N94-22365

2D & 3D HYPERSONIC FLOWS WITH UNSTRUCTURED MESHES

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OUTLINE

Introduction

2D Viscous Shock-Shock Interaction

3D Inviscid NASP-Like (Unadapted)

3D Inviscid NASP-Like (Adapted)

INTRODUCTION

Funded by Aerothermal Loads Branch (NASA LaRC)

Development of finite elements in fluids and unstructured grid generation (began 1983-1984)

In-house research

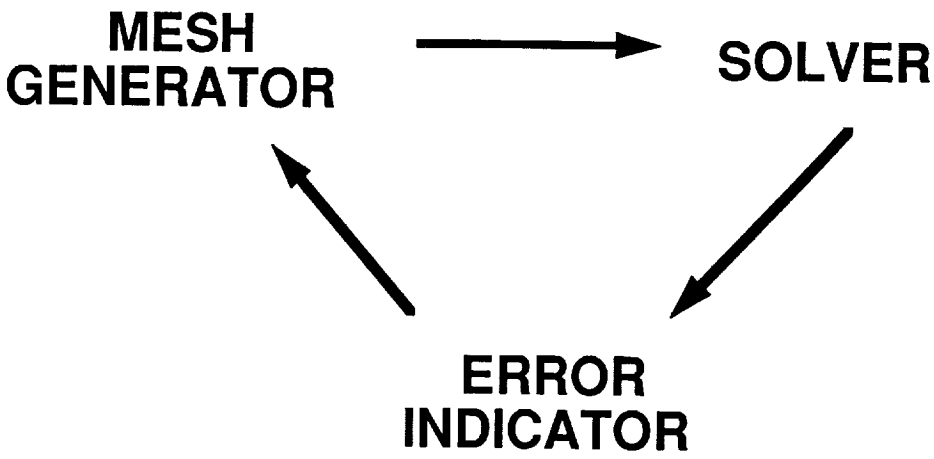
- Civil servants and contractors

Grantees' research

- Morgan, Lohner, Peraire (Swansea)
- Hughes (Stanford)
- Oden (Austin)
- Thornton (ODU)

Current status

COUPLED MODULES



MESH GENERATION

Advancing Front Method

Generation Parameters

- Spacing
- Orientation
- Stretching

Sources

- Point
- Line
- Triangles

Background Mesh

2D CAPABILITIES
(LARCNESS)

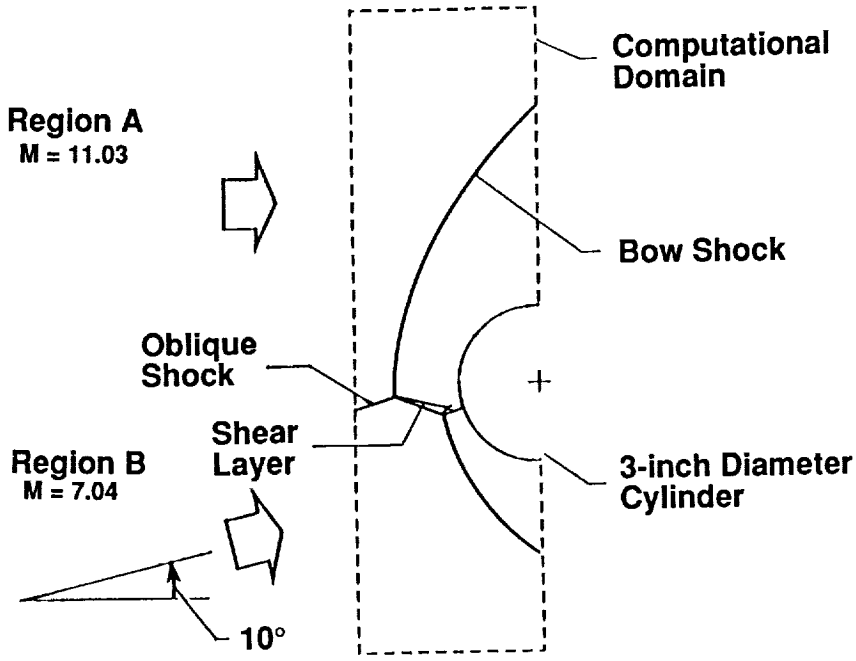
Generation of initial meshes
- Structured near walls
- Unstructured elsewhere

Generation of adapted meshes (Remeshing) from previous solution

Mesh refinement
- Solution adaptive
- Geometry-based

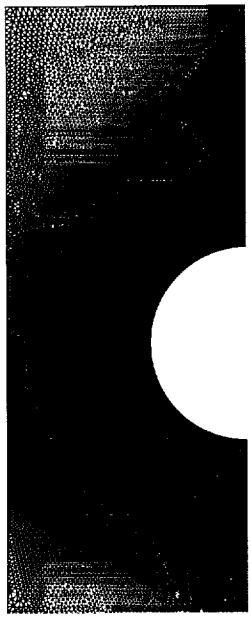
Mesh movement

2D SHOCK-SHOCK INTERACTION
Schematic



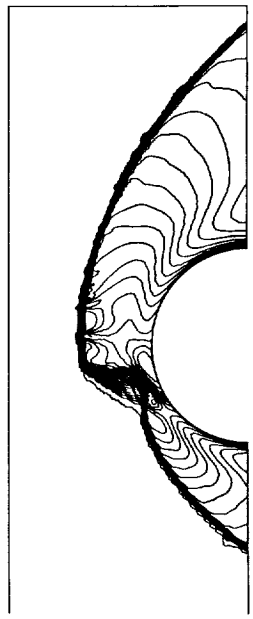
INITIAL MESH

Mesh



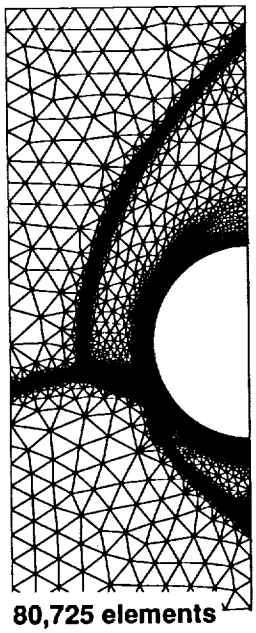
29,499 elements

U-Velocity Contours



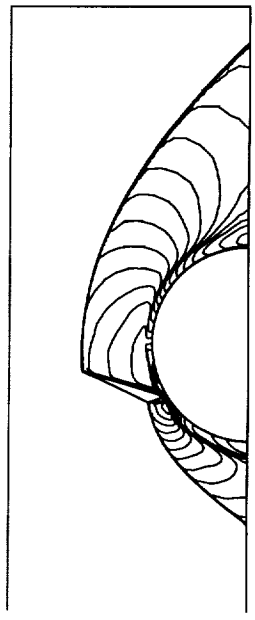
ADAPTED MESH

Mesh



80,725 elements

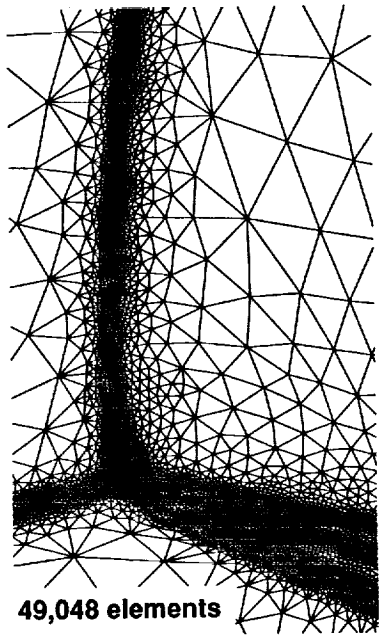
U-Velocity Contours



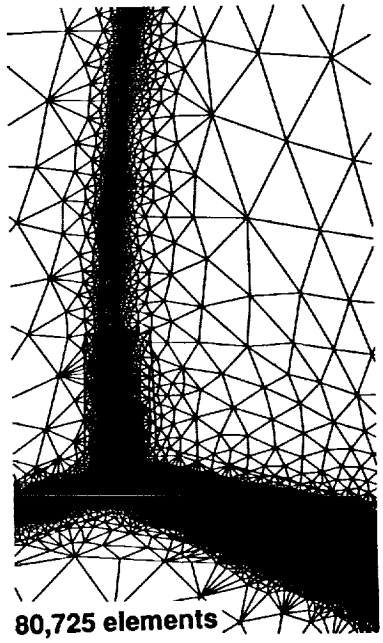
MESH REFINEMENT

Meshes

Original



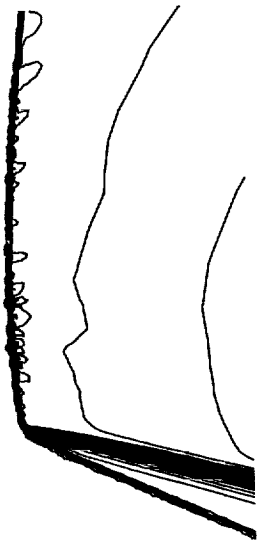
Refined



MESH REFINEMENT

U-Velocity Contours

Original



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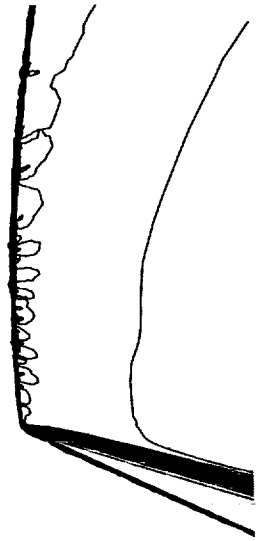
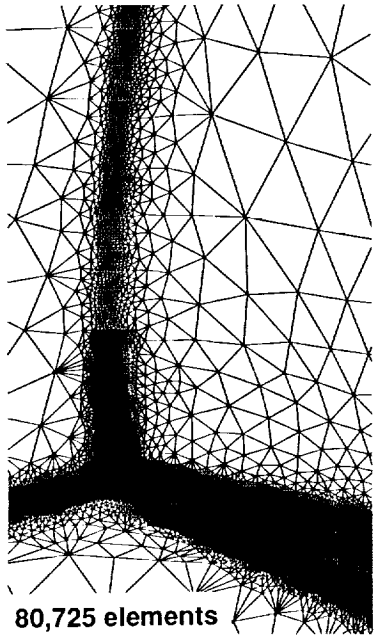


MESH MOVEMENT

Meshes

Original



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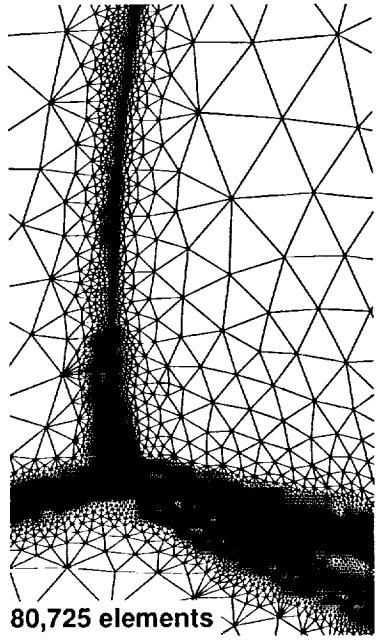
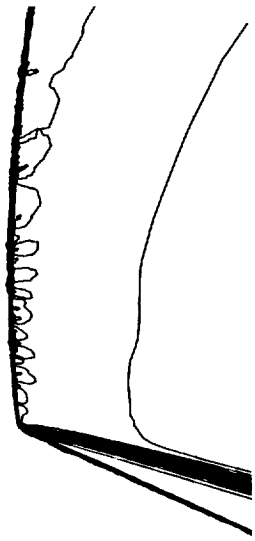


MESH MOVEMENT

U-Velocity Contours

Original



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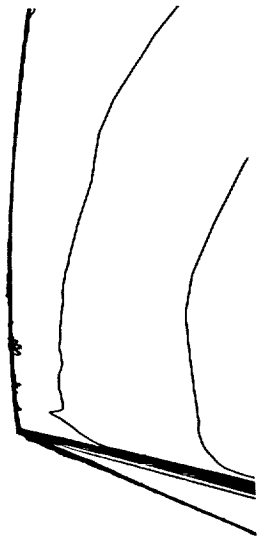


3D CAPABILITIES
(FELISA)

Developed by Peraire, Morgan, Peiro

3D Unstructured Mesh Generator

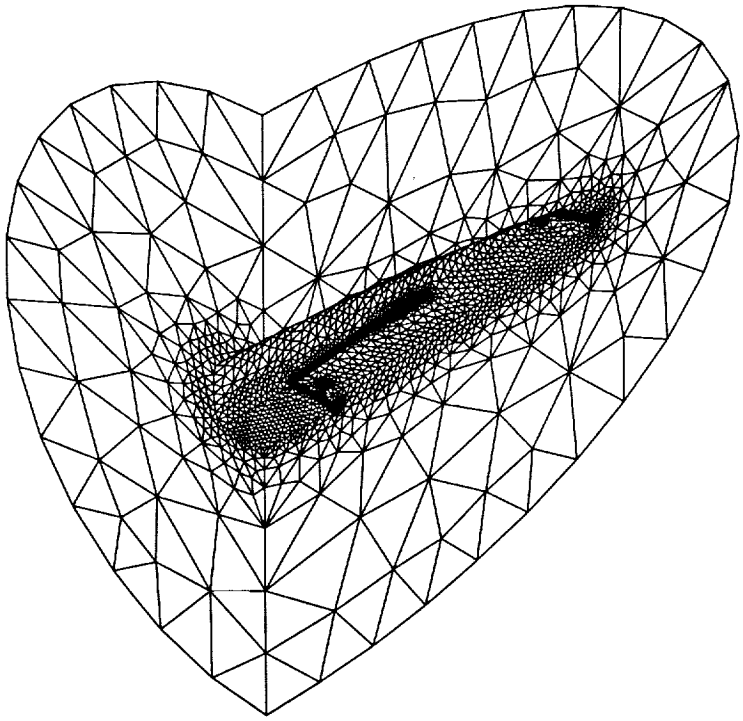
Solver
- Hypersonic Flows
- Unstructured Multigrid
- Matrix Dissipation

Adaption
- Remeshing
- Refinement

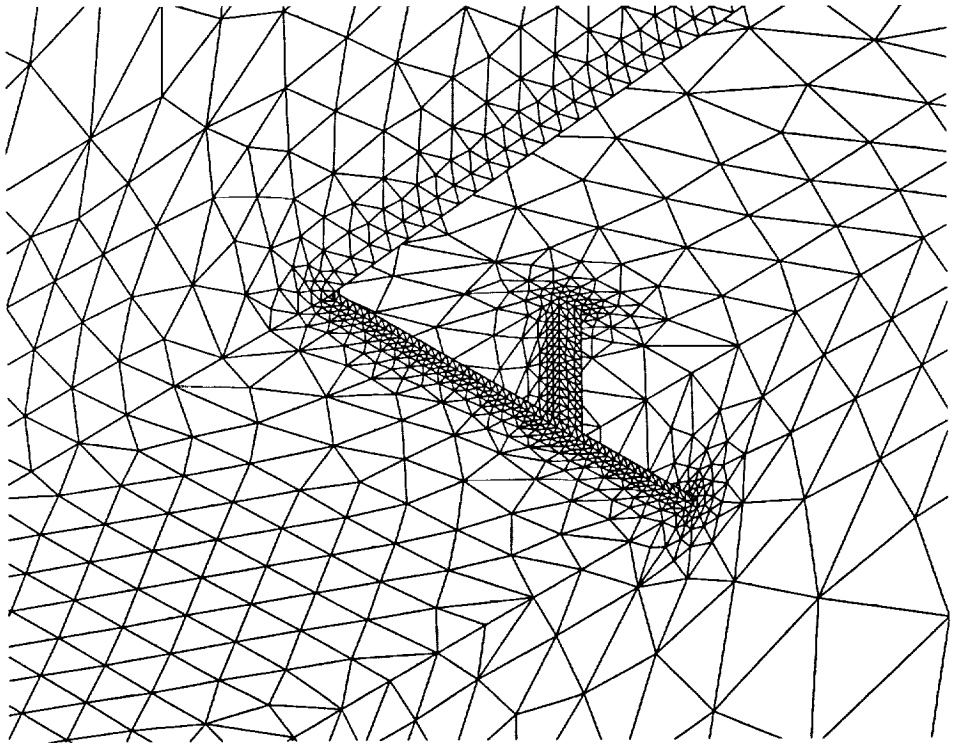
SUMMARY OF MESHES GENERATED BY VARYING SOURCE STRENGTHS

MESH	SURFACE TRIANGLES	VOLUME TETRAHEDRA
1	6,348	39,004
2	24,402	255,853
3	76,254	1,303,666

MESH 1

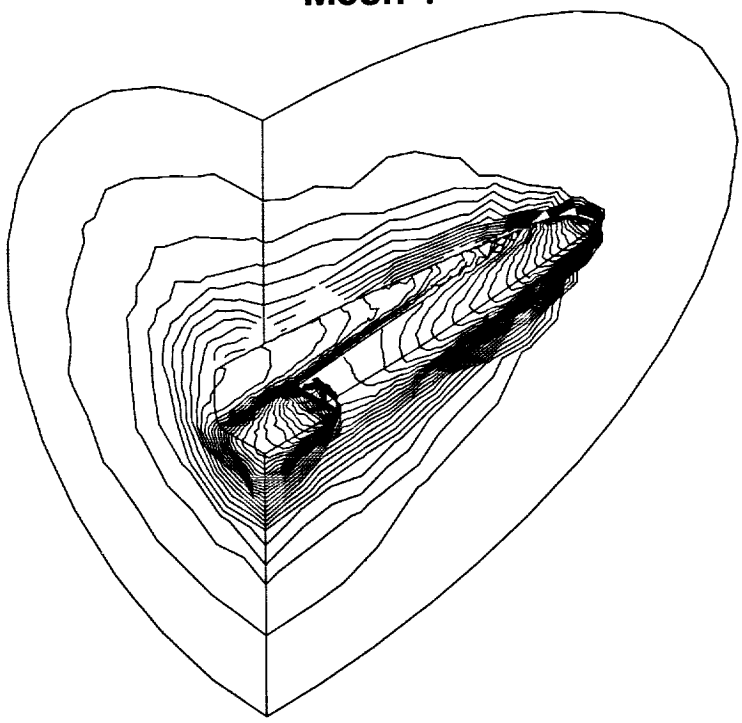


CLOSE-UP OF MESH 1



MACH NUMBER CONTOURS

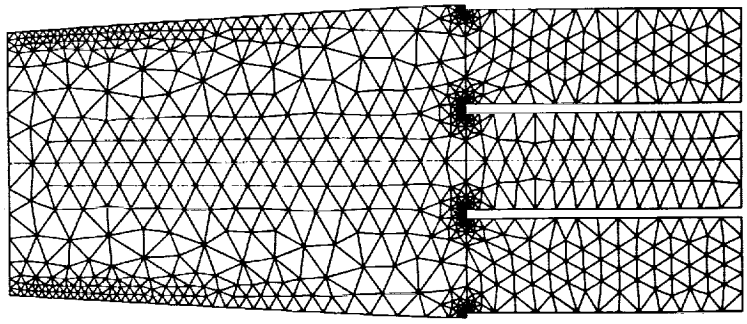
Mesh 1



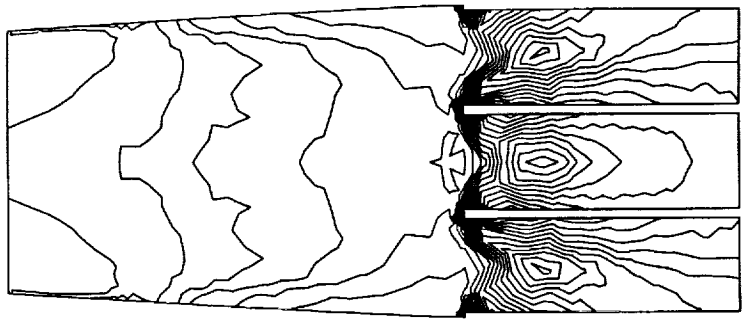
VEHICLE BOTTOM SURFACE

Mesh 1

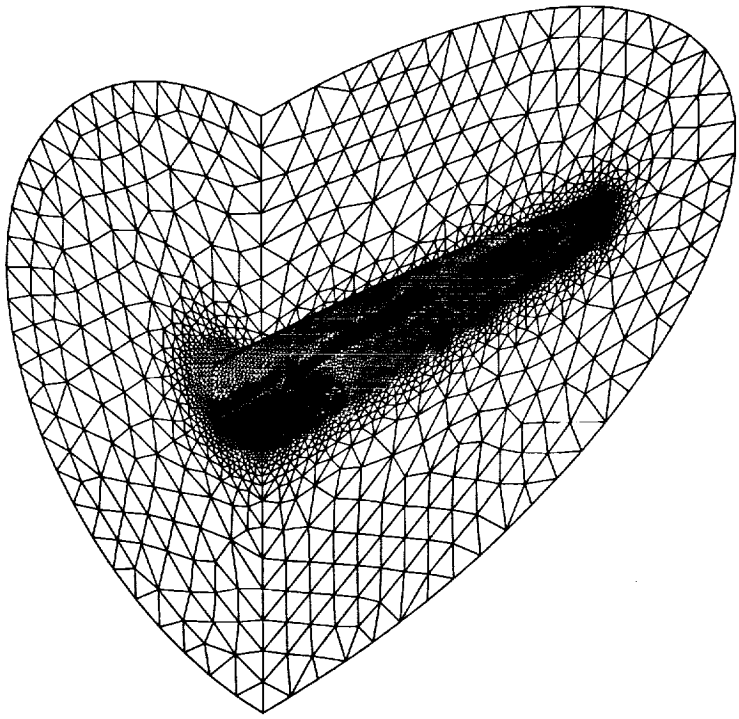
Mesh



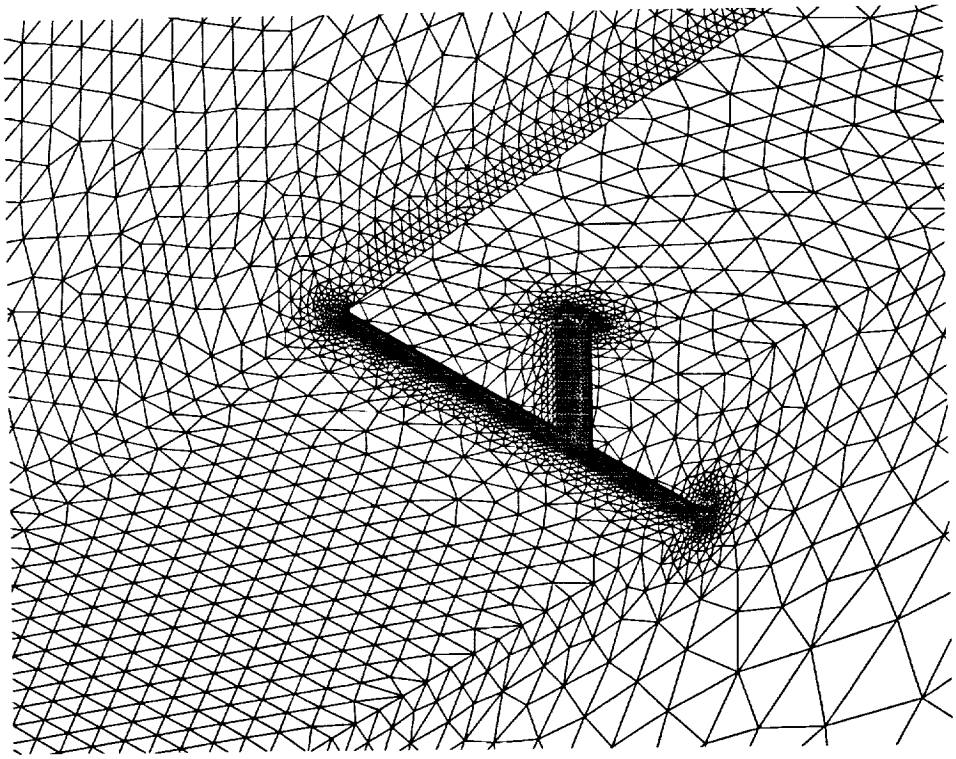
Density Contours



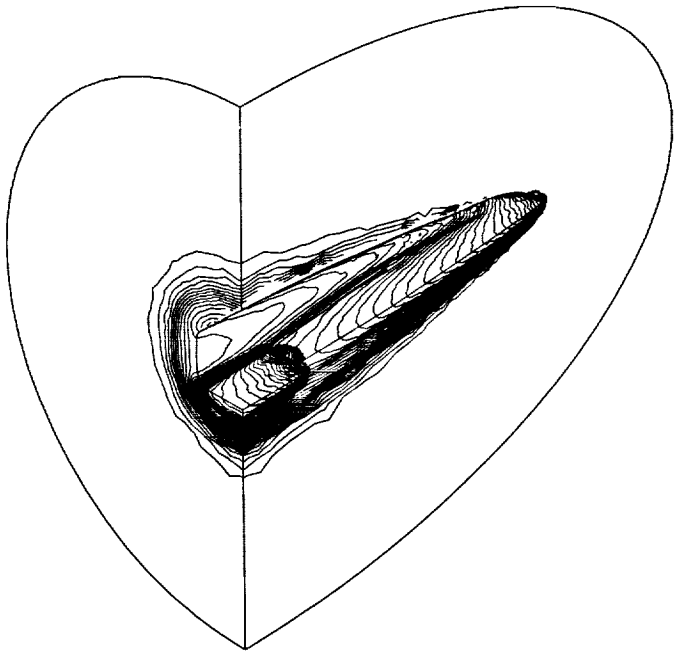
MESH 2



CLOSE-UP OF MESH 2

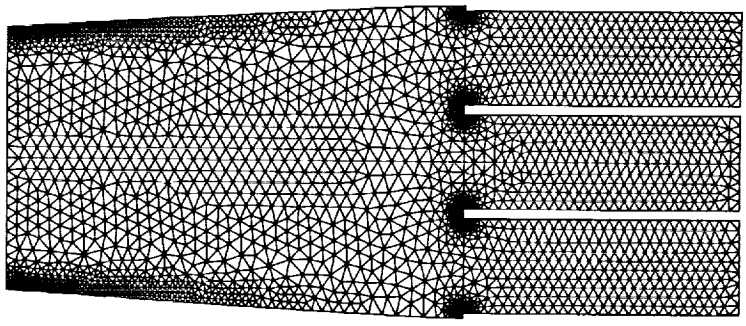


MACH NUMBER CONTOURS
Mesh 2

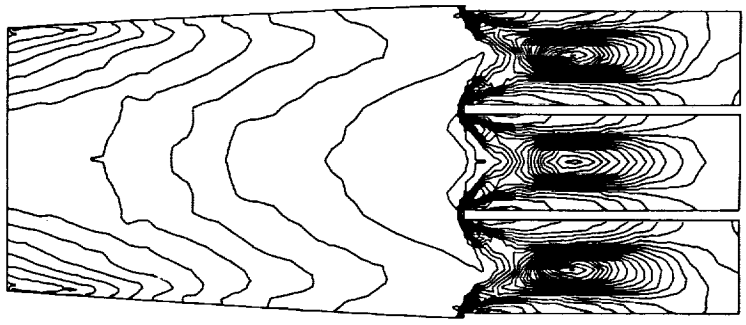


VEHICLE BOTTOM SURFACE
Mesh 2

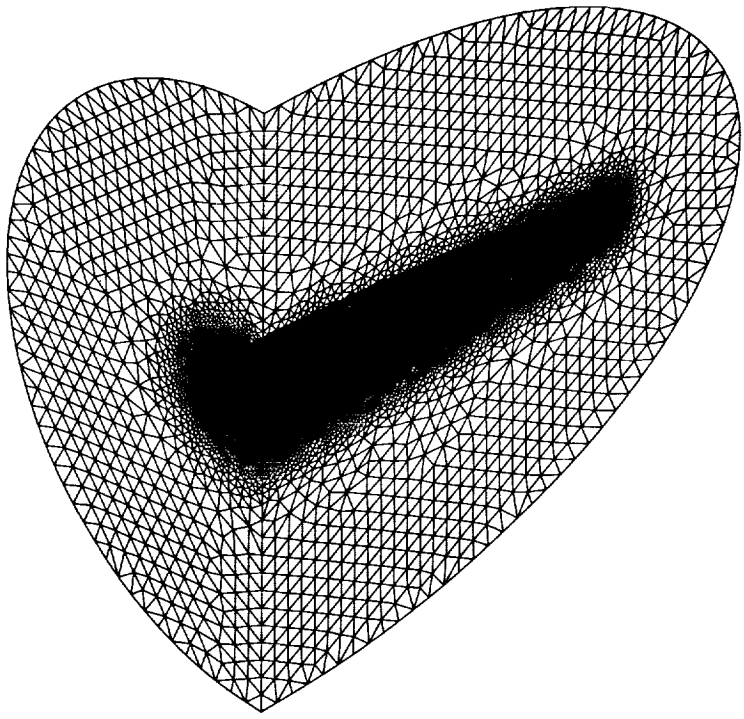
Mesh



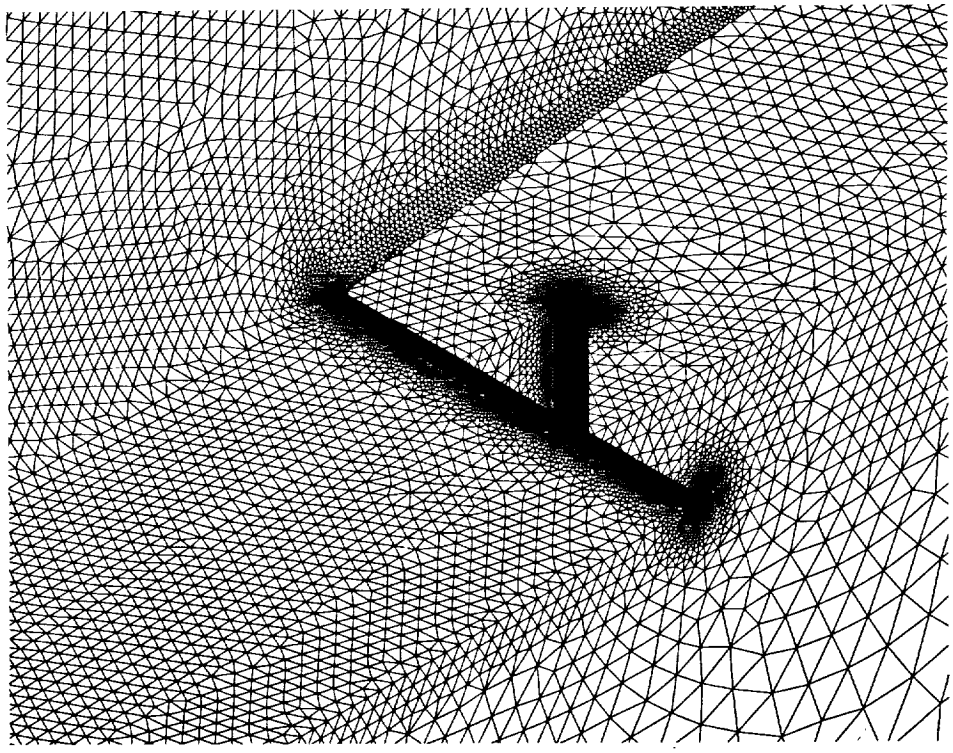
Density Contours



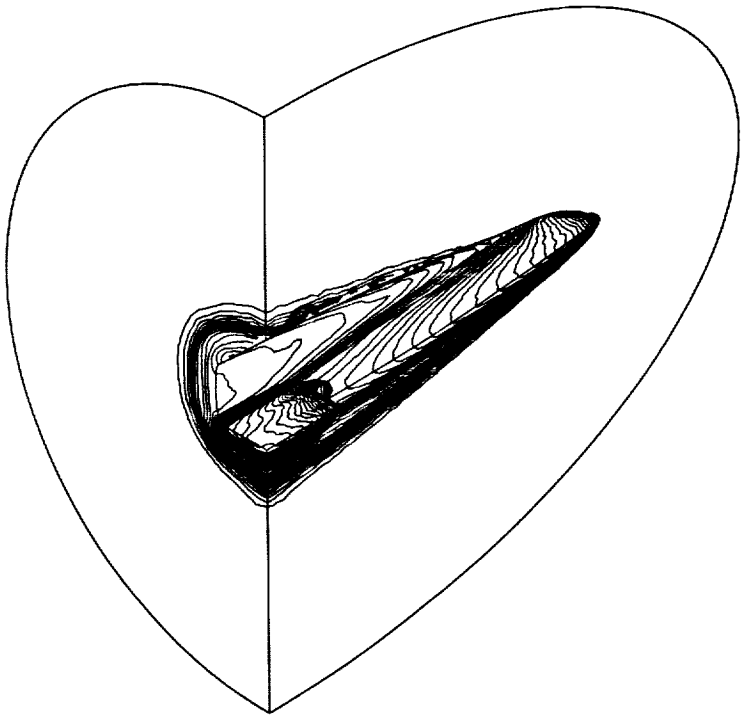
MESH 3



CLOSE-UP OF MESH 3

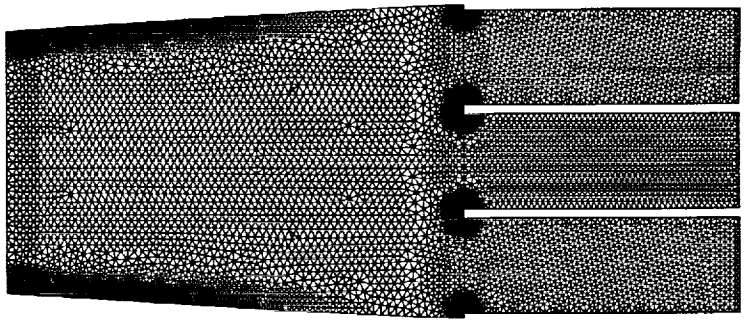


MACH NUMBER CONTOURS
Mesh 3

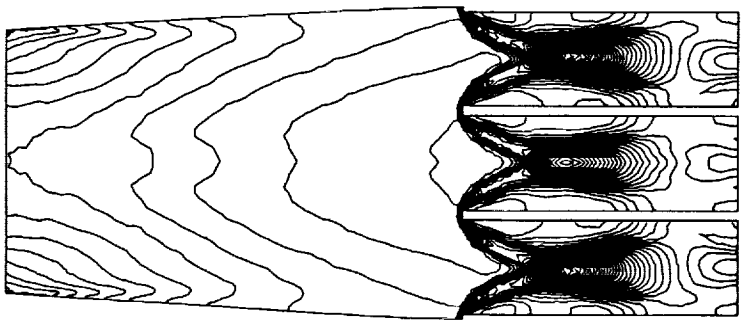


VEHICLE BOTTOM SURFACE
Mesh 3

Mesh



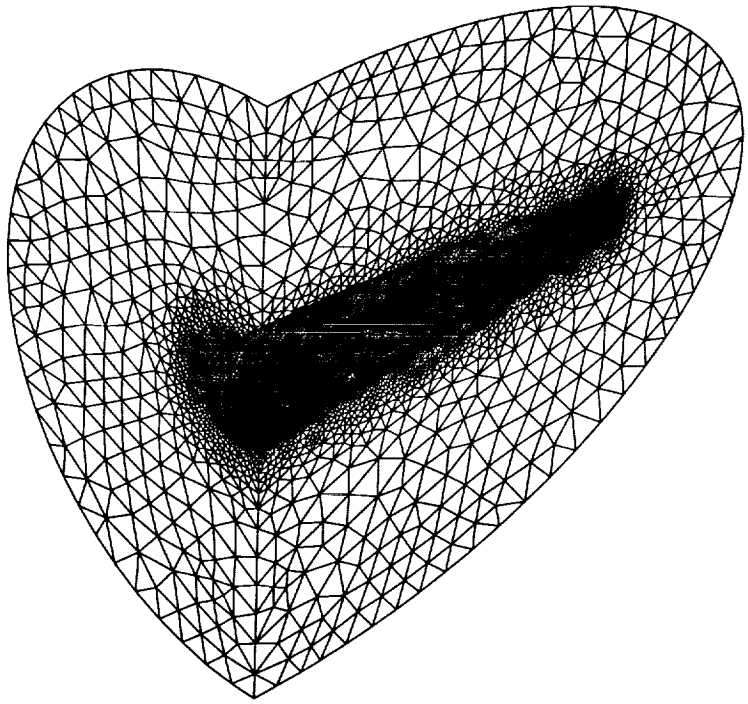
Density Contours



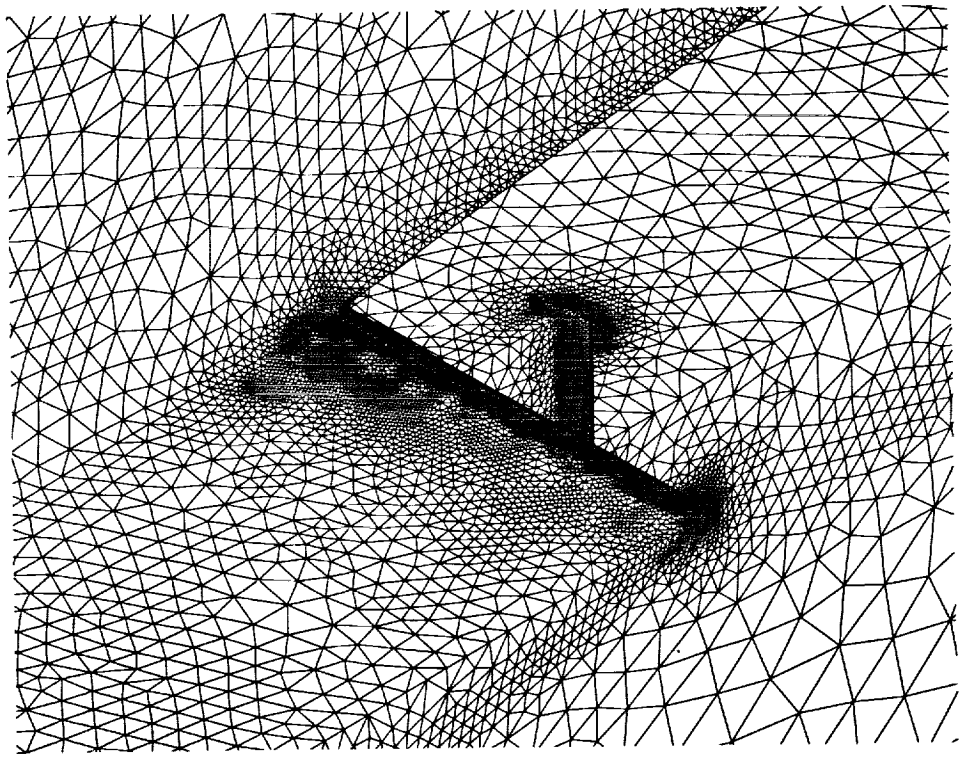
SUMMARY OF ADAPTED MESHES

MESH	SURFACE TRIANGLES	VOLUME TETRAHEDRA
1	41,736	531,610
2	73,930	1,469,105

ADAPTED MESH 1

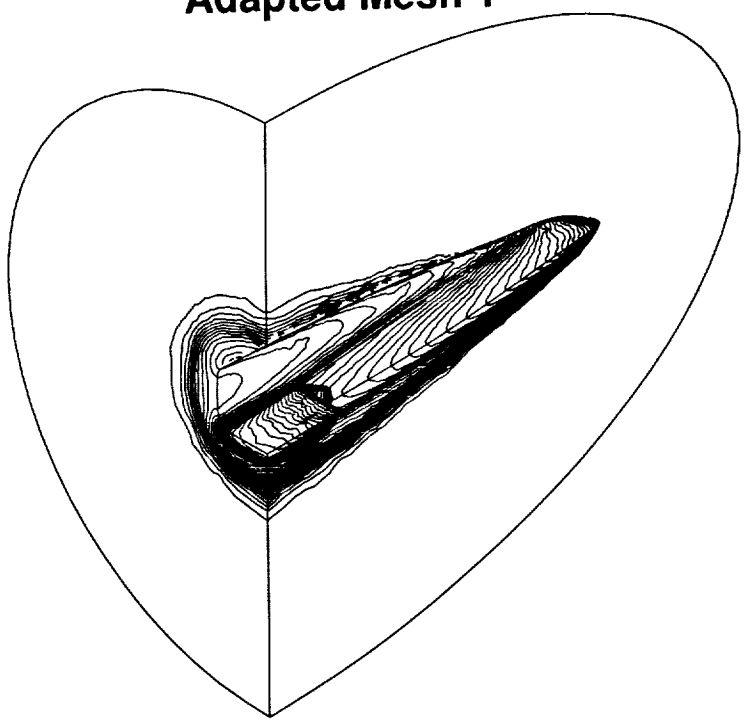


CLOSE-UP OF ADAPTED MESH 1



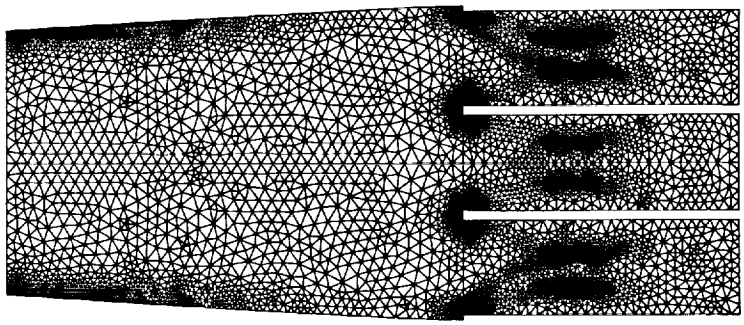
MACH NUMBER CONTOURS

Adapted Mesh 1

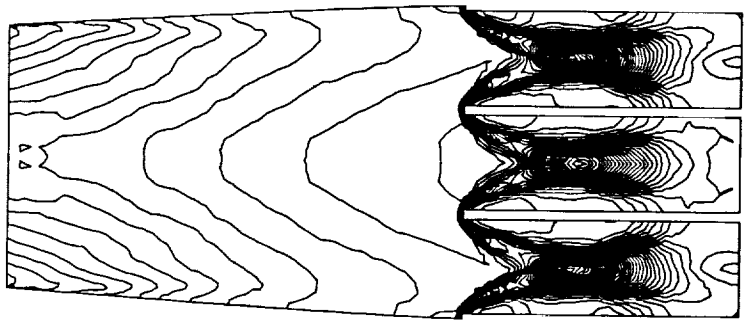


VEHICLE BOTTOM SURFACE
Adapted Mesh 1

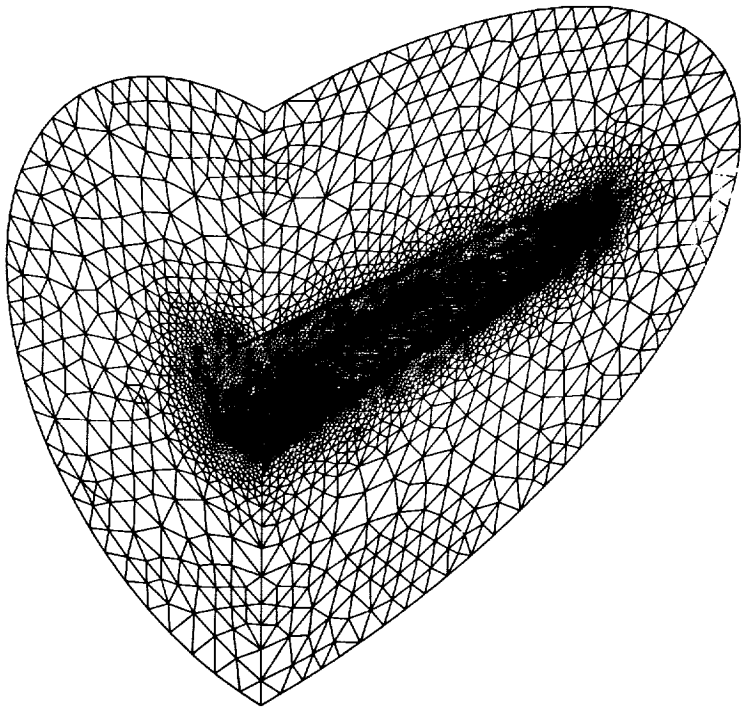
Mesh



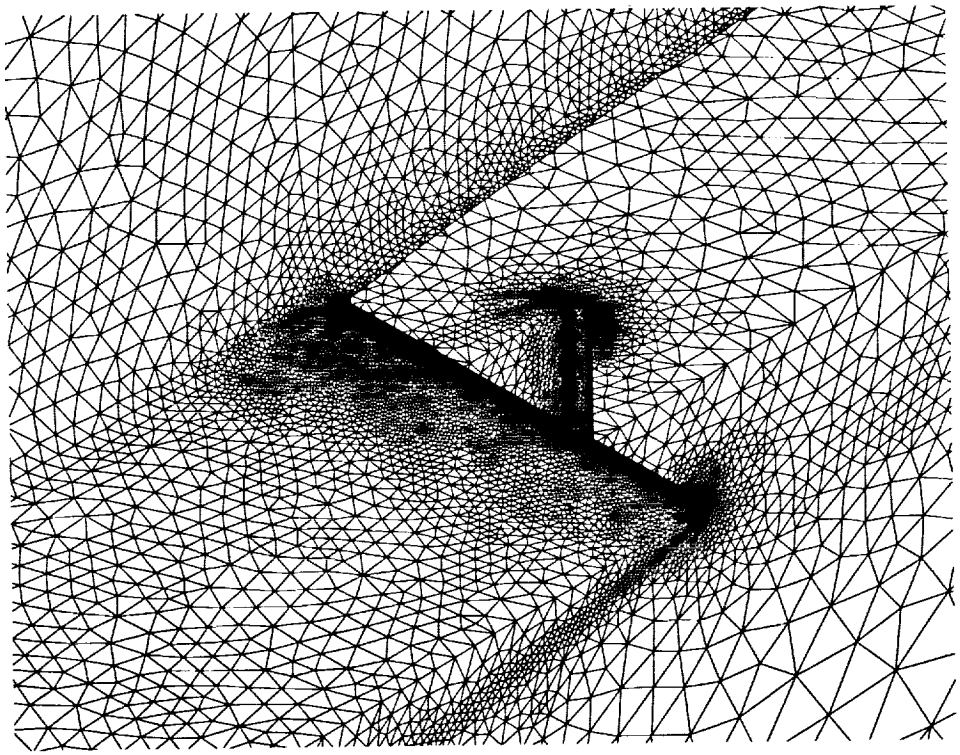
Density Contours



ADAPTED MESH 2

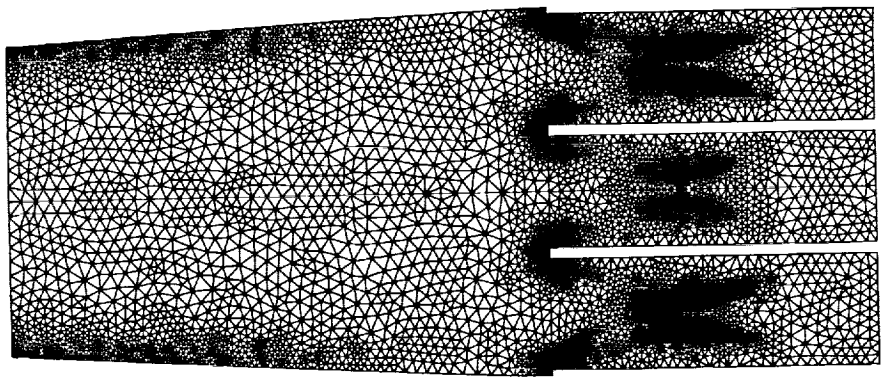


CLOSE-UP OF ADAPTED MESH 2



VEHICLE BOTTOM SURFACE
Adapted Mesh 2

Mesh



Density
Contours

CONCLUSIONS

- Adaptive remeshing demonstrated for problems with large number of elements
- Though efficient, these schemes exhaust cpu-time, memory and disk-space on current computers
- 3D meshes with element sizes equivalent to those necessary in 2D would need more than 10 million elements
- Current capability is significantly better than what was available only a few years ago
- Further improvements in mesh generation, flow solvers and adaptivity still needed