N94-22353

UNSTRUCTURED GRID RESEARCH AND USE AT NASA LEWIS RESEARCH CENTER

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CFD Applications at Lewis Research Center

- Inlets, Nozzles, and Ducts
- Turbomachinery
- Propellors - Ducted and Unducted
- Aircraft Icing

Grid Generation Development and Use at Lewis Research Center

- Inlets and Nozzles
  - GRIDGEN
  - TURBO-I/SG
- Turbomachinery and Propellors
  - TIGER
  - TCGRID
  - TIGMIC
  - IGB
  - TIGGERC
  - HGRID
  - TRBGRD
- General
  - GENIE
  - RAMPANT
  - ICEM
- Aircraft Icing
  - HYPGRID
  - GRAPE
  - MINMESH

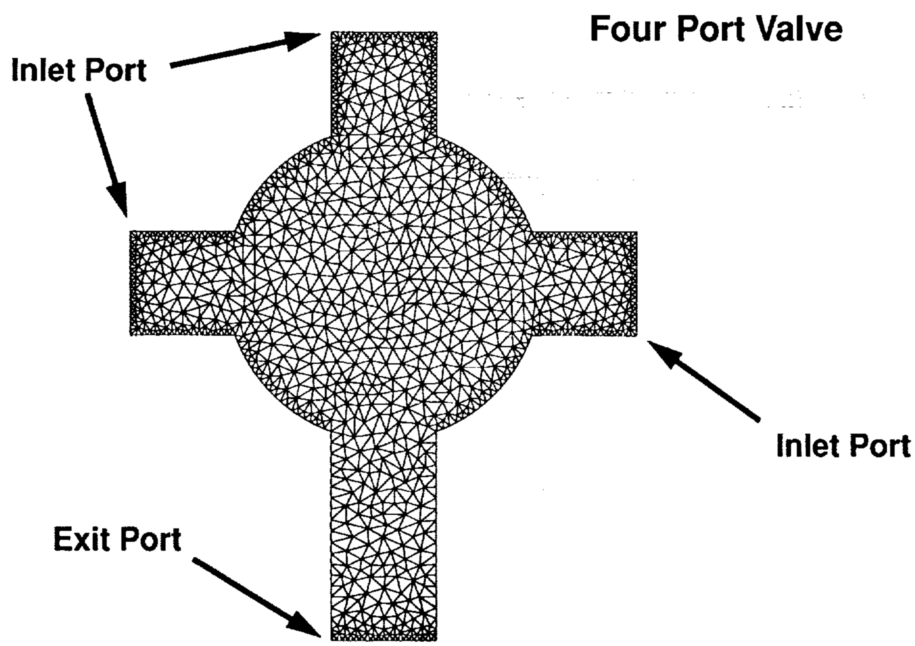
Some Issues related to Internal Flow Grid Generation

- Resolution requirements on several boundaries
- Shock resolution vs. grid periodicity
- Grid spacing at blade/shroud gap
- Grid generation in turbine blade passages
- Grid generation for Inlet/Nozzle geometries

Resolution Requirements on Several Boundaries

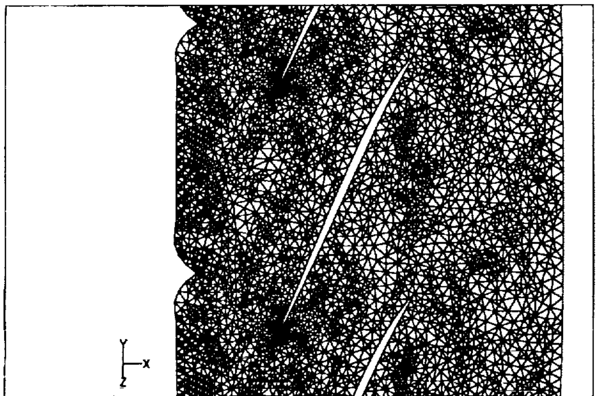
- Internal flow problems may have many intersecting surfaces
- Resolution requirements along surfaces may vary
- Structured grid generators can have great difficulty in meeting both requirements simultaneously

Resolution Requirements on Several Boundaries

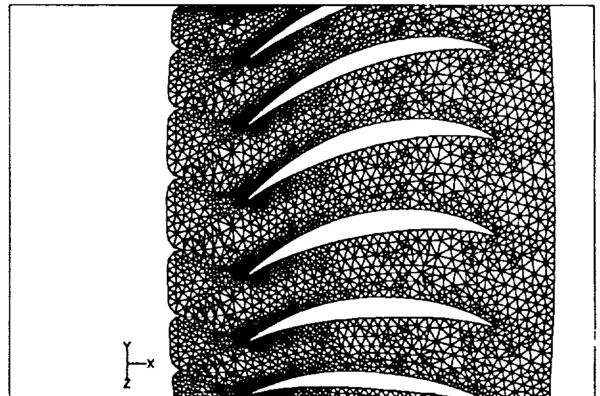


Shock Resolution vs. Grid Periodicity

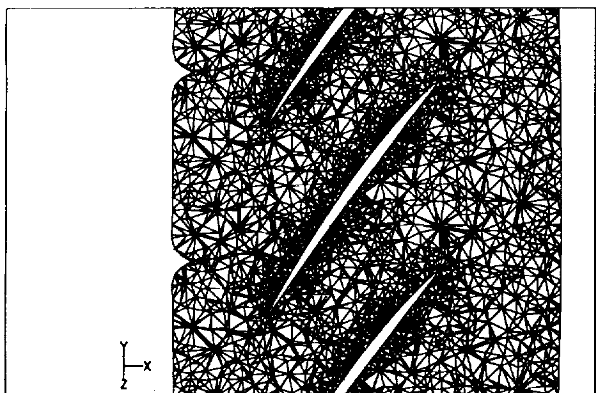
- Shock locations on upper and lower blade surfaces of cascade occurr at different chordwise locations
- Geometry of shock does not correspond to direction of grid lines
- These two requirements result in highly skewed grids and in an excessive number of grid points



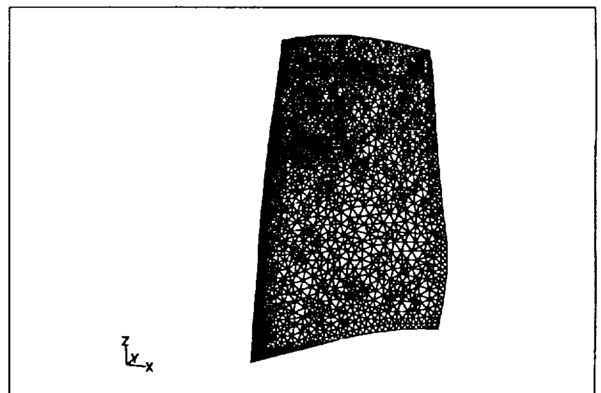
Rotor 67 (0% span)
Surface Grid
Rampant 3drke 2.0



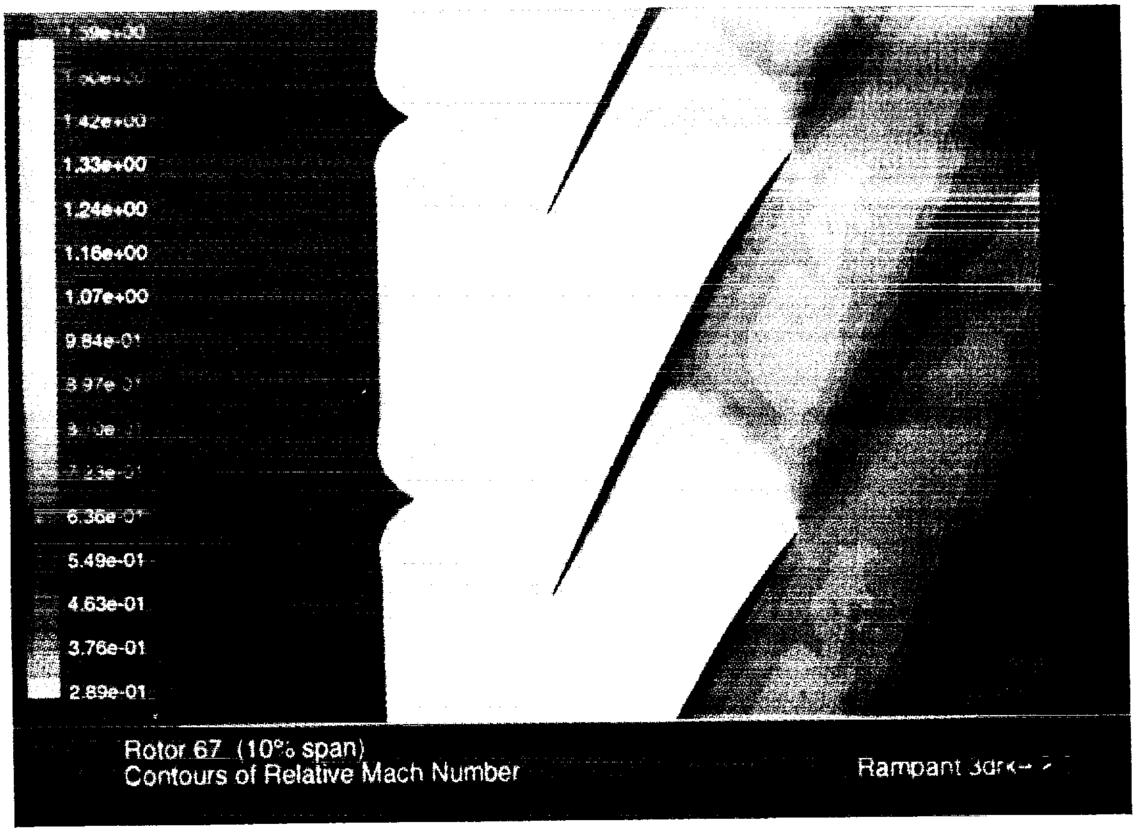
Rotor 67 (100% span)
Surface Grid
Rampant 3drke 2.0



Rotor 67 (30% span)
Grid Slice
Rampant 3drke 2.0



Rotor 67 (blade surface)
Surface Grid
Rampant 3drke 2.0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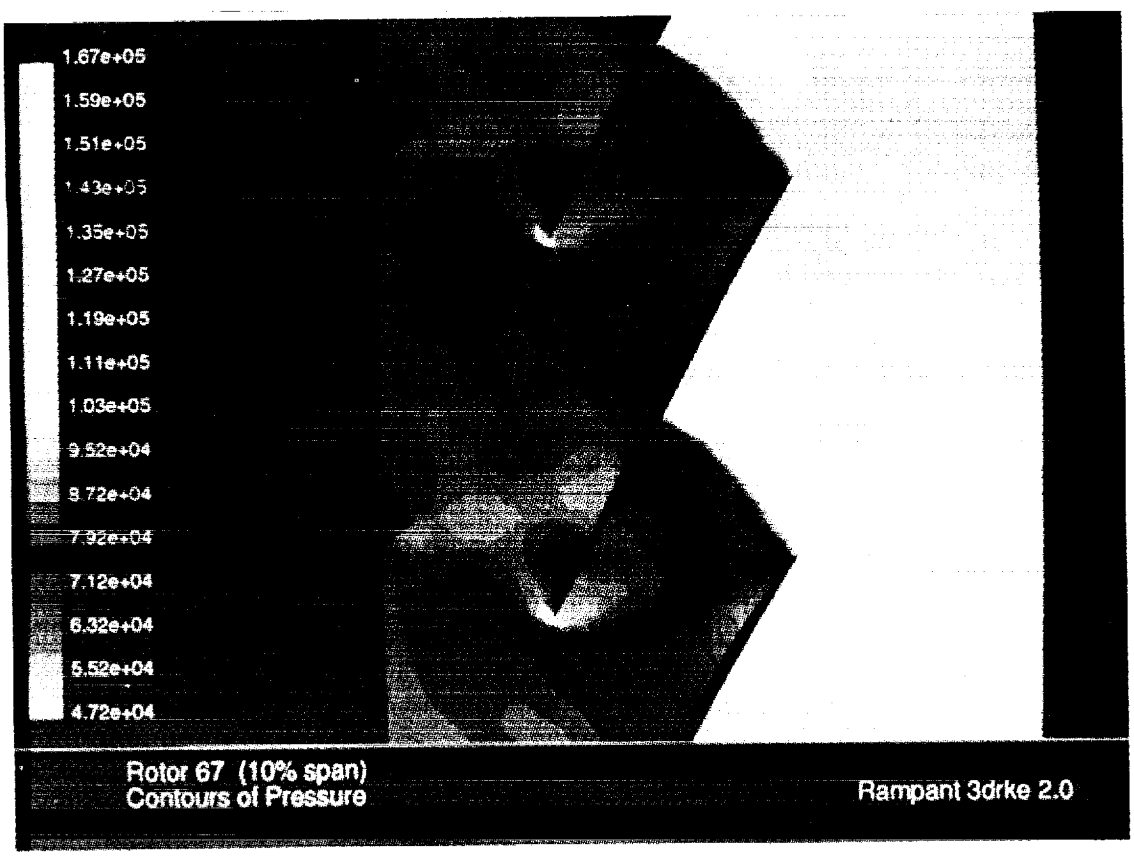
4.63e-01
3.76e-01
2.89e-01
Rotor 67 (10% span)
Contours of Relative Mach Number
Rampant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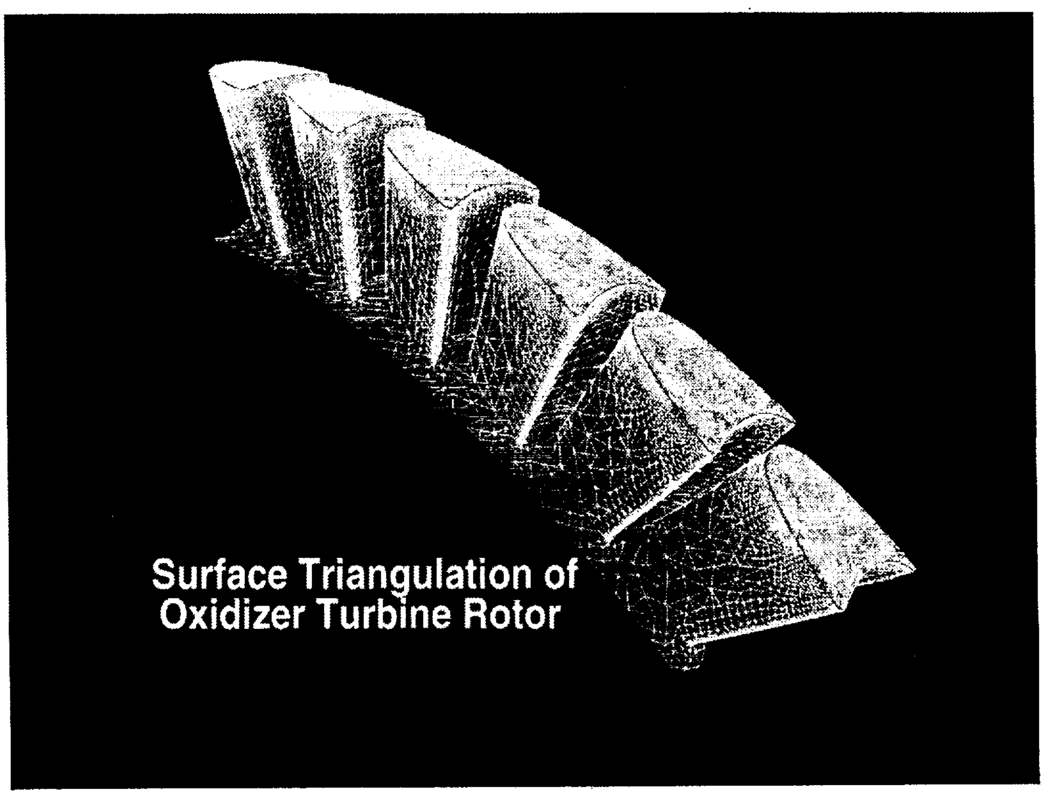
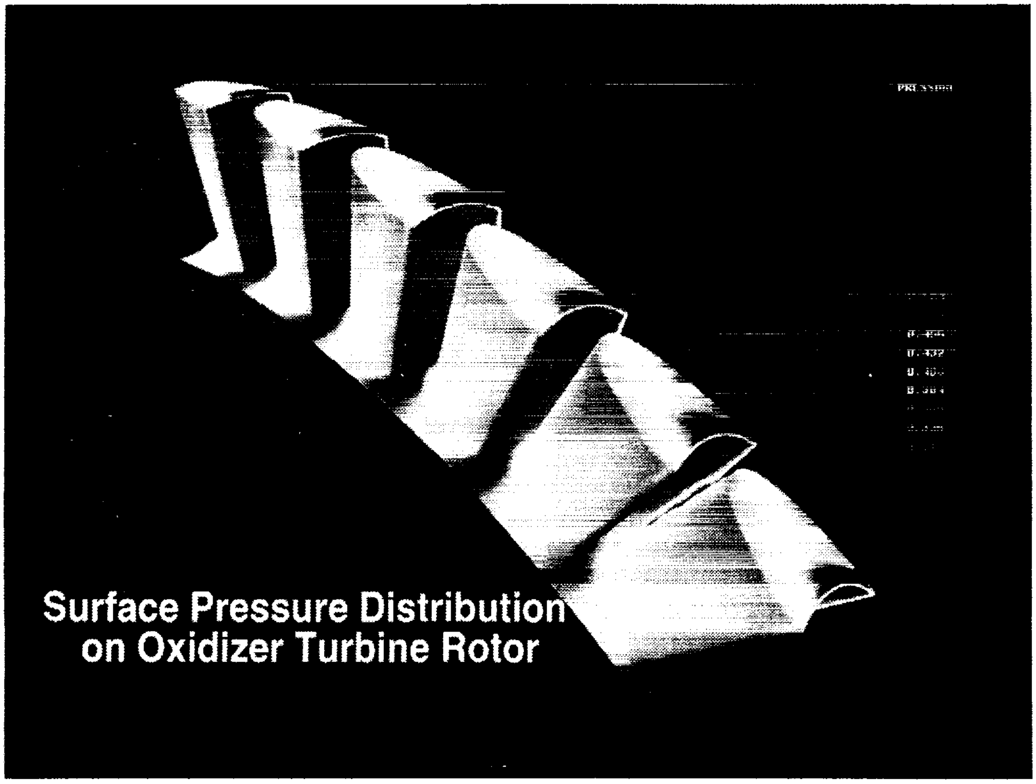
1.03e+05
9.52e+04
8.72e+04
7.92e+04
7.12e+04
6.32e+04
5.52e+04
4.72e+04
Rotor 67 (10% span)
Contours of Pressure
Rampant 3drke 2.0

Grid Spacing at Blade/Shroud Gap

- Small gap (<.2% of blade span) exists between rotor blades and surrounding shroud
- Attempts at modeling gap result in high grid skewing and large number of grid points
- Many structured grid solutions neglect the gap region



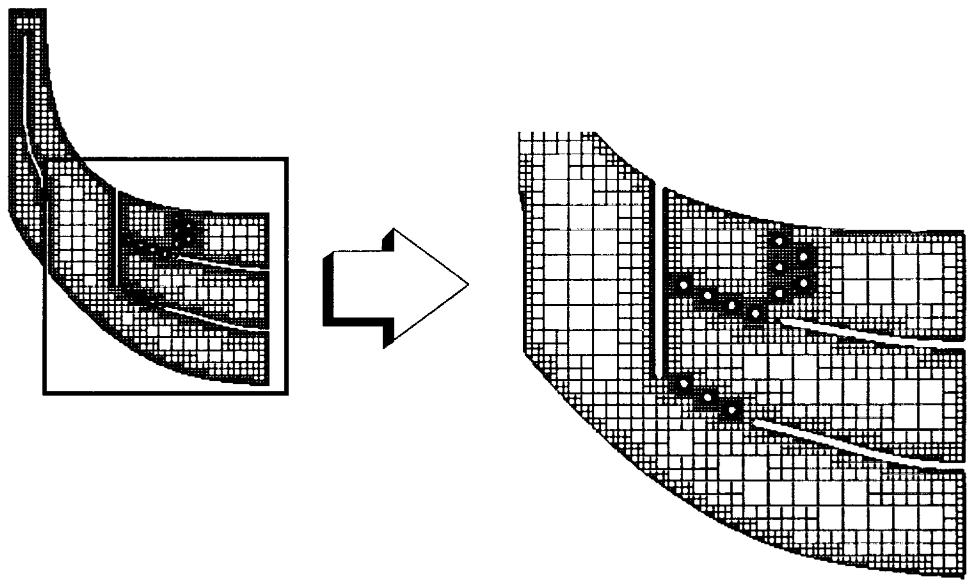


Grid Generation in Turbine Blade Passages

- Complex geometry and viscous flow modeling results in:
  - Multi-block grid
  - Large number of grid points
  - Labor-intensive grid generation effort

- Automatic generation of internal grid points is required

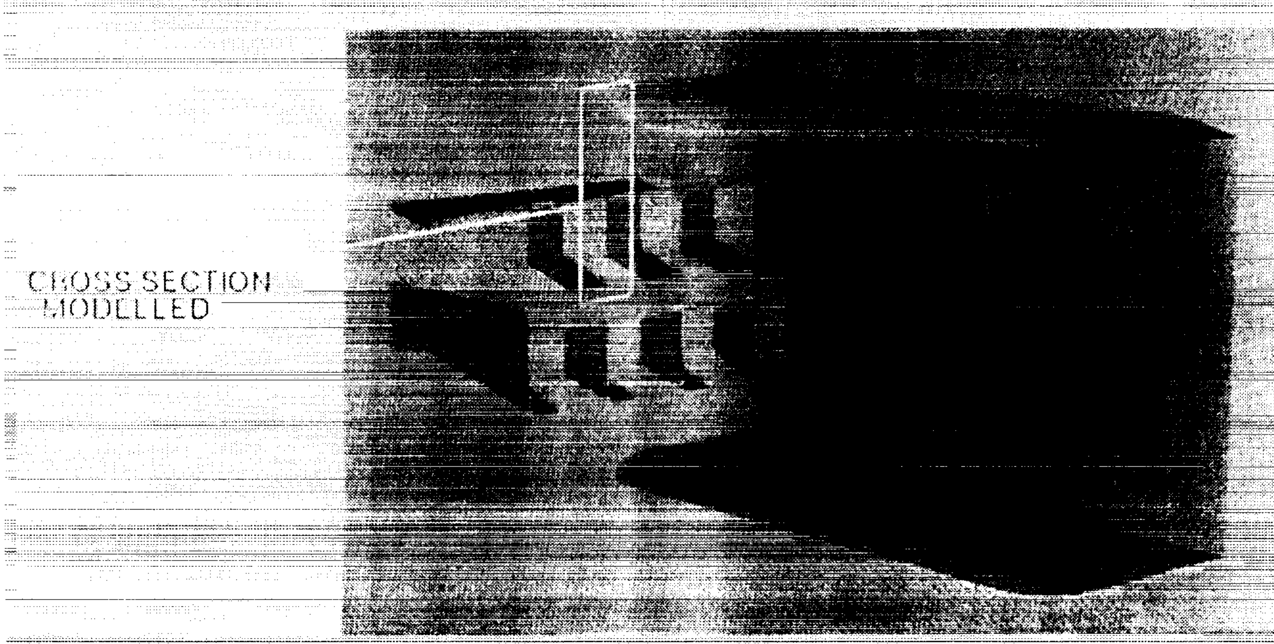
Grid Generation in Turbine Blade Passages



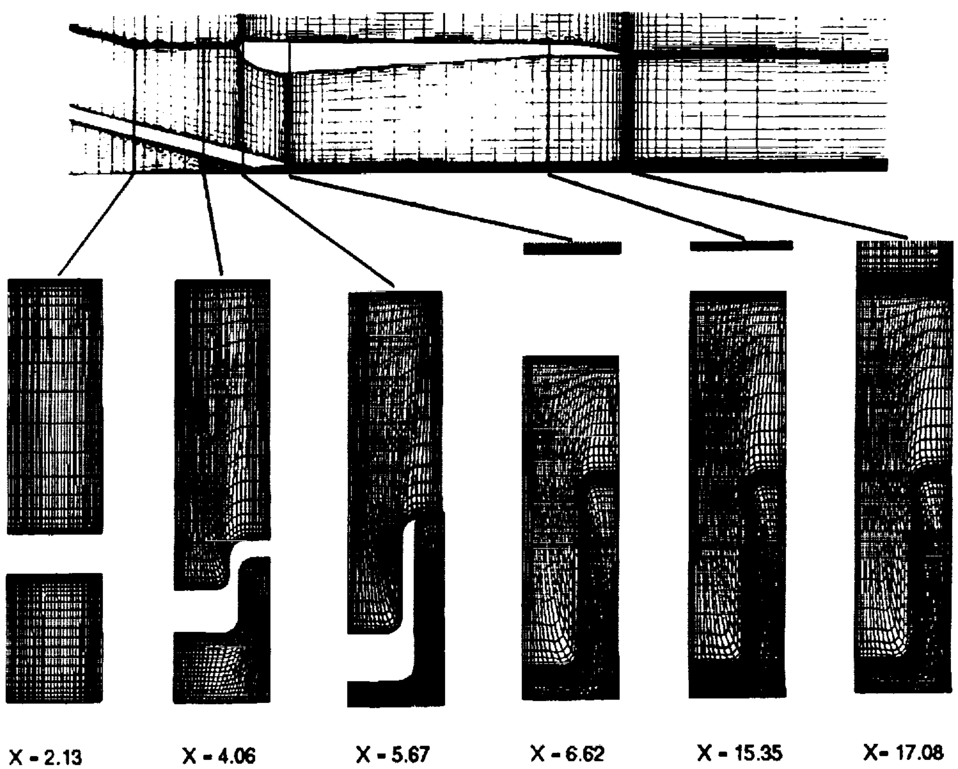
Grid Generation for Inlet/Nozzle Geometries

- Rapidly varying flow passage geometries can result in difficult blocking schemes
- Interfacing of blocks at regions of rapid geometry change can be difficult to achieve
- Geometry and flow phenomena resolution requirements can be conflicting and result in excessively large grids
- Grid development time can be extensive

PRATT & WHITNEY 2D MIXER-EJECTOR NOZZLE GEOMETRY



AXIAL CUTS THROUGH 3-D GRID

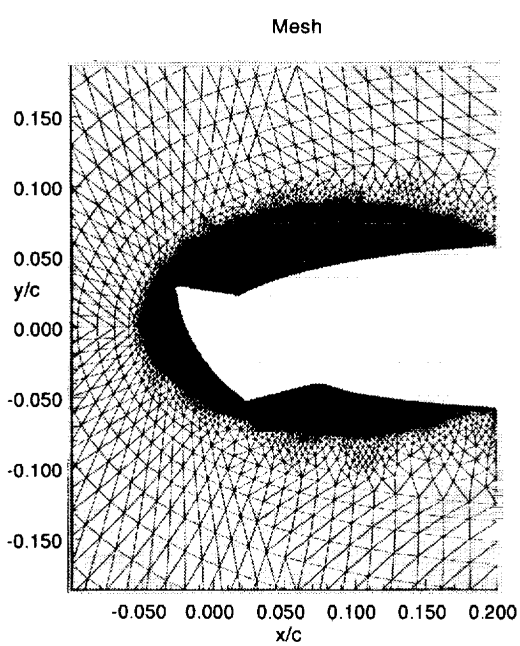


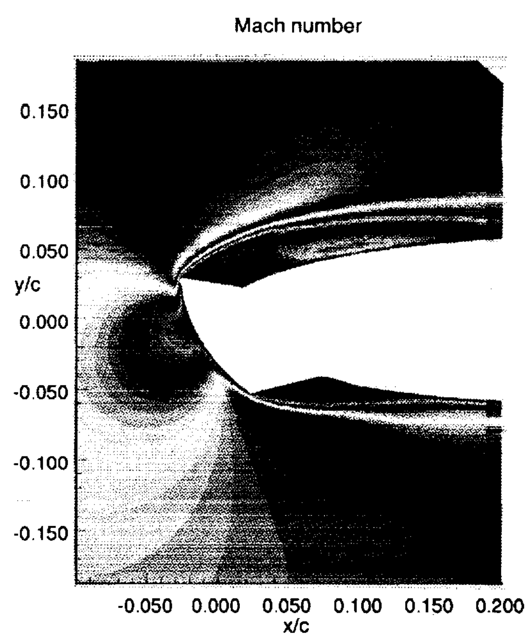
Aircraft Icing Grid Generation Issues

- Small structures relative to airfoil chord must be resolved
- Excessive number of grid points in far-field using structured grid
- Grid must be re-created as ice shape grows

NACA 0012 Airfoil with Simulated Glaze Ice

$M_\infty = 0.12, \alpha = 4°$

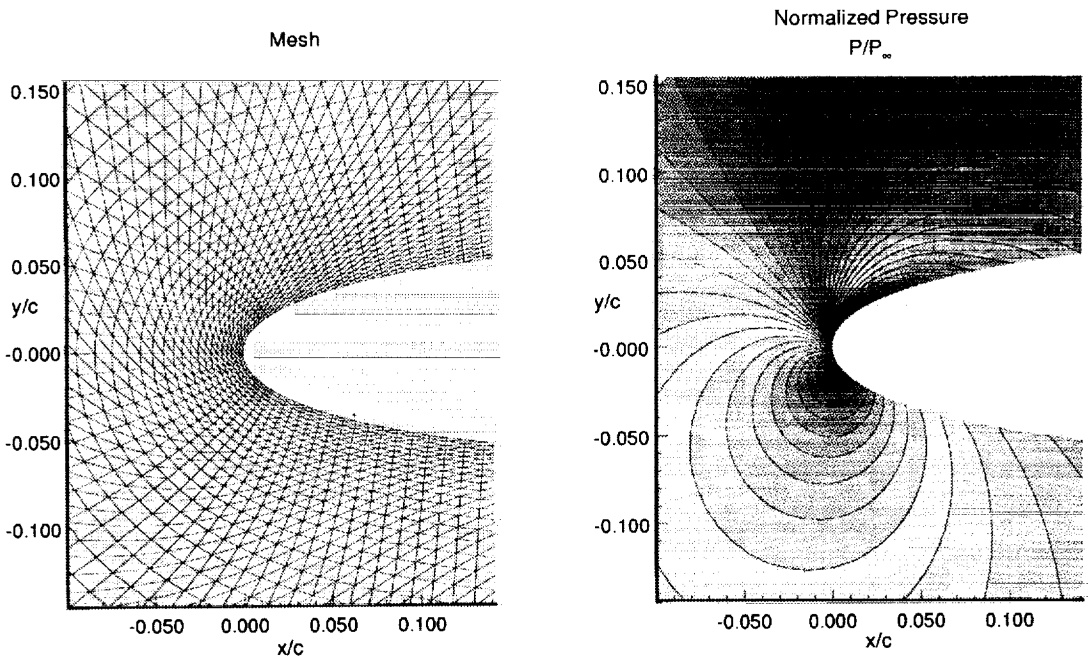




LEWICE/UE Ice Shape Prediction for Iced NACA 0012 Airfoil

Example 2, Clean Airfoil Calculation

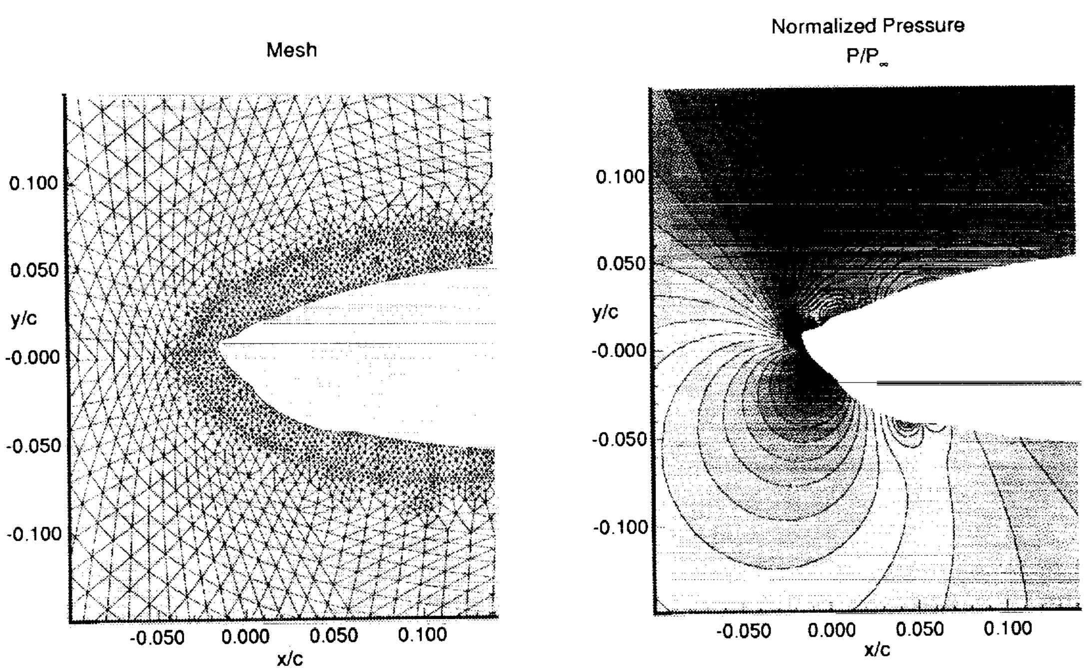
Mach = 0.4, $\alpha = 4°$



LEWICE/UE Ice Shape Prediction for Iced NACA 0012 Airfoil

Example 2, Time = 60 sec.

Mach = 0.4, $\alpha = 4°$



Concluding Remarks

- LeRC has several general-purpose and many application-specific grid generators for internal flow CFD analysis

- LeRC has some unstructured grid generation development activities in-house targeted at internal flow problems

- Unstructured grids can simplify and in some cases enable CFD analysis of internal flow geometries

- Unstructured grids are ideally suited for complex, changing geometries such as ice growth on aircraft surfaces