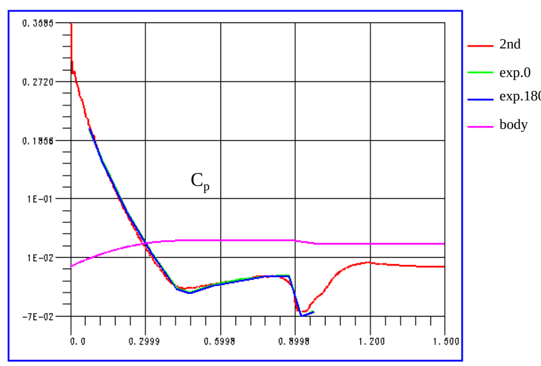
Mach 1.6 flow past a circular-arc-cylinder-boattail projectile with Reynolds number equal to $6.6x10^6$.



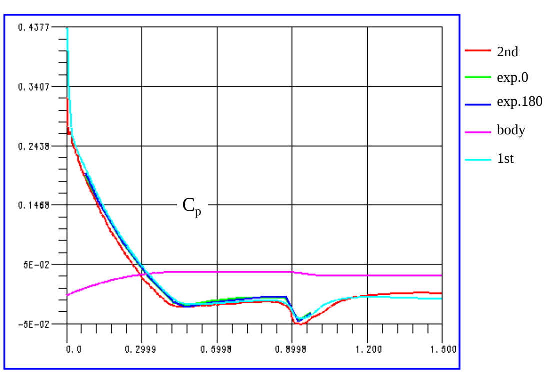
Finite element mesh for flow past a circular-arc-cylinder -boattail projectile.



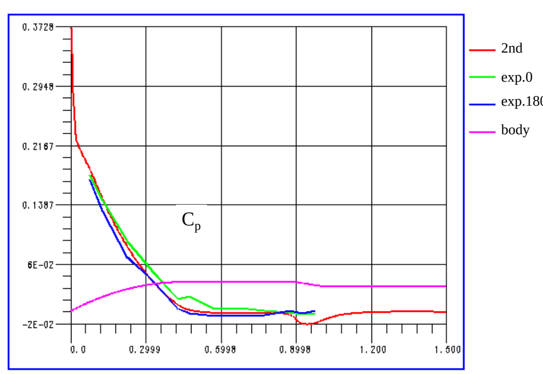
Cp distribution along the solid surface for Mach 1.6 flow past a circular-cylinder-boattail projectile with $Re=6.6x10^6$.



Cp distribution along the solid surface for Mach 2.3 flow past a circular-cylinder-boattail projectile with $Re=6.6x10^6$.



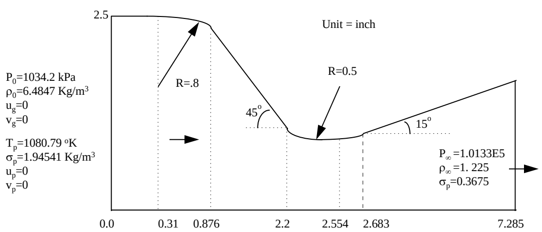
Cp distribution along the solid surface for Mach 2.96 flow past a circular-cylinder-boattail projectile with $Re=6.6x10^6$.

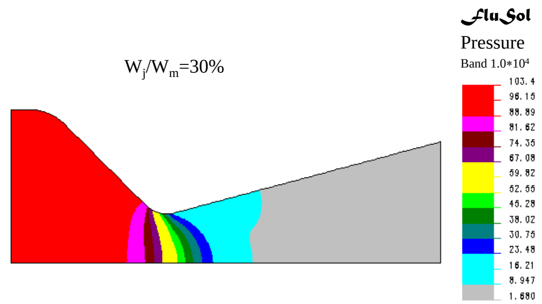


Cp distribution along the solid surface for Mach 4.63 flow past a circular-cylinder-boattail projectile with $Re=6.6x10^6$.

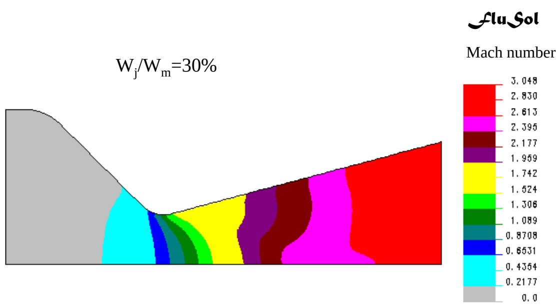
Problem: Solid particles + gas, two phase, flow through a convergent divergent nozzle

* Solid particles + gas flow
* Totally coupled flow
* Eulerian-Eulerian approaches

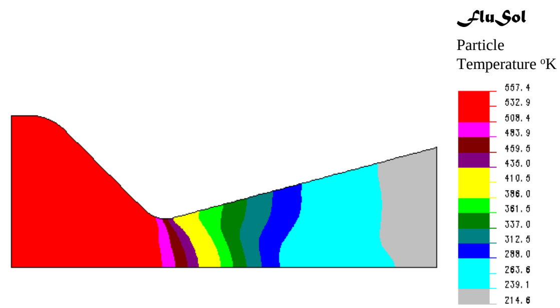




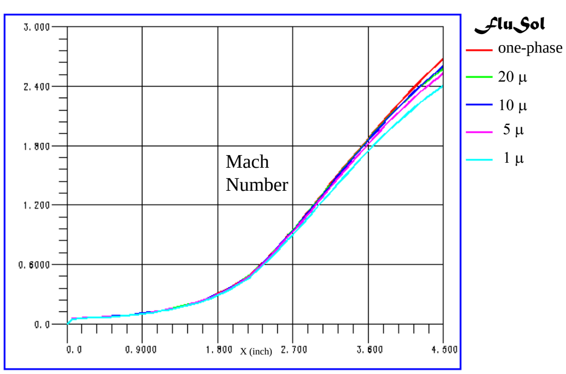
Gas pressure contour for mixture of solid particles and gas flow through a convergent-divergent nozzle. The solid particles have 1μ meter in diameter.



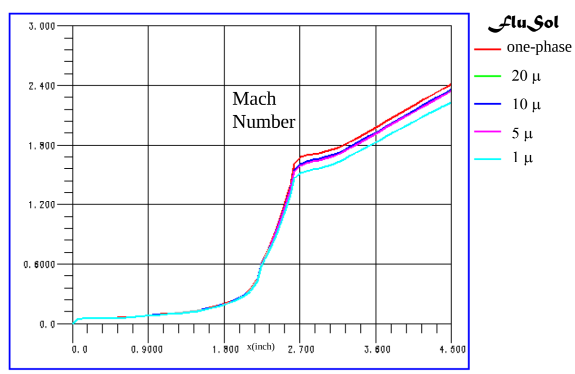
Gas Mach number contour for mixtures of solid particles and gas flow through a convergent divergent nozzle. The solid particles have 1μ meter in diameter.



Particle temperature contour for mixture of solid particles and gas flow through a convergent divergent nozzle. The solid particles have 1μ meter in diameter.



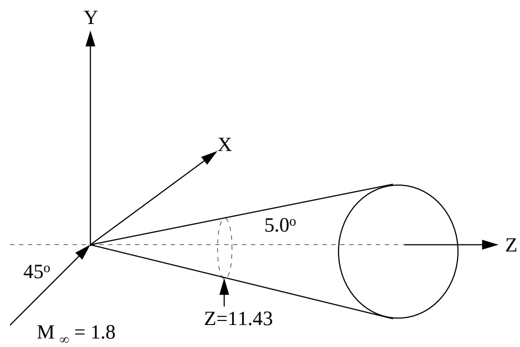
Mach number distribution along the axis line for different particle sizes.



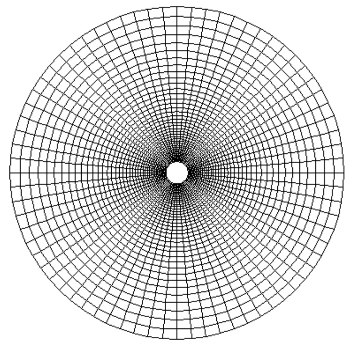
Mach number distribution along the solid wall for different particle sizes.

Problem: Mach 1.8 flow past a 5° cone at 45° angle of attack.

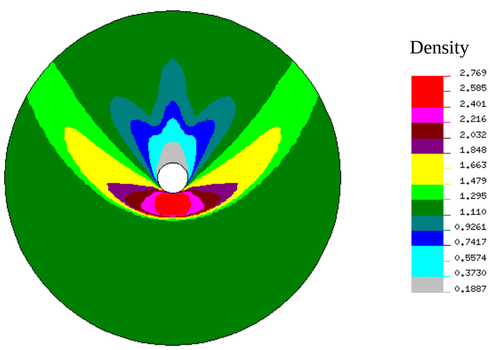
* Supersonic inviscid flow
* Finite element
* Conical flow solution
* Unstructured grid



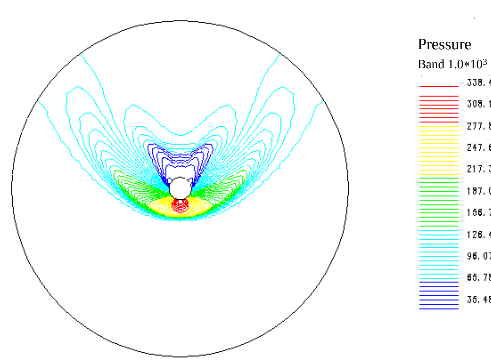
Computational domain for Mach 1.8 flow past a 5° cone at 45° angle of attack.



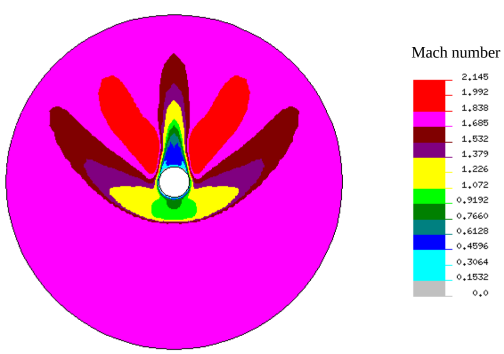
Cross sectional finite element mesh for Mach 1.8 flow past a 5° cone at 45° angle of attack.



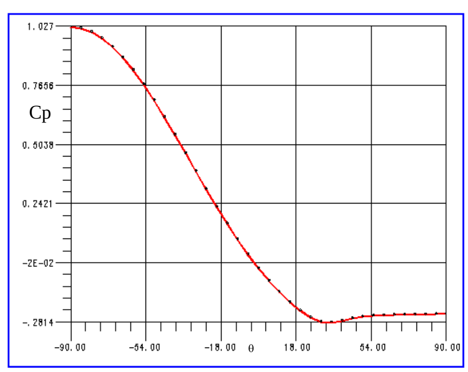
Cross sectional density contour for Mach 1.8 flow past a 5° cone at 45° angle of attack.



Cross sectional pressure contour line for Mach 1.8 flow past a 5°cone at 45° angle of attack.



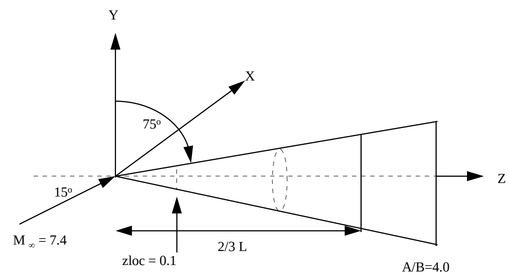
Cross sectional Mach number contour for Mach 1.8 flow past a 5° cone at 45° angle of attack.



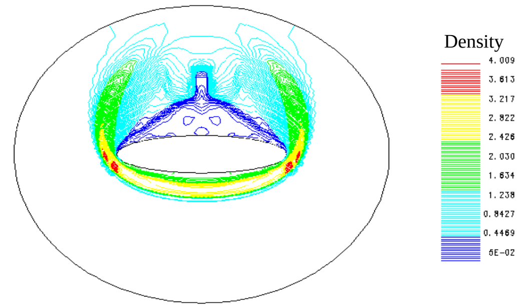
Cross sectional Cp distribution along the elliptical surface for Mach 1.8 flow past a 5°cone at 45° angle of attack.

Problem: Mach 7.4 flow past a 75° swept ellipse cone at 15° angle of attack.

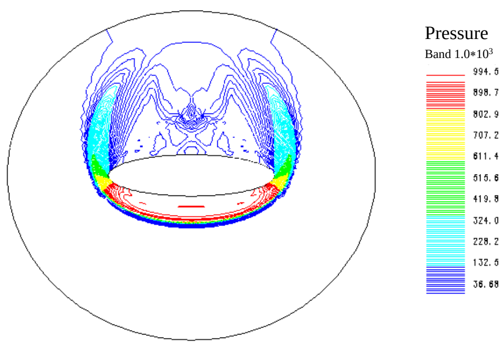
* Supersonic inviscid flow
* Finite element
* Conical flow solution
* Unstructured grid



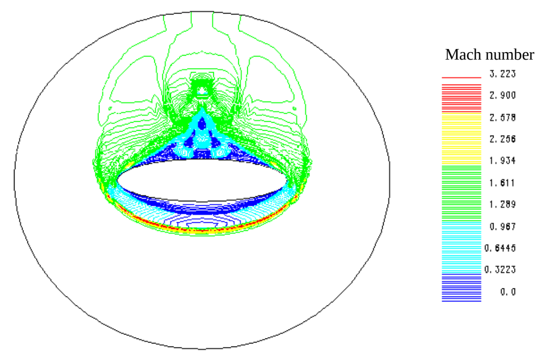
Computational domain for Mach 7.4 flow past a 75° swept ellipse cone with axis length ratio A/B = 4.0 and α = 15°.



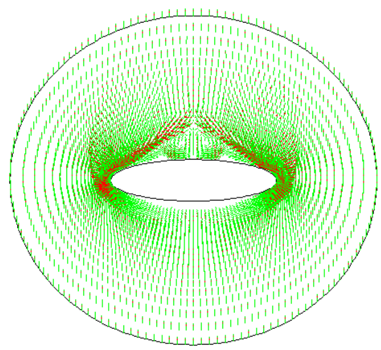
Density contour lines for Mach 7.4 flow past a 75° swept ellipse cone with axis length ratio A/B=4.0 and α = 15°.



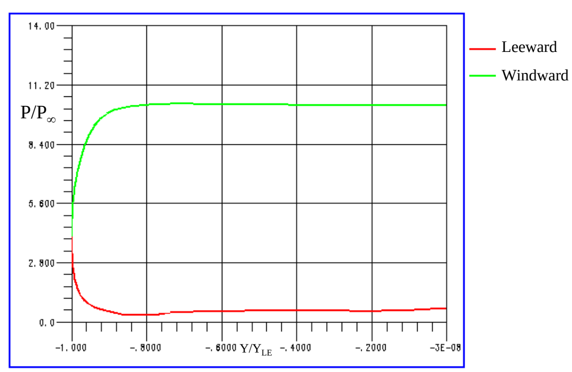
Pressure contour lines for Mach 7.4 flow past a 75° swept ellipse cone at α = 15°.



Cross sectional Mach number contour lines for Mach 7.4 flow past a 75° swept ellipse cone at α = 15°.



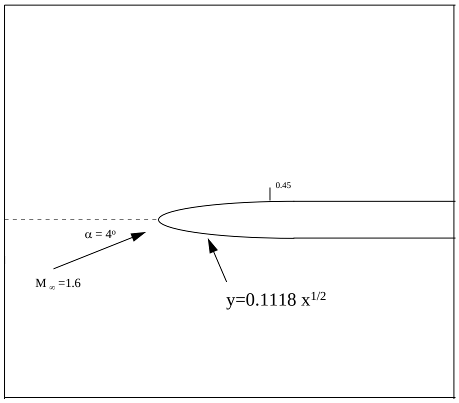
Velocity vector plot for Mach 7.4 flow past a 75° swept ellipse cone at α = 15°.



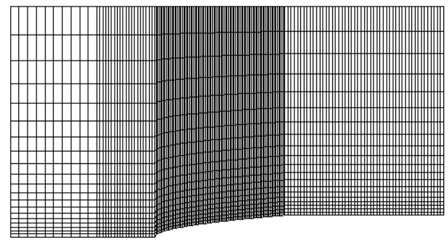
Spanwise surface pressure P/P_∞ distribution at X/L=0.1 for Mach 7.4 flow past a 75° swept ellipse cone at α = 15°.

Problem: Mach 1.6 flow past a blunt-nose-cylinder projectile at 4° angle of attack (NASA-TMX-3558)

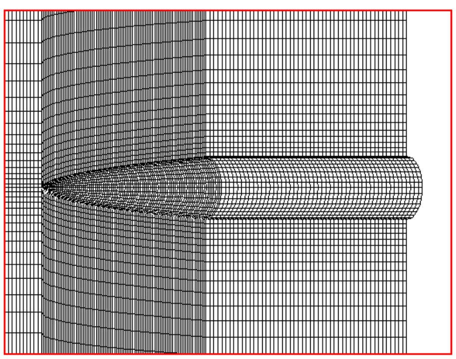
* Create 2D mesh, 3,400 quads
* Rotating the 2D meshes around the axis line to create 3D mesh
* Unstructured hybrid grid (20,214 Hexahedrons, 1,800 Prisms and 120 Pyramids)
* Inviscid flow results



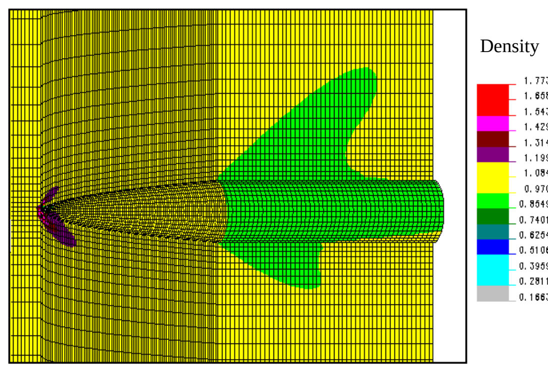
Conputational domain for flow past an blunt nose cylinder projectile.



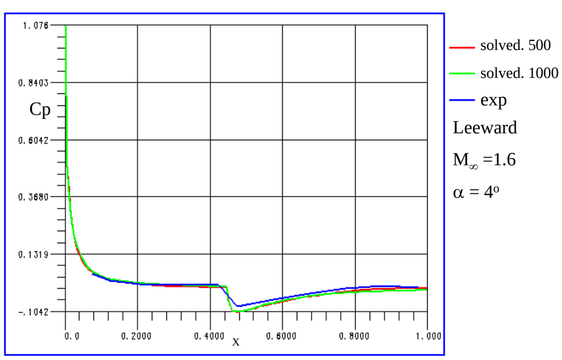
Finite element mesh in two dimensional plane.



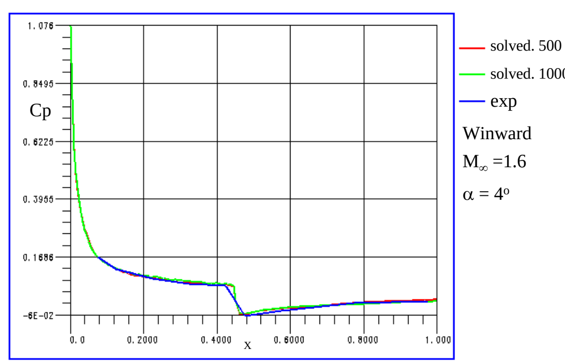
3D finite element mesh created by rotating the 2D mesh around the axis line.



Density contour for Mach 1.6 flow past an blunt nose cylinder projectile at 4° angle of attack.



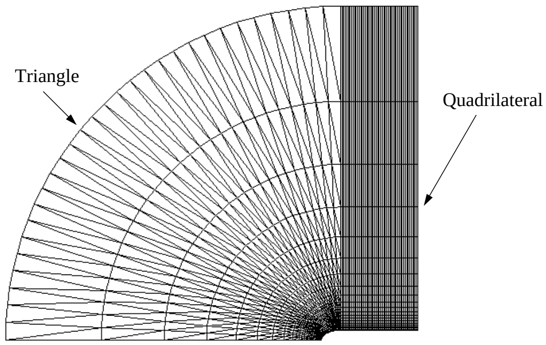
Comparison of Cp distributions along the body surface in Leeward direction.



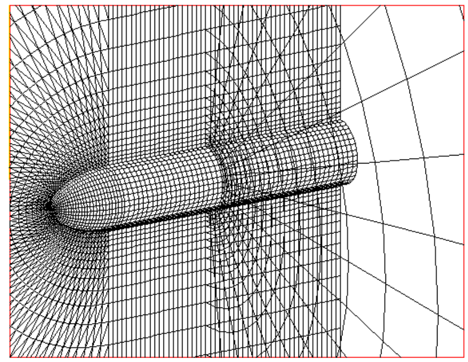
Comparison of Cp distributions along the body surface in the windward direction.

Problem: Mach 1.2 flow past an ellipse-cylinder projectile at 8° angle of attack.

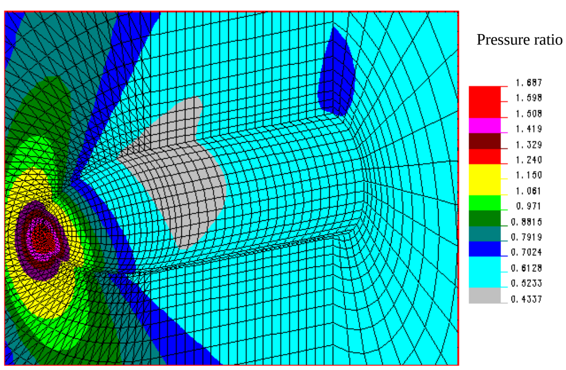
1. Create 2D mesh, all quadrilateral
2. Rotating the 2D mesh around the axis line to create 3D mesh
3. Solve the 3D problem under this hybrid meshes. (Hexadral, Prism, Pyramid and Tetrahedral)
4. Unstructured hybrid grid
5. Euler Solutions



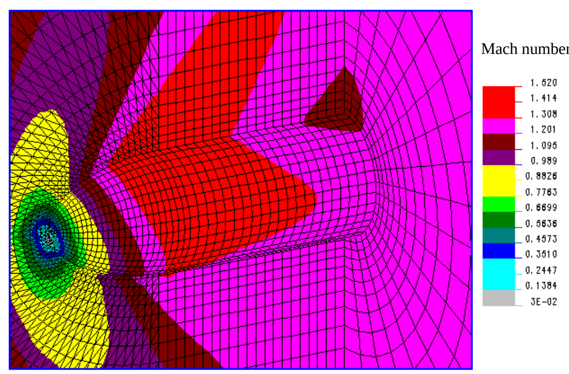
Two dimensional finite element mesh for flow passes an ellipse-cylinder. Hybrid elements.



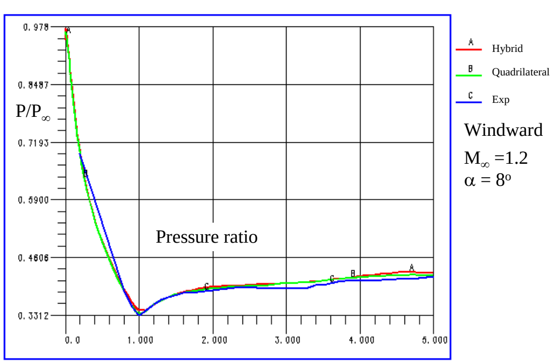
Three dimensional finite element mesh generated by rotating hybrid type 2D element mesh around the axis line.



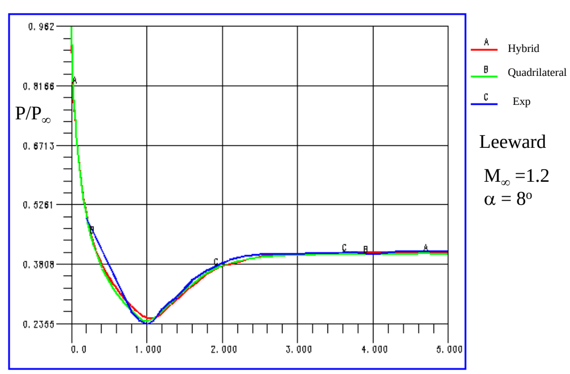
Pressureratio contour for Mach 1.2 flow passes an ellipse-cylinder at 8^{o} angle of attack.



Mach number contour for Mach 1.2 flow passes an ellipse-cylinder at 8^{o} angle of attack.



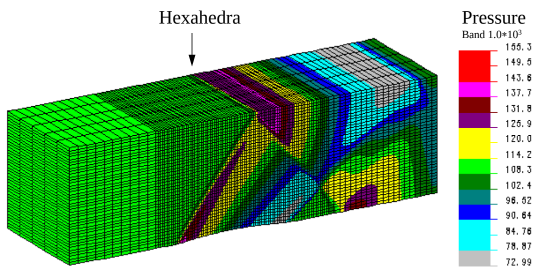
Comparison of pressure ratio along the solid wall between the calculations and wind tunnel test results.



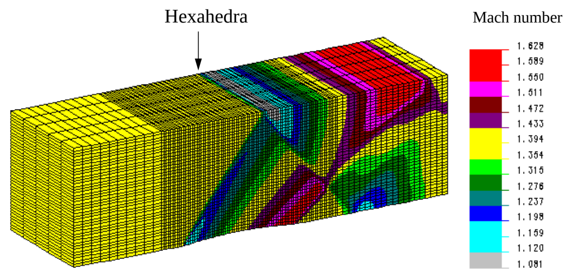
Comparison of pressure ratio along the solid wall between the calculations and wind tunnel test results.

Problem: Mach 1.4 flow past a 4% circular bump.

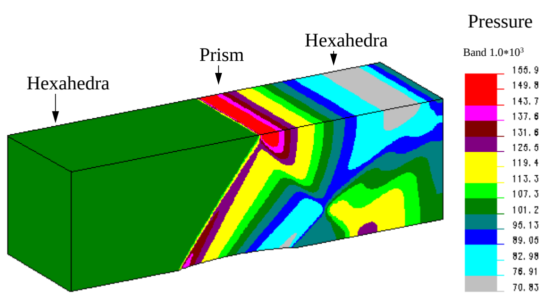
1. Unstructured hybrid grid   2. Euler Solutions



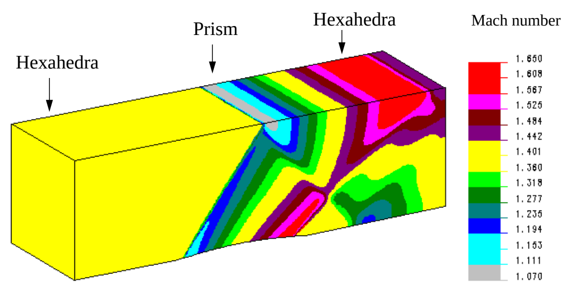
Pressure contour for Mach 1.4 flow past a 4% circular bump.



Mach number contour for Mach 1.4 flow past a 4% circular bump.

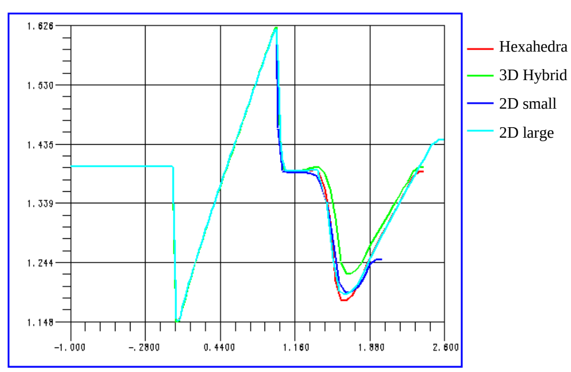


Pressure contour for Mach 1.4 flow past a 4% circular bump.



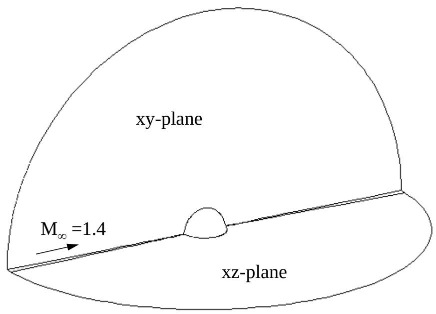
Mach number contour for Mach 1.4 flow past a 4% circular bump.

Mach number contour for Mach 1.4 flow past a 4% circular bump. 2D solution.

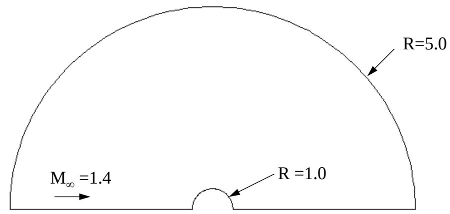


Mach number distributions along the bottom wall.

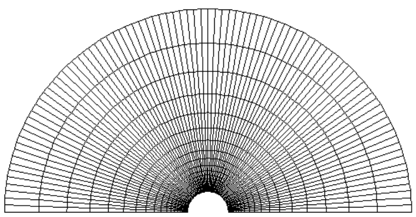
Problem: Mach 1.4 flow past a sphere



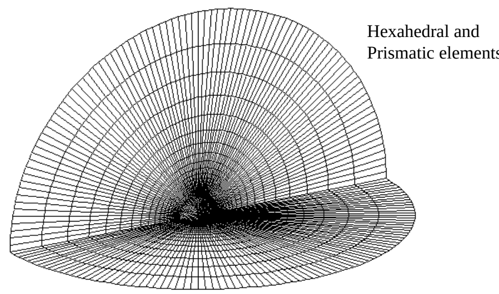
Mach 1.4 flow past a sphere.



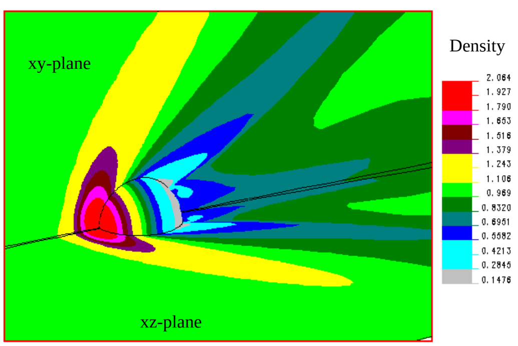
Step 1. Set computational domain for flow past a sphere in xy plane.



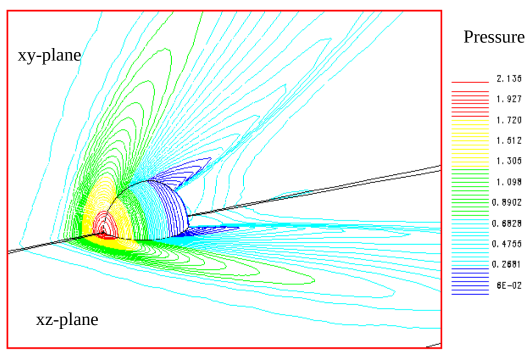
Step 2. Create 2D finite element mesh on xy plane.



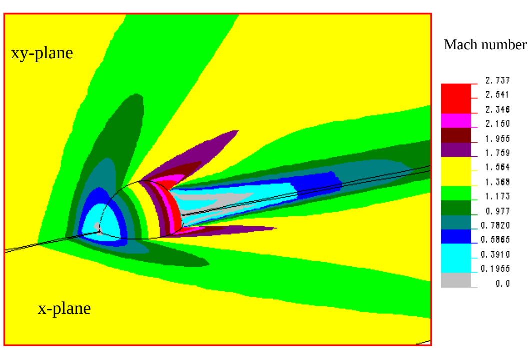
Step 3. Sweep the 2D mesh around the x-axis line to create 3D finite element mesh.



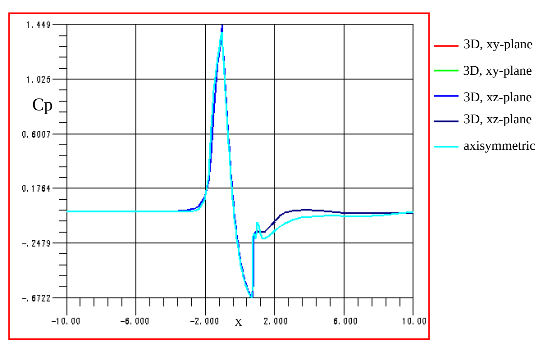
Density contour line for Mach 1.4 flow past a sphere.



Pressure contour line for Mach 1.4 flow past a sphere.

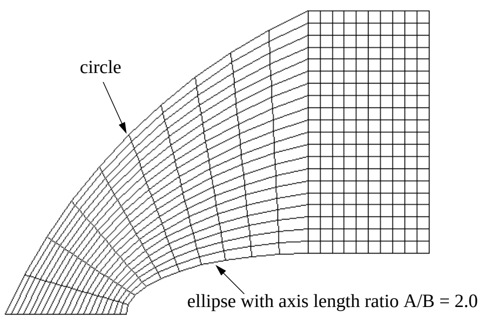


Mach number contour line for Mach 1.4 flow past a sphere.

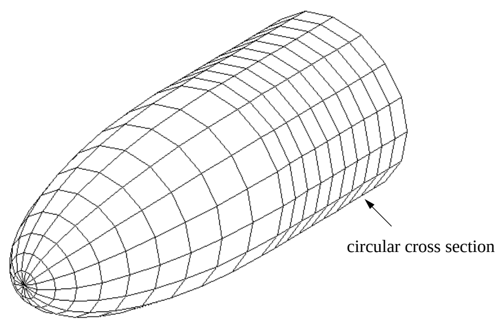


Cp distribution along the sphere surface obtained from 3D and axisymmetric calculations.

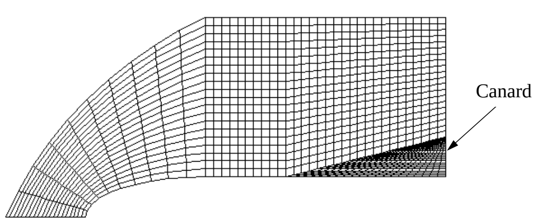
- The following figures show you how simple it is for *FluSol* to generate 3D finite element meshes for arbitrary number of wings and body combination. At the same cross section, user can specify up to 4 wings. The generated body cross section can be a circle or an ellipse shape. 3D full or half (symmetry) meshes can be generated by one command. *FluSol* will also generate corresponding initial and boundary conditions at the same time. After the Euler or Navier Stokes calculations, the pressure force coefficients (CDX, CDY, CDZ) at any specified surface will be integrated. The whole process of generating 3D mesh takes less than one hour instead of days. Another advantage of this tool is that, by using the explicit scheme to solve the fluid flow equations without matrix operation involved, very large problem can be handled easily with limited RAM space. A PC with 1 Giga bytes of RAM can be used to solve the 3D Euler flow problem with CFD model contains 700,000 elements.



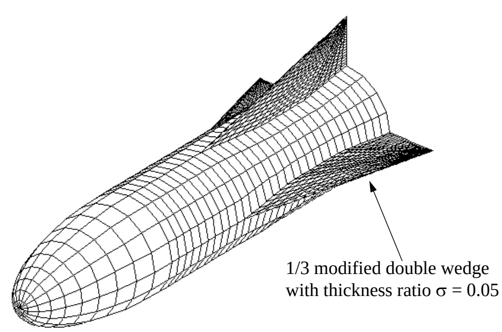
Step 1. Generating 2D mesh for nose-cylinder portion.



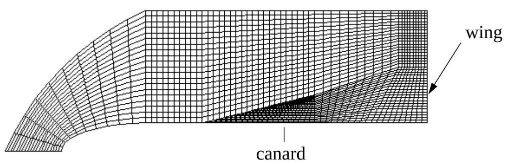
Step 2. Sweeping the 2D mesh around the axis line to create 3D mesh and corresponding initial and boundary conditions.



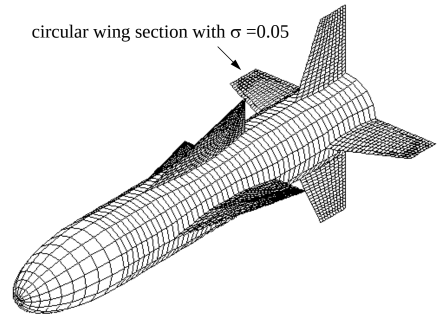
Step 3. Adding a triangle canard to the existing nose-cylinder and create 2D mesh.



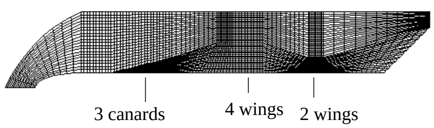
Step 4. Sweeping the existing 2D mesh around the axis line to create 3D canard-body mesh. Note only three canards are specified.



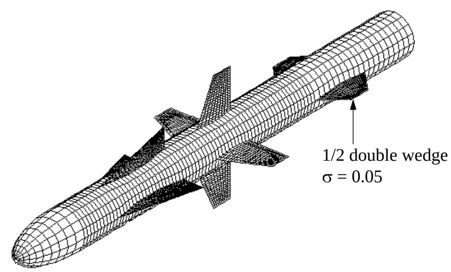
Step 5. Adding another wing.



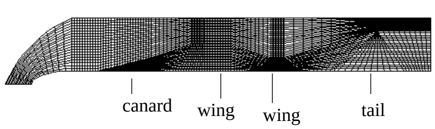
Step 6. Creating 3D canard-wing body mesh and corresponding initial and boundary conditions.



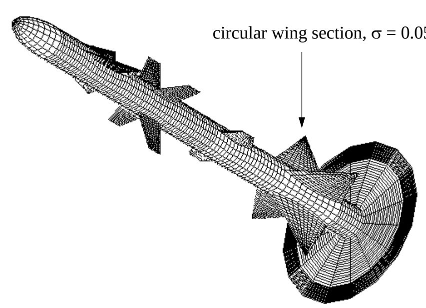
Step 7 Adding another wing and creates 2D mesh.



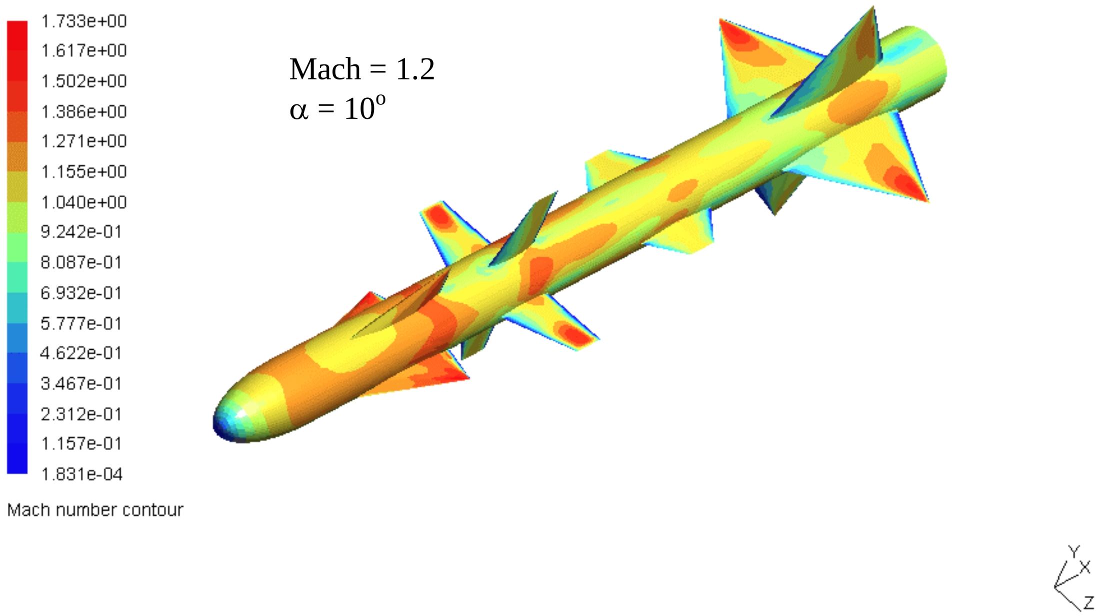
Step 8. Sweeping 2D mesh around the axis line and creating 3D mesh.

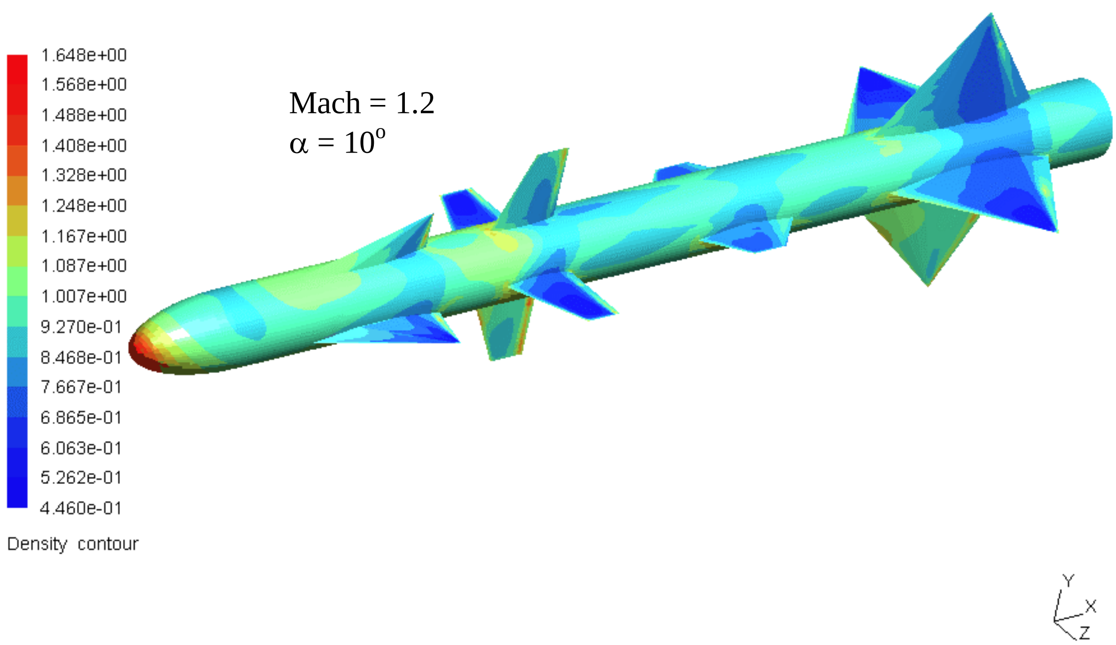


Step 9. Adding another tail and build 2D mesh.

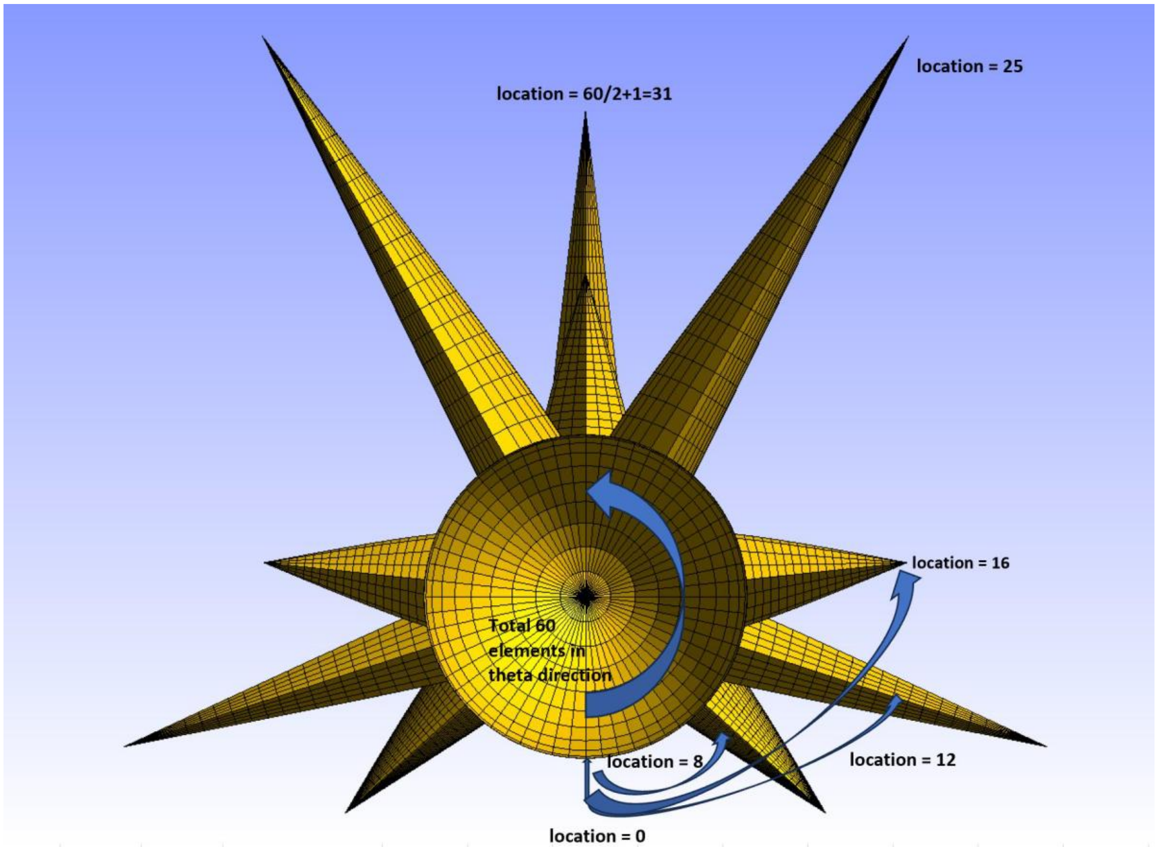


Step 10. Creating 3D mesh for arbitrary number of wings and body combination and corresponding initial and boundary conditions.

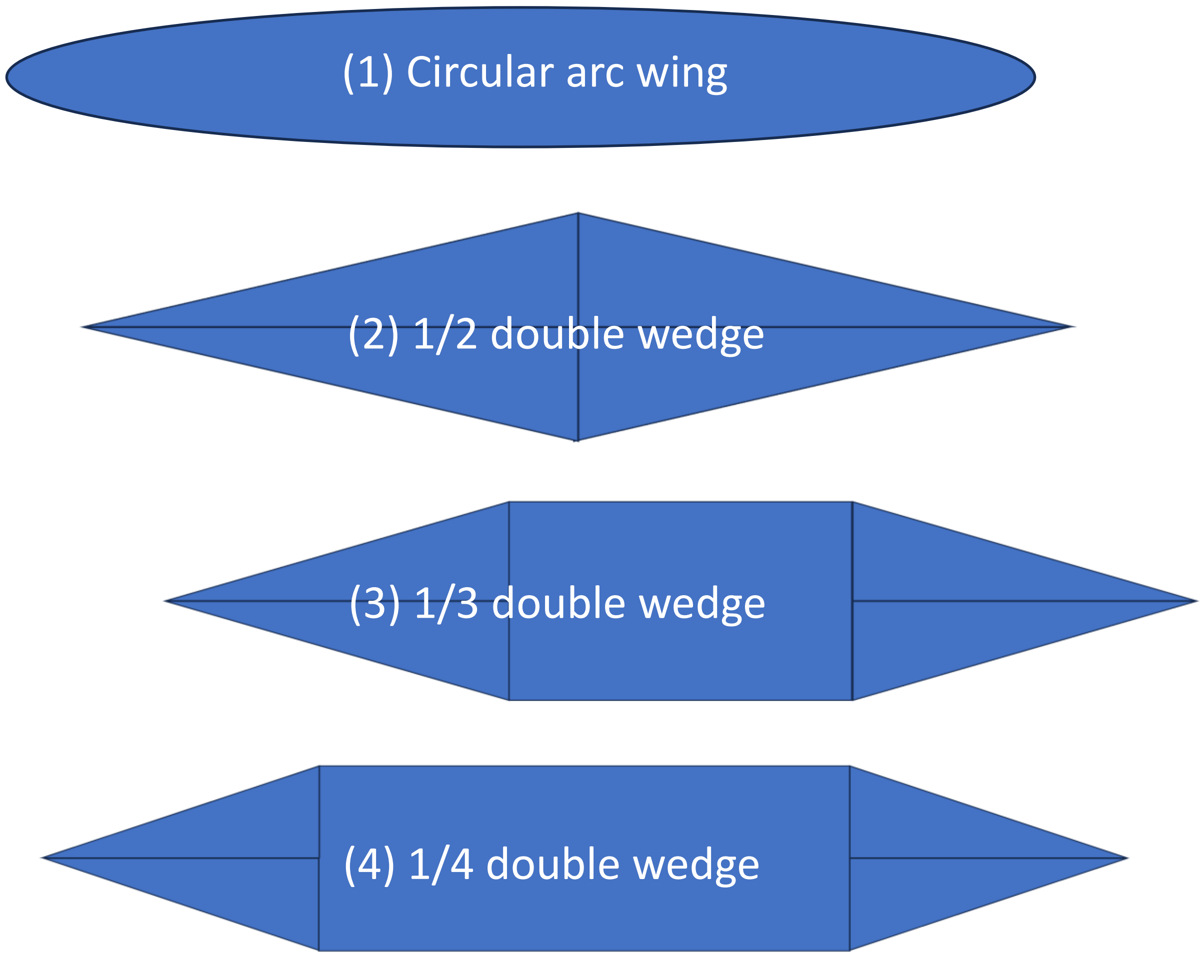

1.733e+00
1.617e+00
1.502e+00
1.386e+00
1.271e+00
1.155e+00
1.040e+00
9.242e-01
8.087e-01
6.932e-01
5.777e-01
4.622e-01
3.467e-01
2.312e-01
1.157e-01
1.831e-04
Mach number contour
Mach = 1.2
α = 10°
Y
X
Z


1.648e+00
1.568e+00
1.488e+00
1.408e+00
1.328e+00
1.248e+00
1.167e+00
1.087e+00
1.007e+00
9.270e-01
8.468e-01
7.667e-01
6.865e-01
6.063e-01
5.262e-01
4.460e-01
Density contour
Mach = 1.2
α = 10°
Y
X
Z

Wing Locations for Two and three Wings



Shapes of Wing Cross-Sections



5. NACA 4 digit airfoil (xxxx, 0012 or 2412)

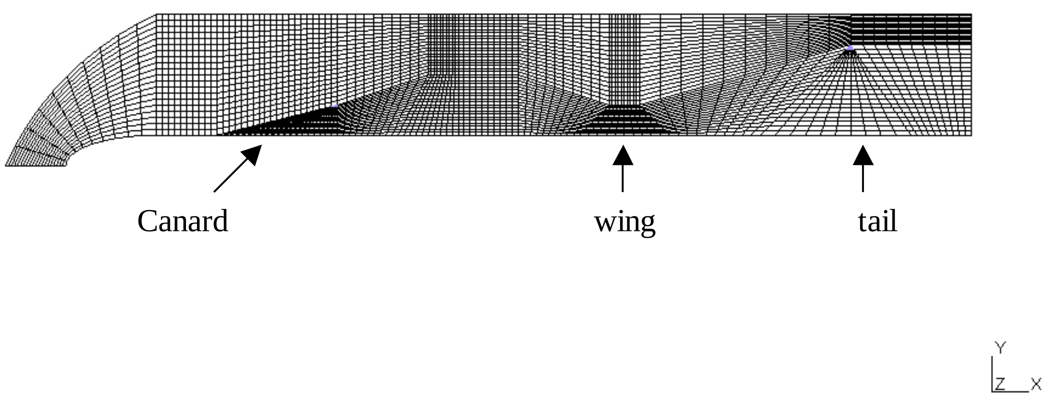
6. Ellipse wing

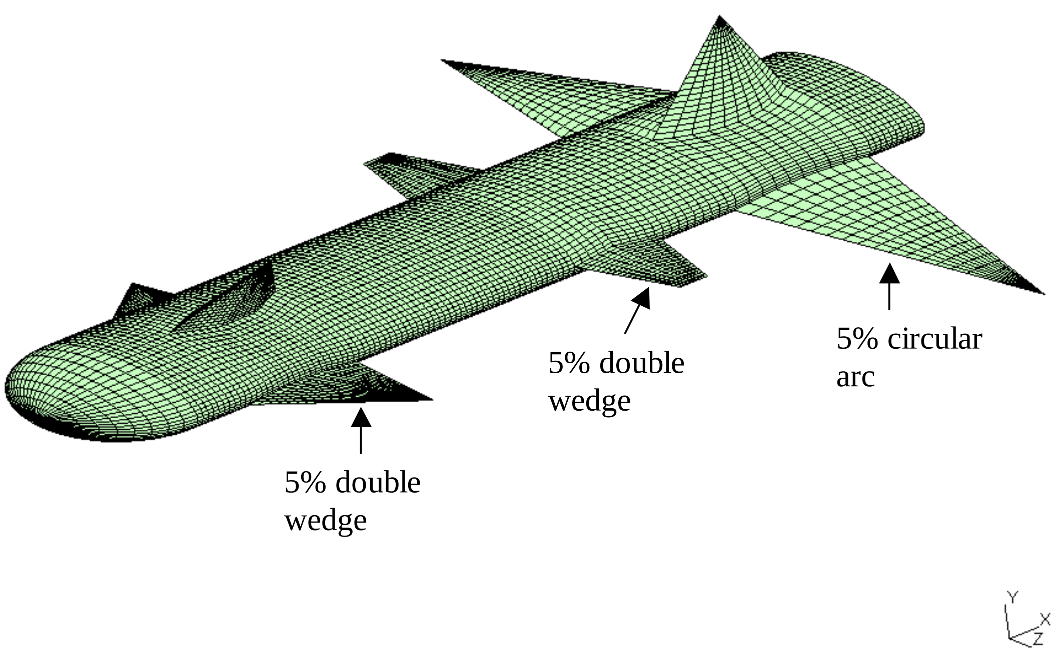
7. User inputs upper and lower profiles

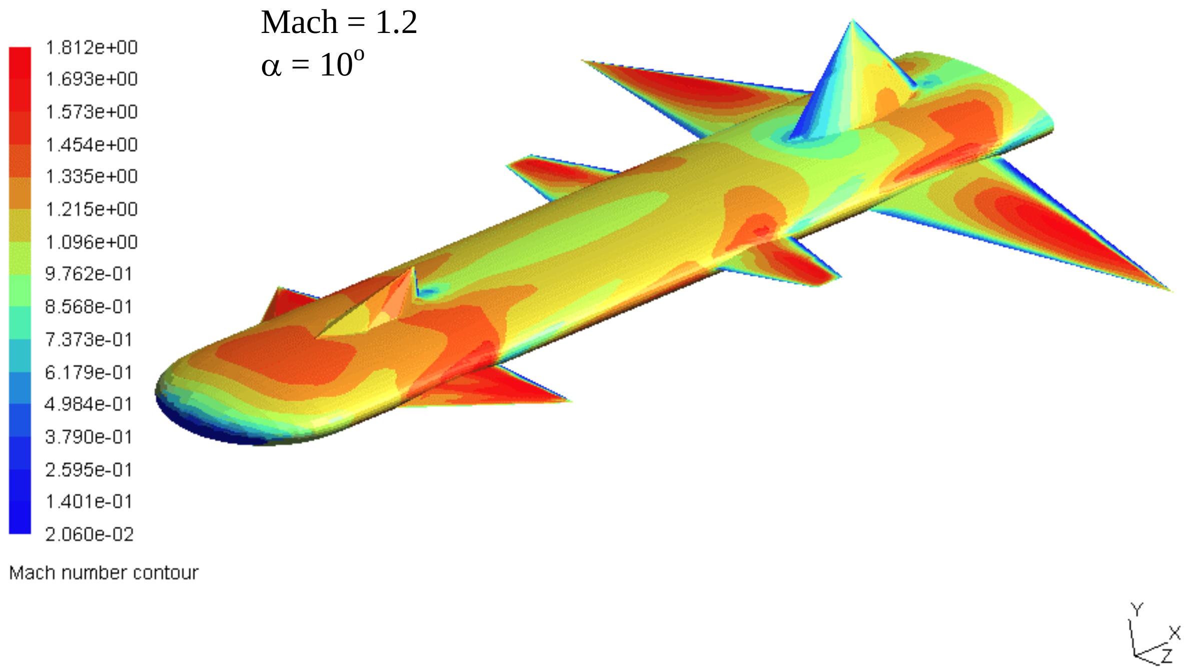
Problem: **Mach 1.2 flow past the elliptical rocket at 10 degrees angle of** attack.

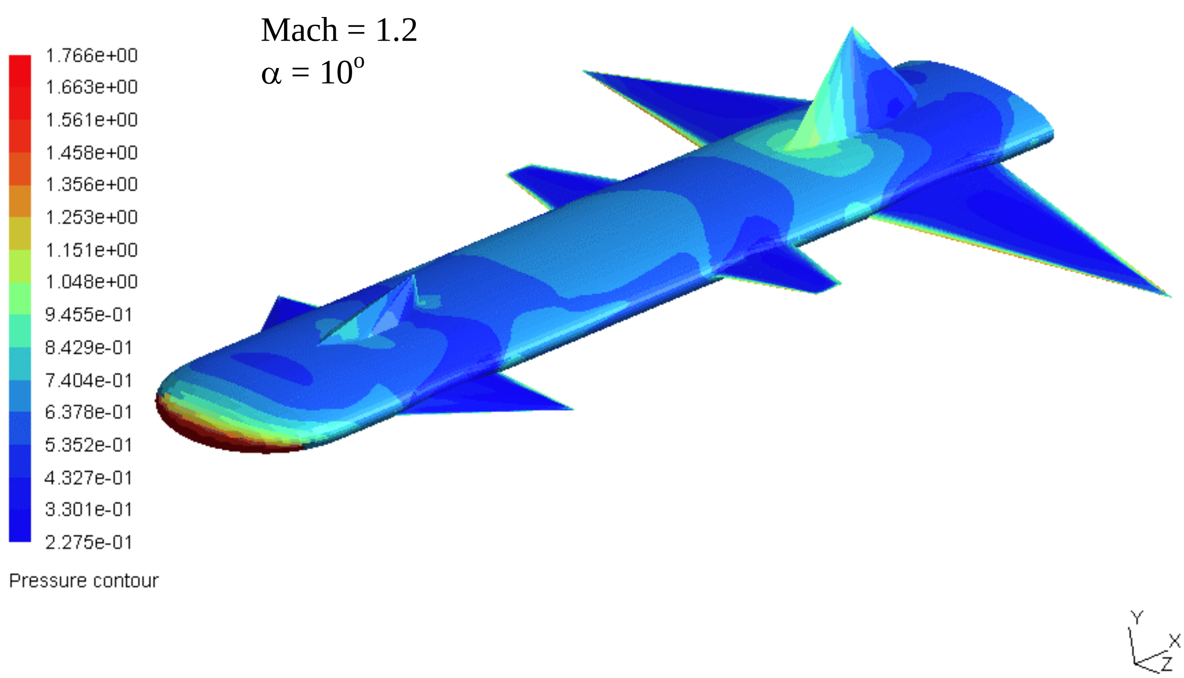
* Build 2D mesh, 4 200 elements, 4,331 nodes
* Sweep 2D mesh around the axis to generate 3D mesh.
* The 3D mesh contains 260 661 nodes and 3 000 pyramids, 249 000 hexahedron.

*Assign tail surface and wing cross section shape

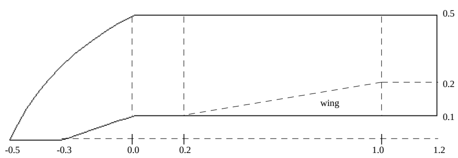




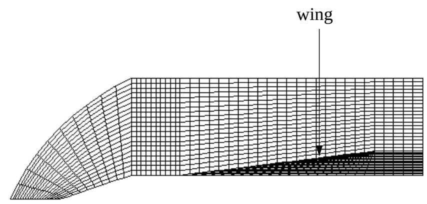

Mach = 1.2
α = 10°
1.812e+00
1.693e+00
1.573e+00
1.454e+00
1.335e+00
1.215e+00
1.096e+00
9.762e-01
8.568e-01
7.373e-01
6.179e-01
4.984e-01
3.790e-01
2.595e-01
1.401e-01
2.060e-02
Mach number contour
Y
X
Z


Mach = 1.2
α = 10°
1.766e+00
1.663e+00
1.561e+00
1.458e+00
1.356e+00
1.253e+00
1.151e+00
1.048e+00
9.455e-01
8.429e-01
7.404e-01
6.378e-01
5.352e-01
4.327e-01
3.301e-01
2.275e-01
Pressure contour
Y
X
Z

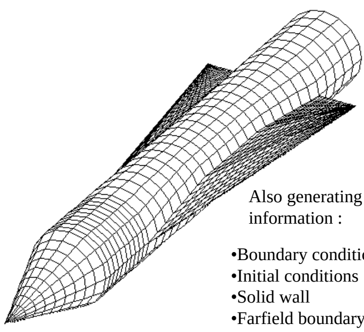
Problem: Mach 0.4, 0.9 and 1.4 flow past a cone-cylinder-wing combination at 10^o angle of attack



Step 1. Computational domain for wing-body combination.



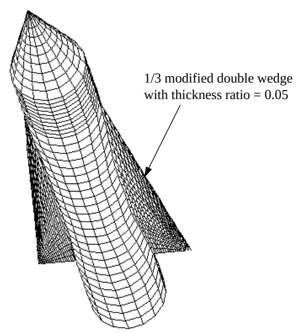
Step 2. Create 2D finite element mesh for wing-body combination. The shape of wing section and total number of wing to be created are also specified.



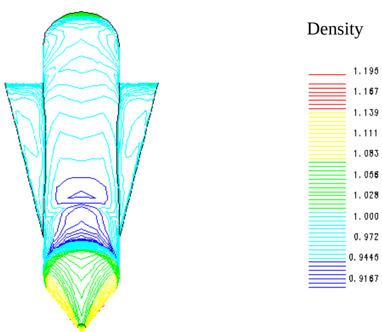
Also generating following information :

- Boundary conditions
- Initial conditions
- Solid wall
- Farfield boundary

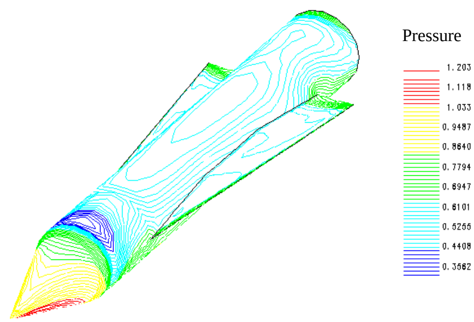
Step 3. Sweep 2D mesh around the axis line and create 3D mesh.



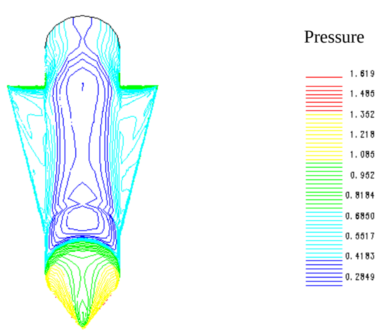
Step 3. Sweep 2D mesh around the axis line and create 3D mesh.



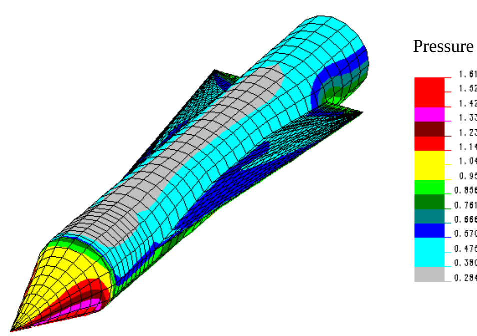
Density contour for Mach 0.4 flow past a cone-cylinder wing-body combination at 10^o angle of attack.



Pressure contour for Mach 0.9 flow past a cone-cylinder wing-body combination at 10^o angle of attack.



Pressure contour for Mach 1.4 flow past a cone-cylinder wing-body combination at 10^o angle of attack.

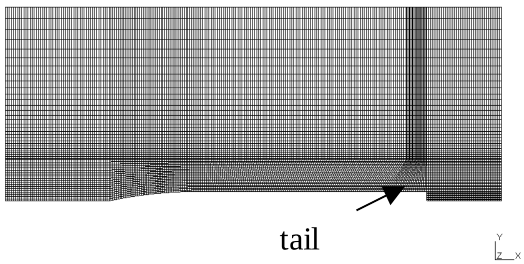


Pressure contour for Mach 1.4 flow past a cone-cylinder wing-body combination at 10^o angle of attack.

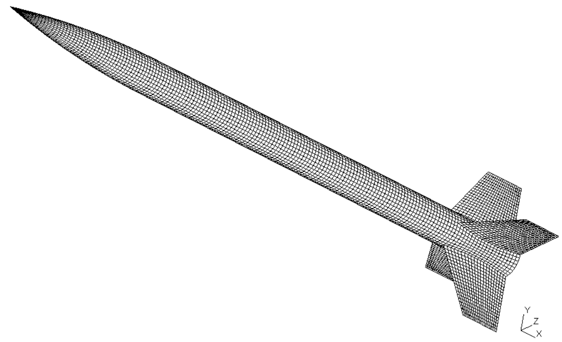
Problem: **Mach 1.2 and 0.2 flow past the Javelin rocket at 10 and 5 degrees angle of** attack.

* Build 2D mesh, 13,400 elements, 13,721 nodes
* Sweep 2D mesh around the axis to generate 3D mesh.
* 64 pyramids, 2880 prisms and 425,88 hexahedron.

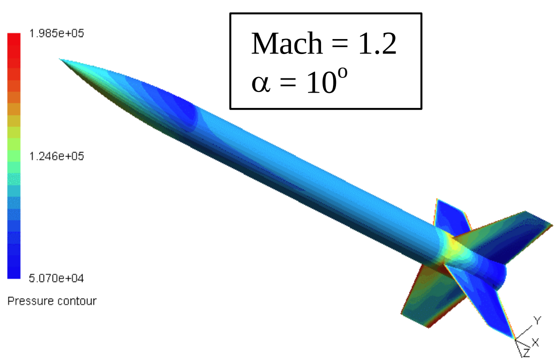
*Assign tail surface and wing cross section shape



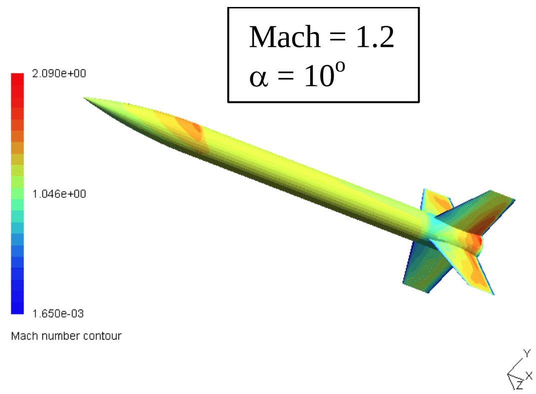
2D mesh with tail surface



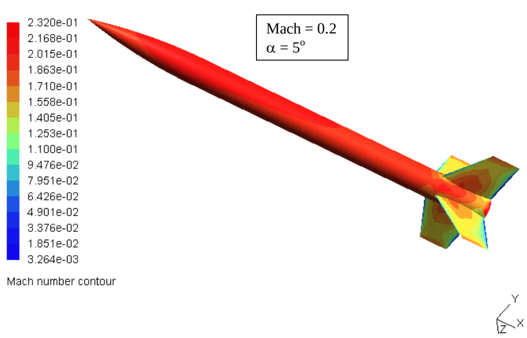
Surface mesh after sweeping around the axis



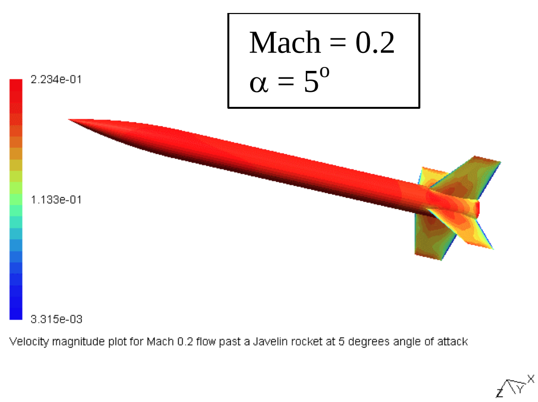
Pressure contour



Mach number contour



Velocity plot contour



Mach number contour

Problem: **Mach 1.2 and 0.95 flow past the Arconi-Hi rocket at 10 and 5 degrees angle of attack**.

* Build 2D mesh. 16,400 elements, 16,781 nodes
* 25 minutes to generate the 2D mesh
* Assign wing and tail surface
* Sweep 2D mesh around axis to generate 3D mesh
* Total 3D mesh includes 64 pyramids, 2,880 prisms and 521, 888 hexahedron

2D mesh for Arconi-Hi rocket

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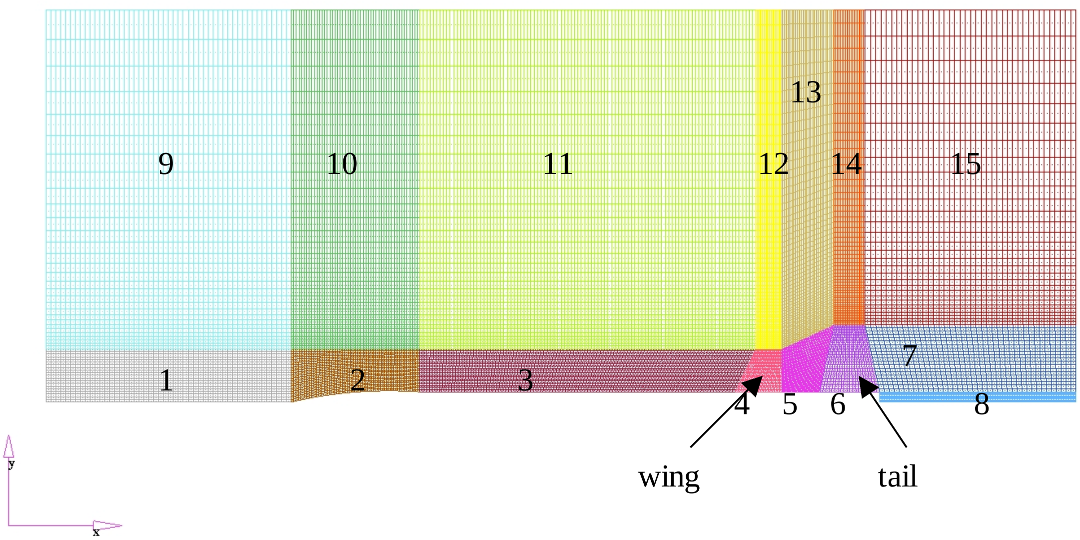
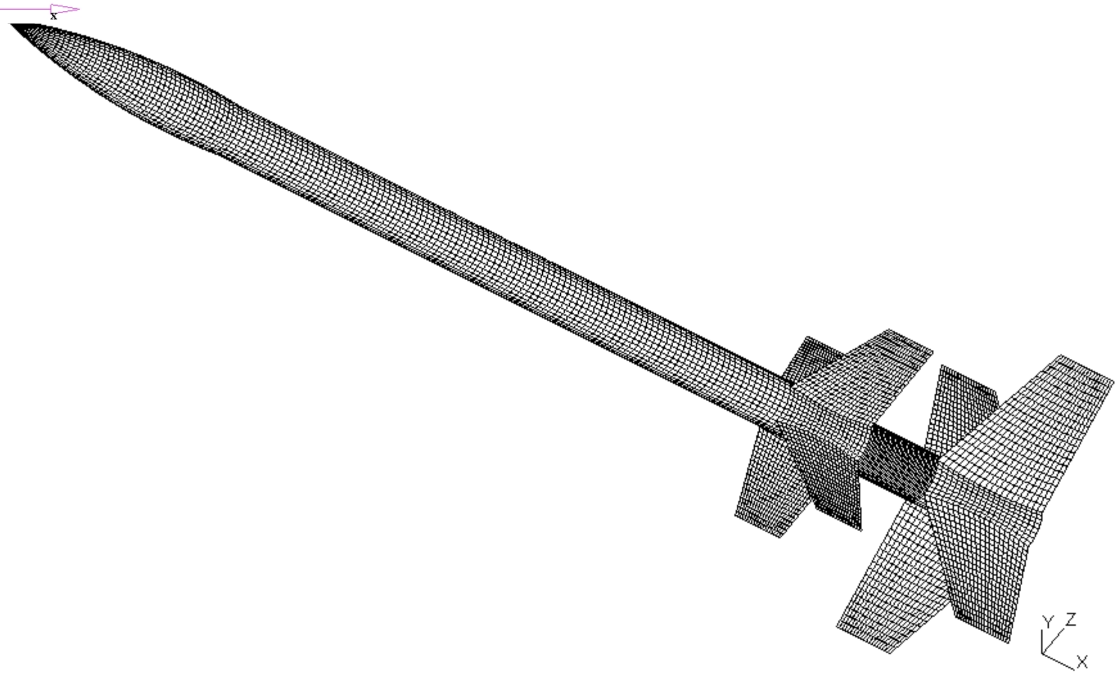
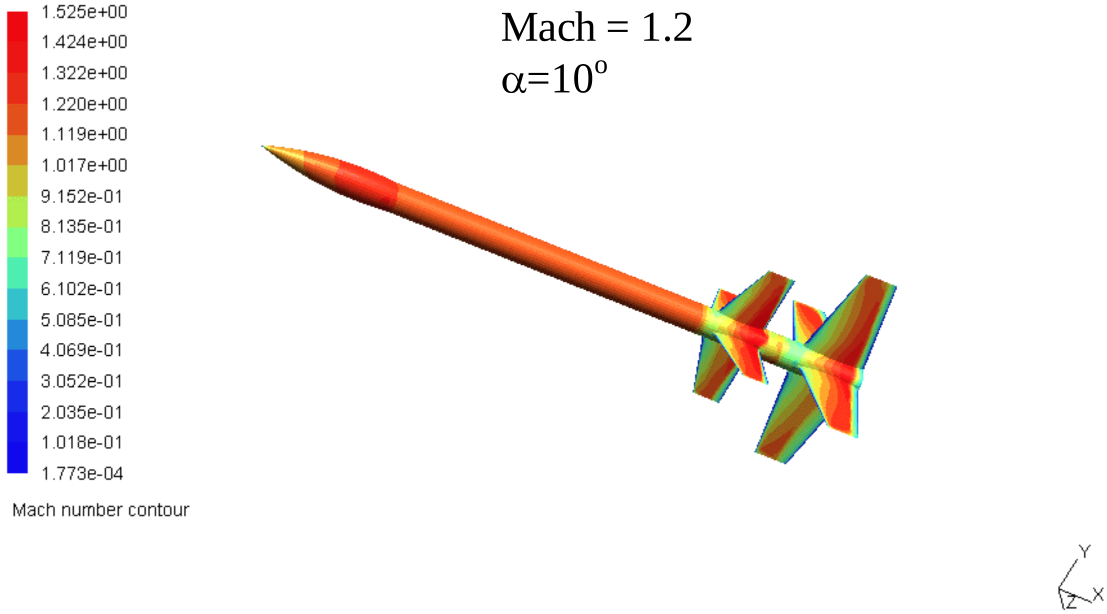
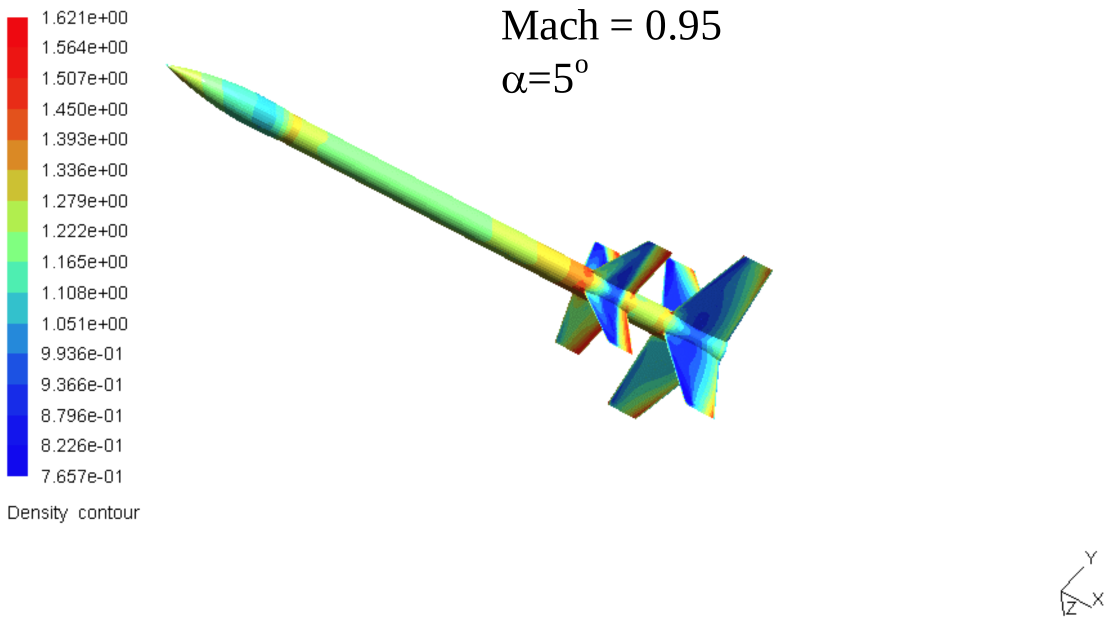




3D surface mesh for Arconi-Hi rocket.

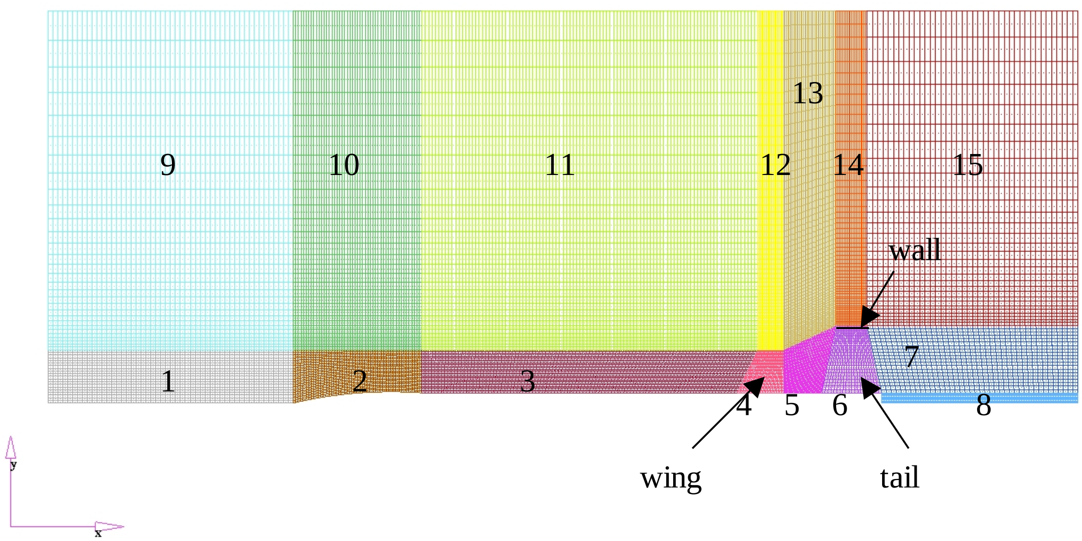

Mach = 1.2
α=10°
1.525e+00
1.424e+00
1.322e+00
1.220e+00
1.119e+00
1.017e+00
9.152e-01
8.135e-01
7.119e-01
6.102e-01
5.085e-01
4.069e-01
3.052e-01
2.035e-01
1.018e-01
1.773e-04
Mach number contour
Y
Z
X


Mach = 0.95
α=5°
1.621e+00
1.564e+00
1.507e+00
1.450e+00
1.393e+00
1.336e+00
1.279e+00
1.222e+00
1.165e+00
1.108e+00
1.051e+00
9.936e-01
9.366e-01
8.796e-01
8.226e-01
7.657e-01
Density contour
Y
Z
X

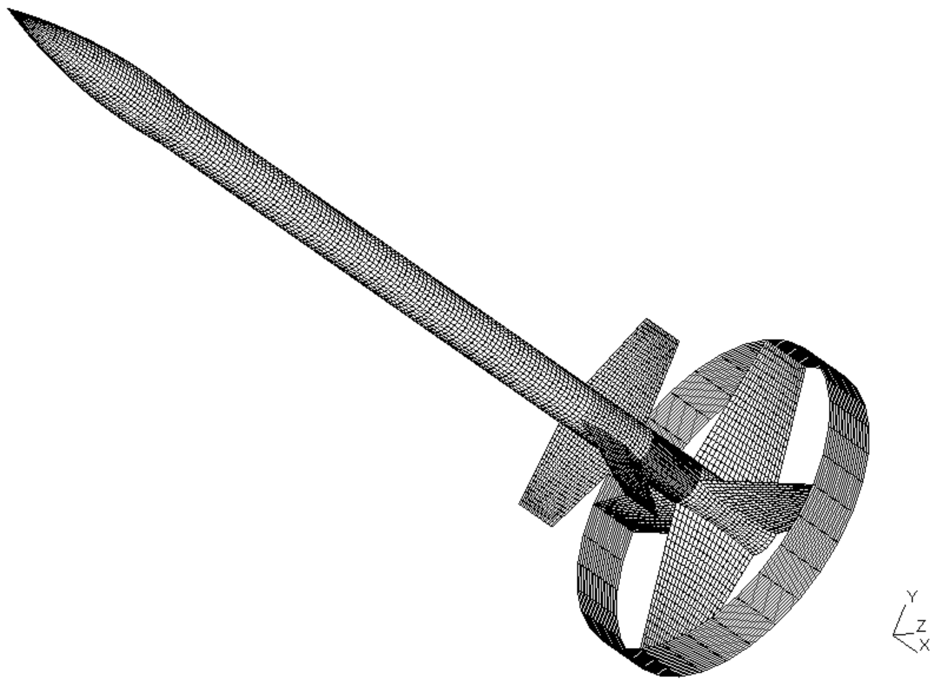
Problem: **Mach 1.2 and 0.95 flow past the Arconi-Hi with tail ring rocket at 10 and 5 degrees angle of attack**.

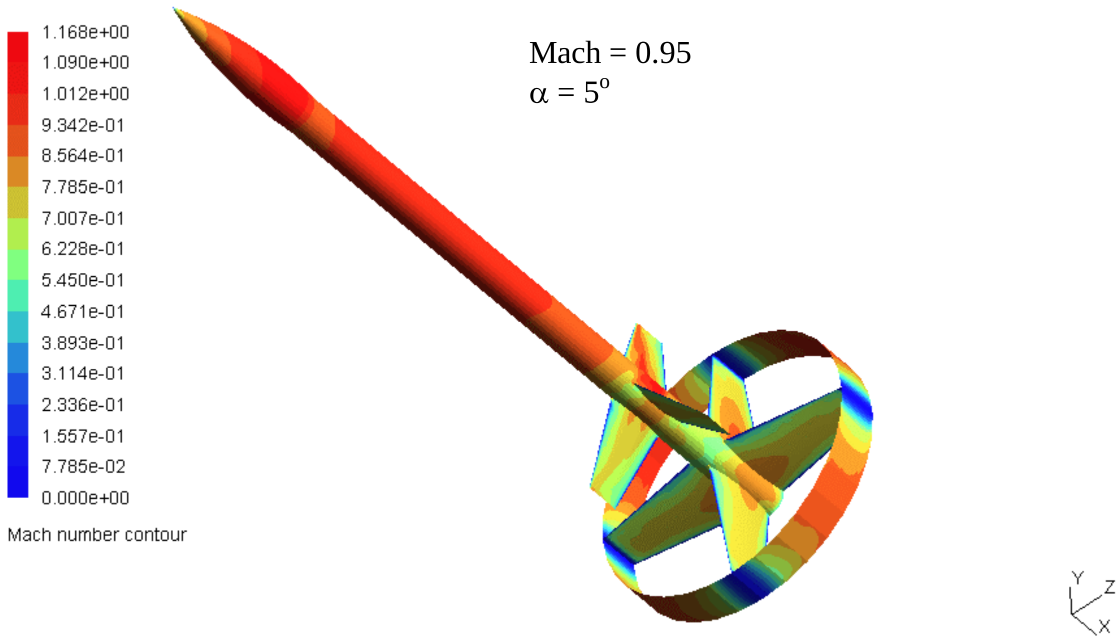
* Build 2D mesh. 16,400 elements, 16,781 nodes
* 25 minutes to generate the 2D mesh
* Assign wing and tail surface
* Sweep 2D mesh around axis to generate 3D mesh
* Total 3D mesh includes 64 pyramids, 2,880 prisms and 521, 888 hexahedron

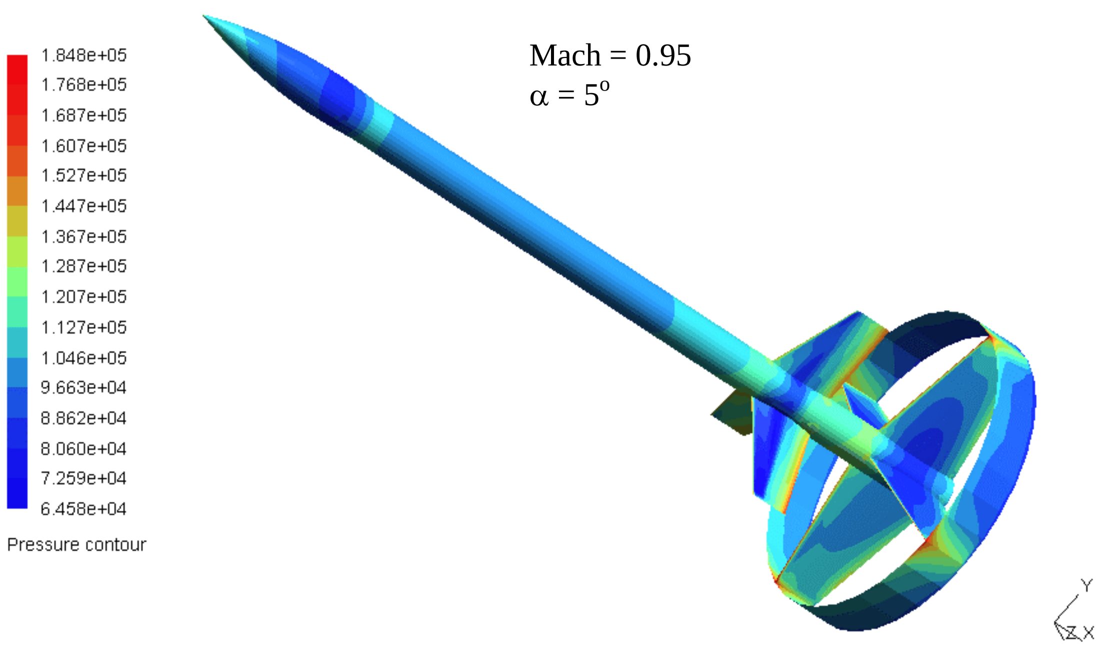
2D mesh for wing-tail-ring rocket



3D surface mesh for 3 wings 4 tails ring rocket

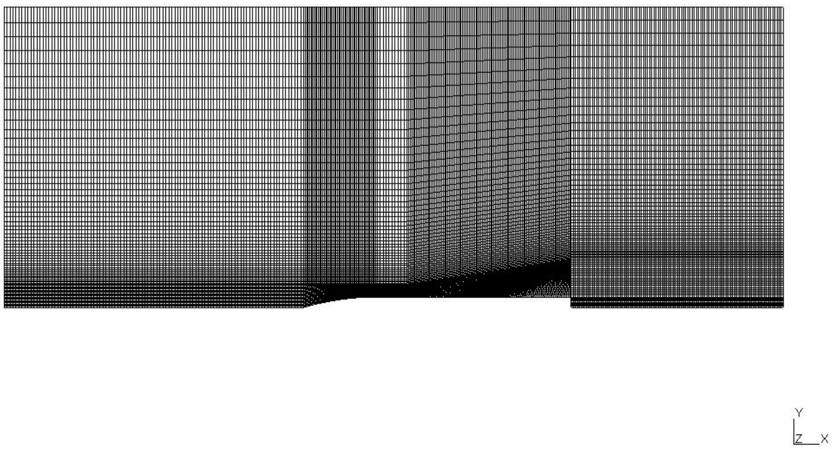



1.168e+00
1.090e+00
1.012e+00
9.342e-01
8.564e-01
7.785e-01
7.007e-01
6.228e-01
5.450e-01
4.671e-01
3.893e-01
3.114e-01
2.336e-01
1.557e-01
7.785e-02
0.000e+00
Mach number contour
Mach = 0.95
α = 5°
Y
Z
X

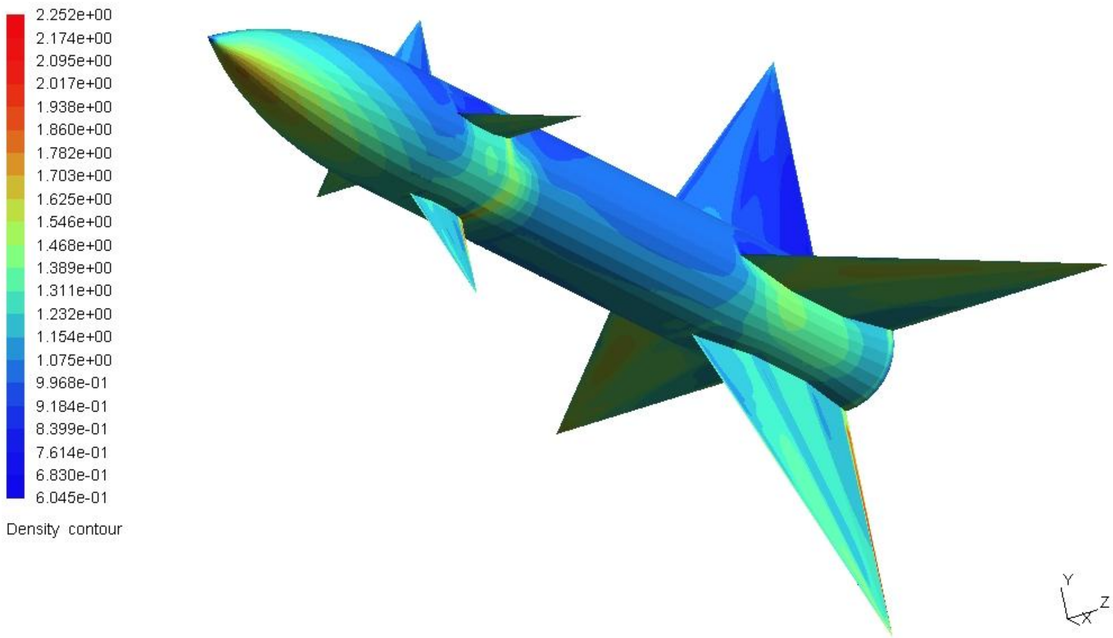

1.848e+05
1.768e+05
1.687e+05
1.607e+05
1.527e+05
1.447e+05
1.367e+05
1.287e+05
1.207e+05
1.127e+05
1.046e+05
9.663e+04
8.862e+04
8.060e+04
7.259e+04
6.458e+04
Pressure contour
Mach = 0.95
α = 5°
Y
Z
X

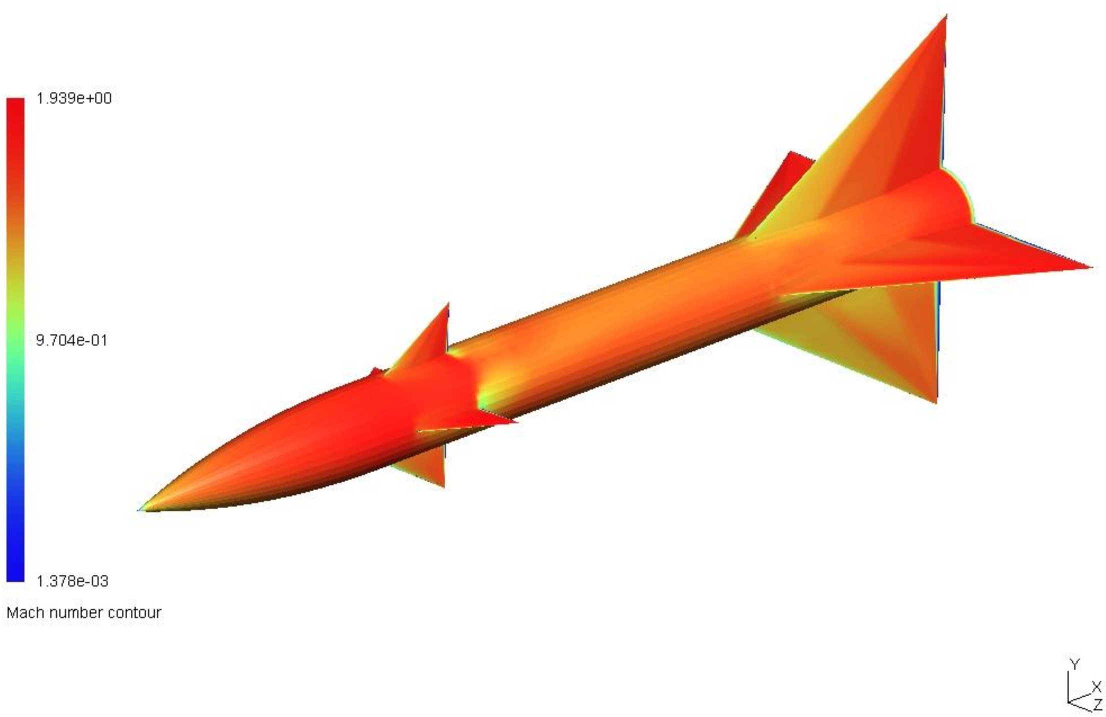
Problem: Mach 1.62 flows past a canard-tail-body at 10 degrees angle of attack. (NACA RM L54E20)

* 2D mesh consists of 27790 elements and 27841 nodes
* 25 minutes to generate the 2D mesh
* Assign wing and tail surface
* Sweep 2D mesh around axis to generate 3D mesh (5 minutes)
* 3D mesh includes 876832 cells and 889290 nodes.
* 64 pyramids, 8320 prisms and 868448 hexahedrons



	Aplha (Degrees)	cdy	xcp
Inviscid	2.00	9.06E-01	6.64E+00
Viscous run	2.00	1.06E+00	6.68E+00
Experiemntal data	2.00	9.00E-01	6.78E+00
Inviscid	5.00	2.32E+00	6.46E+00
Viscous run	5.00	2.77E+00	6.64E+00
Experiemntal data	5.00	2.40E+00	6.79E+00
Inviscid	8.00	3.83E+00	6.48E+00
Viscous run	8.00	4.59E+00	6.58E+00
Experiemntal data	8.00	4.00E+00	6.79E+00
Inviscid	12.00	5.85E+00	6.42E+00
Viscous run	12.00	6.27E+00	6.60E+00
Experiemntal data	12.00	6.00E+00	6.76E+00


2.252e+00
2.174e+00
2.095e+00
2.017e+00
1.938e+00
1.860e+00
1.782e+00
1.703e+00
1.625e+00
1.546e+00
1.468e+00
1.389e+00
1.311e+00
1.232e+00
1.154e+00
1.075e+00
9.968e-01
9.184e-01
8.399e-01
7.614e-01
6.830e-01
6.045e-01
Density contour
Y
Z
X


1.939e+00
9.704e-01
1.378e-03
Mach number contour
Y
X
Z