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# ROBUST UNSTRUCTURED GRID GENERATION WITH VGRID

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## Outline

- Objective and scope of present work
- Methodology
- Applications
- Concluding remarks

## Scope of Present Work

- Objective:

  to develop a **robust**, **user oriented** unstructured grid-generation technique for **fast** generation of Euler/viscous grids around 2D/3D **complex** configurations

- Approach:
  - **Advancing-Front** method for generation of Euler grids (established technique)
  - **Advancing-Layers** method for generation of viscous grids (work in progress)

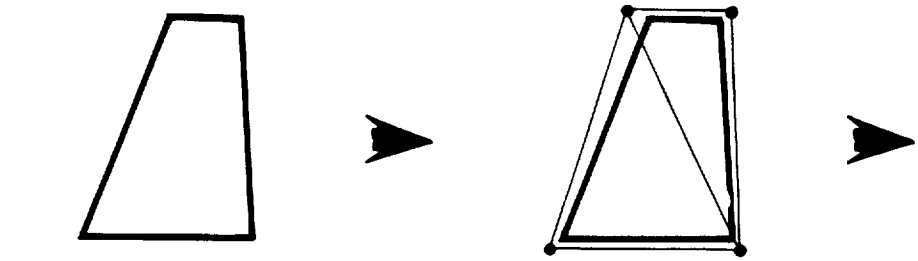
## Advancing-Front Method

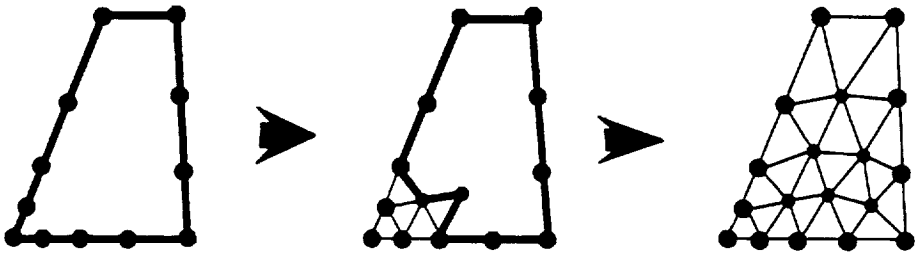
- Salient features:
  - grid quality
  - robustness
  - self-sufficiency for grid point distribution
  - established methodology (especially in 3D)

- Recent developments resulting in substantial enhancement of AFM :
  - structured background grids with source elements (AIAA Journal, Feb. 1993)
  - grid restart capability
  - local remeshing

  } grid post-processing (AIAA paper 92-0445)

### Advancing Front Method

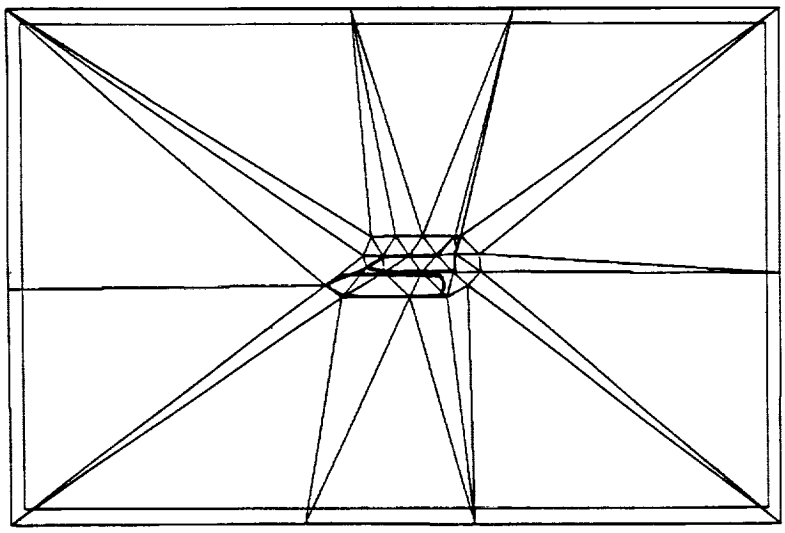


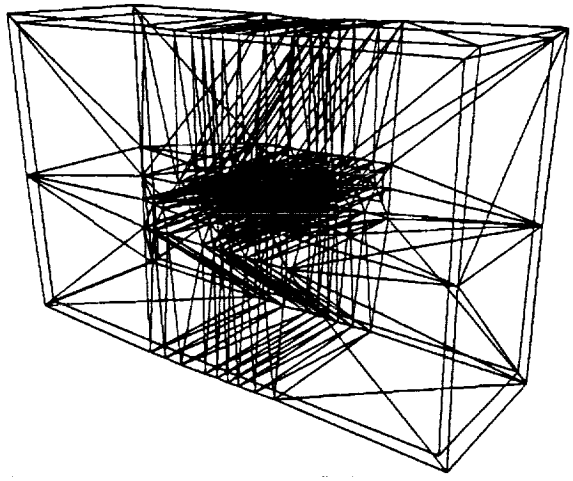
## Background Grids

- A secondary mesh containing grid characteristic information
  - need not conform to the domain boundaries
  - integral to the AFM
- Background grids should
  - be simple to construct
  - provide smooth and controlled variation of grid spacings in the field
  - be flexible to modifications

## Unstructured Background Grids



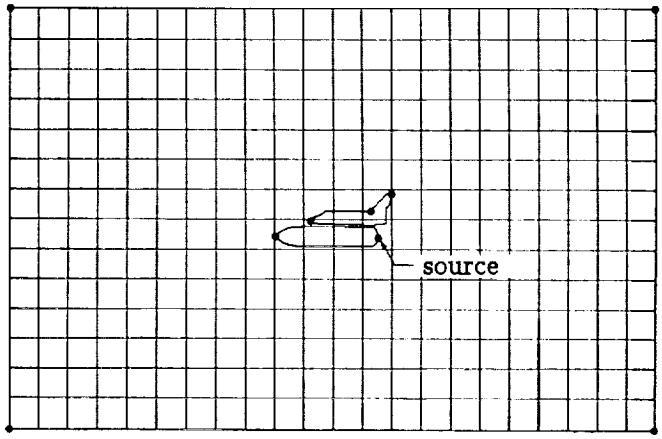
2-D



3-D

### Structured Background Grids

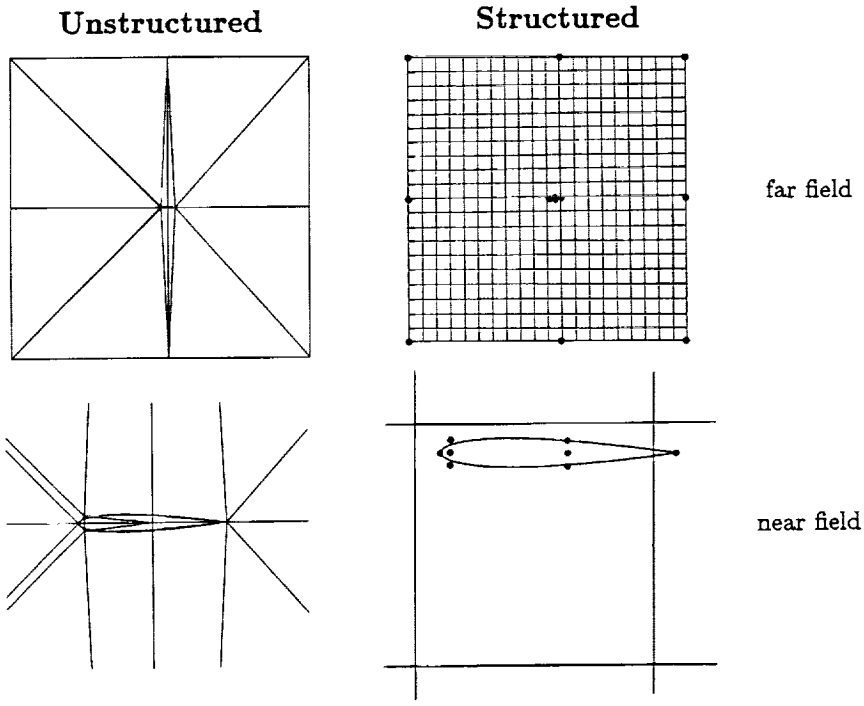
- Simple uniform Cartesian grids; easy to construct
- Source elements with prescribed spacing parameters: nodal and linear elements
- Provides smooth grid distribution, flexible control, and ease of grid modification



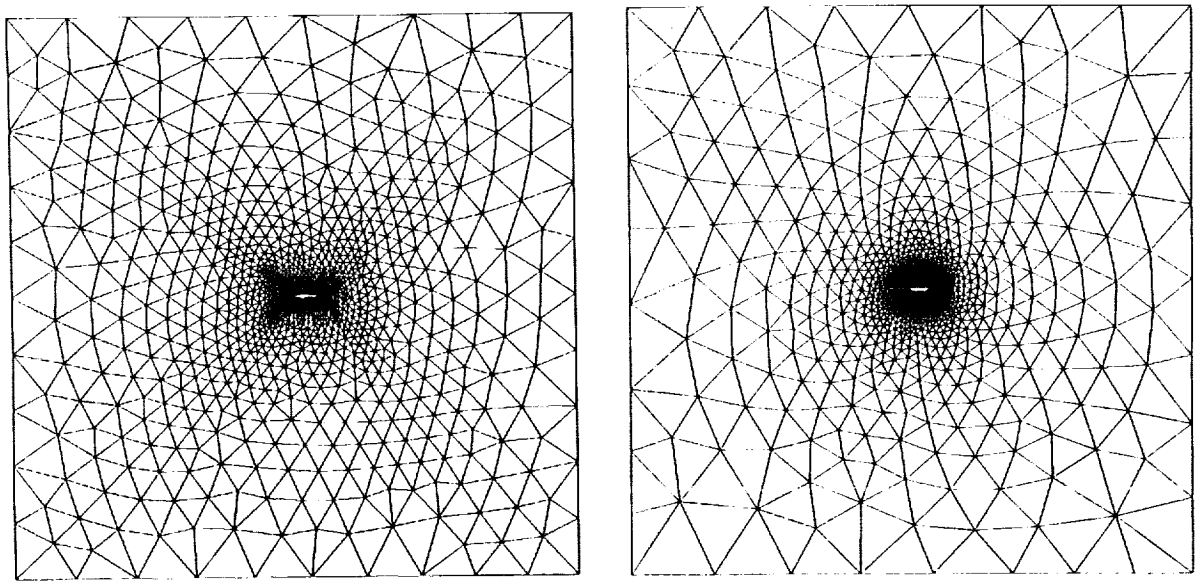

## Distribution of Spacing Parameters

- Determined by a process similar to diffusion of 'heat' from discrete heat sources in a conducting medium
- Modeled by solving a Poisson equation, $\nabla^2 S = G$
- Resulting discretized algebraic equations solved with an iterative method
- The solution provides 'pseudo-isotherms' varying smoothly from high- to low-potential regions

## Background Grid for a NACA 0012 Airfoil




## Unstructured Grid around a NACA 0012 Airfoil

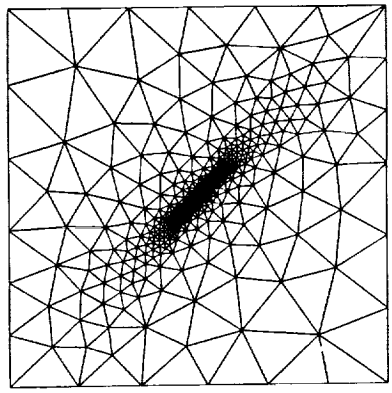


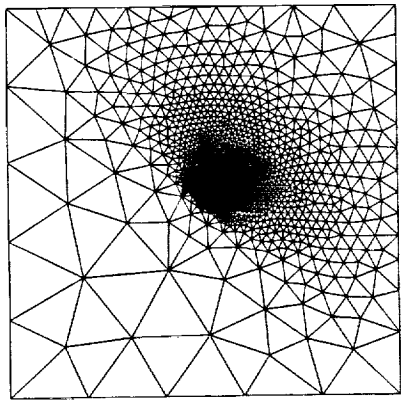
using unstructured background grid

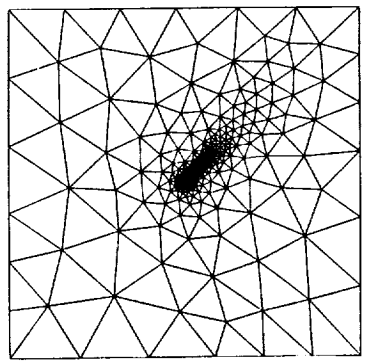
using structured background grid

## Directional Control of Source Intensity

(Nodal Elements)

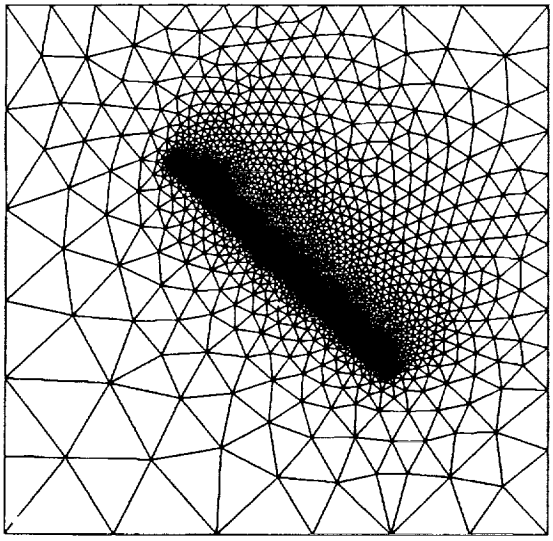


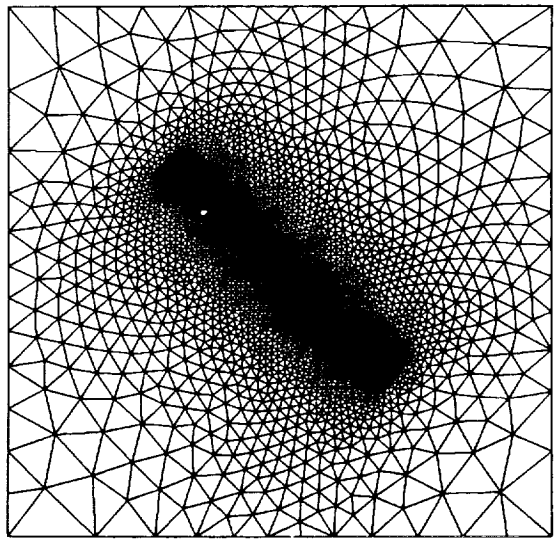




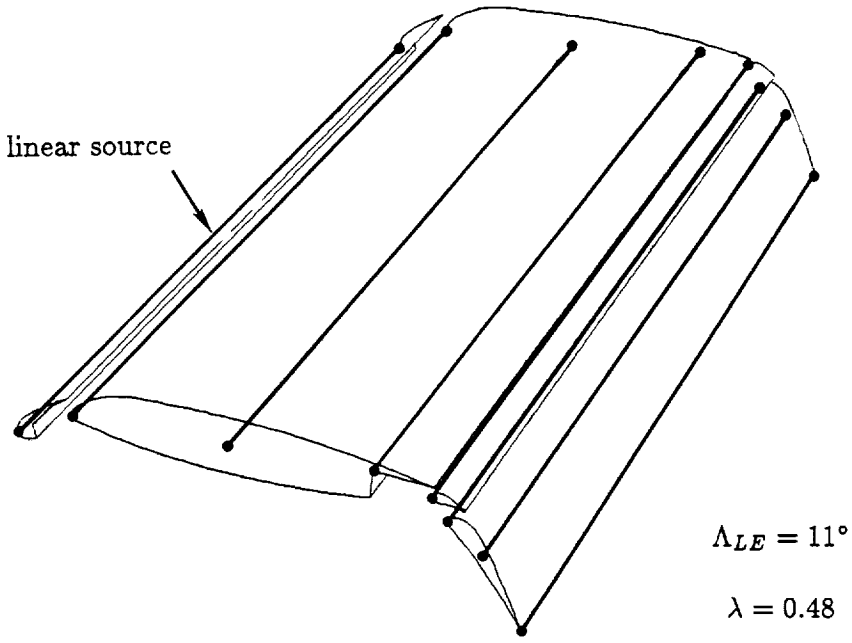
## Directional Control of Source Intensity

(Linear Elements)



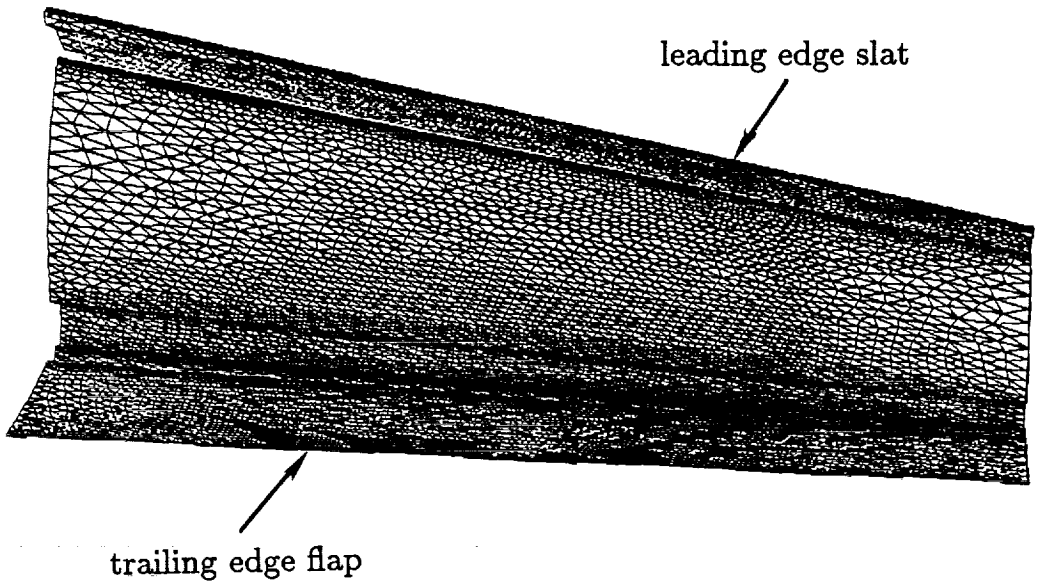


## Source Elements on a Generic Multi-Element Wing




## Surface Triangulation on a Generic Multi-Element Wing

(wing lower surface)



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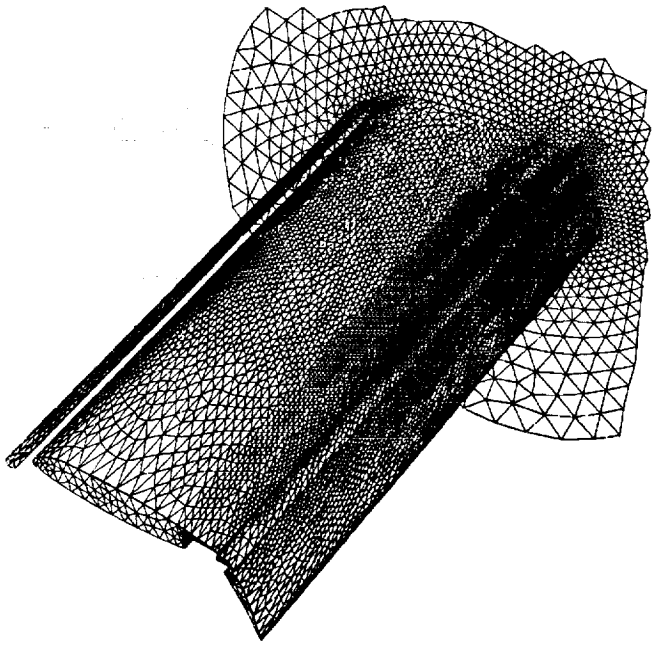
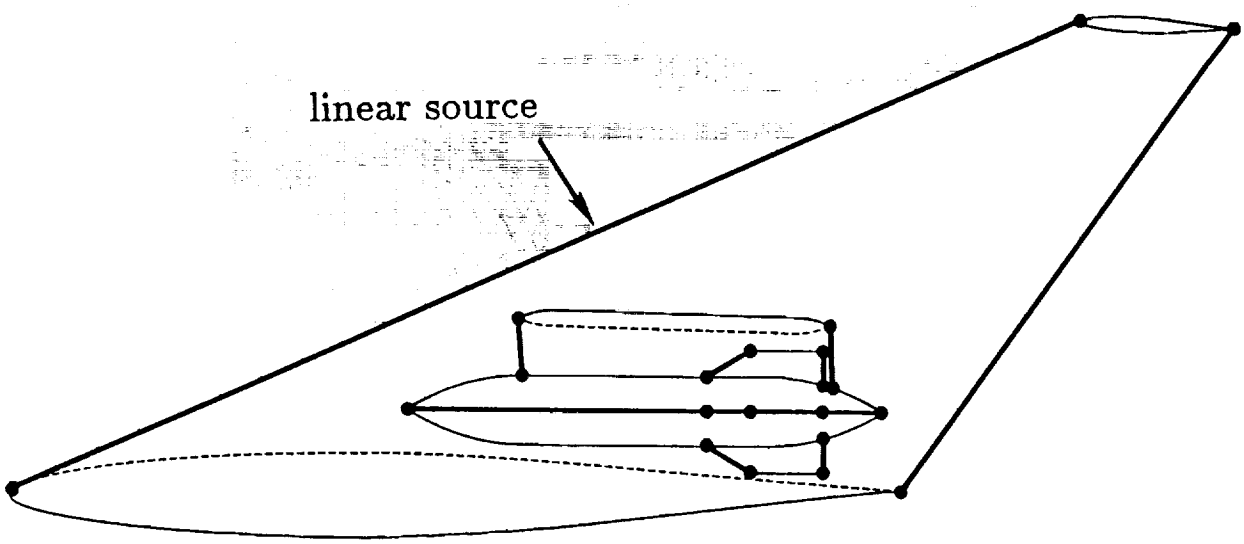
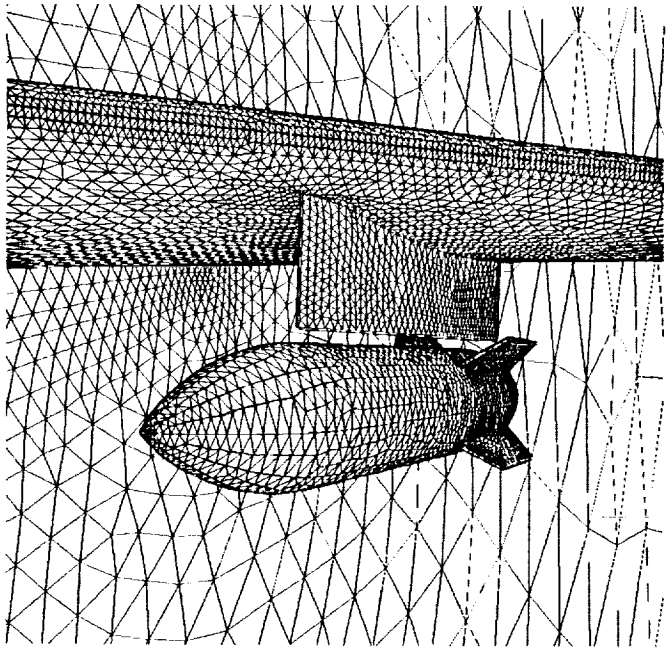


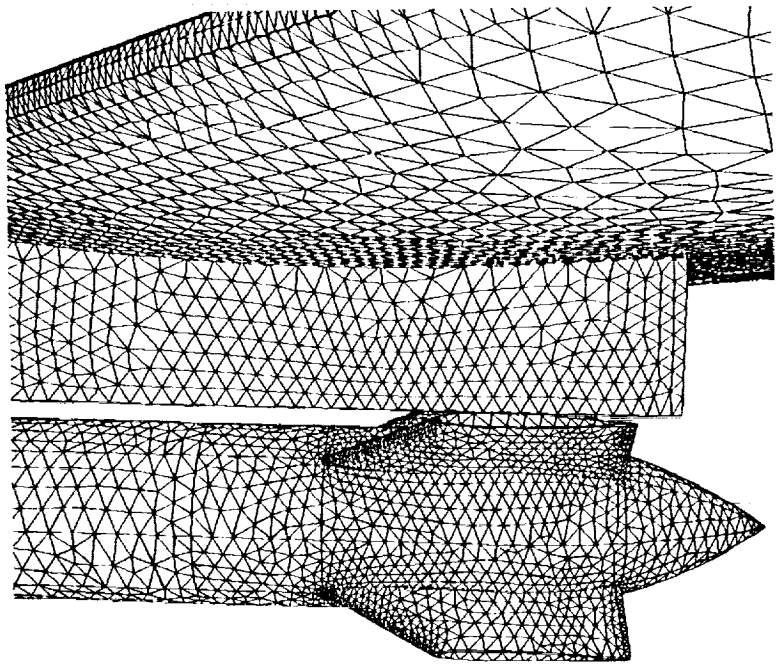
# A Wing/Pylon/Store Configuration



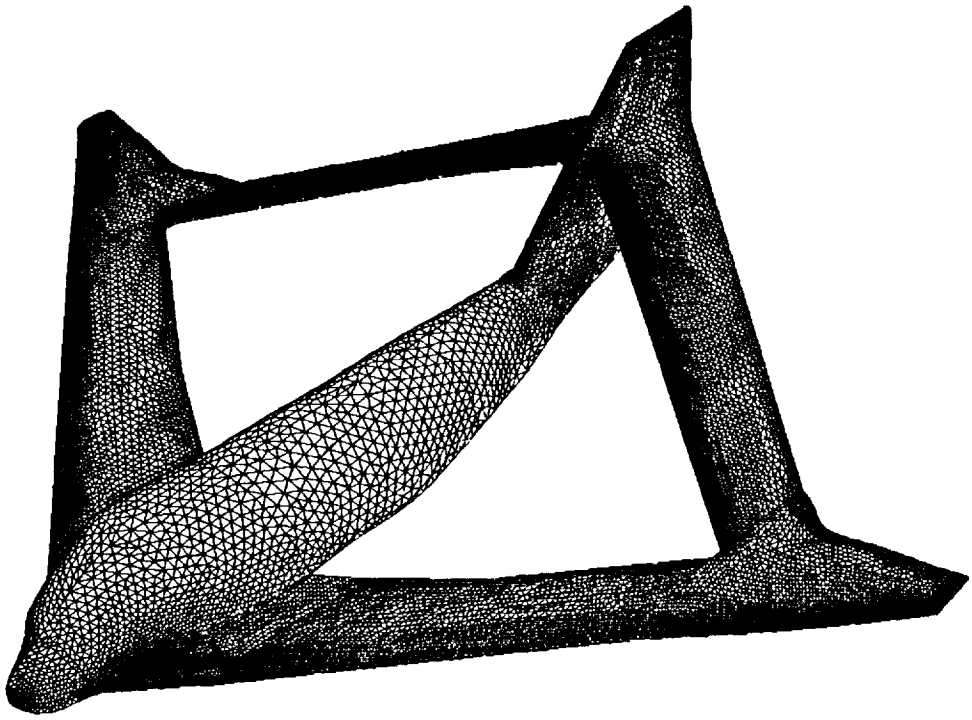
Details of Surface Grid on a
Wing/Pylon/Store Configuration



Details of Surface Grid on a
Wing/Pylon/Store Configuration



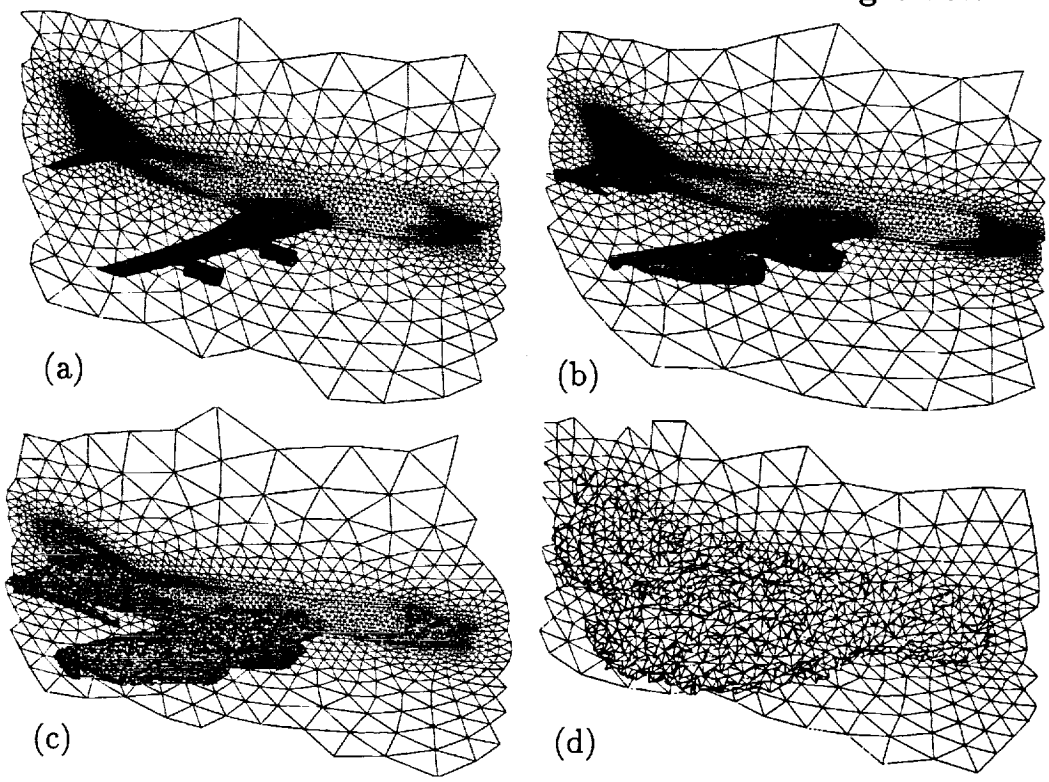
## A Boeing Joined-Wing Aircraft Configuration



## Grid Restarting

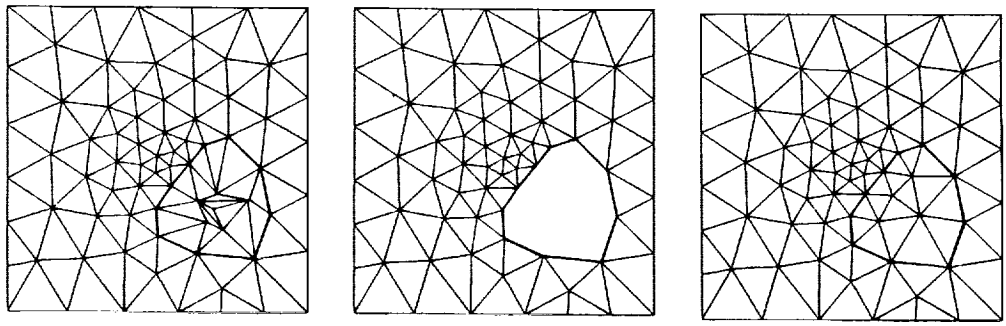
- Grid generated in a marching fashion in AFM
  - only information on the current front needed for further advancement
  - process may be stopped and restarted without carrying previously generated grid
- Procedure based on a recurrent local/global renumbering resulting in:
  - substantial reduction in memory requirement
  - capability of generating large grids on small machines
  - substantial increase in productivity of the method

## Partial Restarted Grids Around a B747 Configuration




## Local Remeshing

- Irregularity of unstructured grids $\Longrightarrow$ arbitrary cell groupings
- A cell grouping, being independent of surrounding mesh, may be
  - removed, creating pockets and new fronts in the grid
  - remeshed with no effect on rest of the grid
- Local remeshing and restart capability have resulted in a useful 3D grid post-processing tool $\Longrightarrow$ program **Postgrid**



## Unstructured Viscous Grid Generation

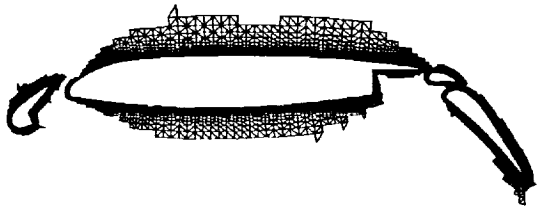
- Problem still unresolved, especially in 3D
- Generation of highly stretched cells proven to be non-trivial
- Issues to be considered:
  - automation
  - self-sufficiency for grid point distribution
  - grid quality
  - flexibility and ease of grid control
  - capability of handling difficult regions such as sharp corners, singular points, wakes, gaps between close surfaces, etc. without users' interaction

## Advancing Layers for Generation of Viscous Grids

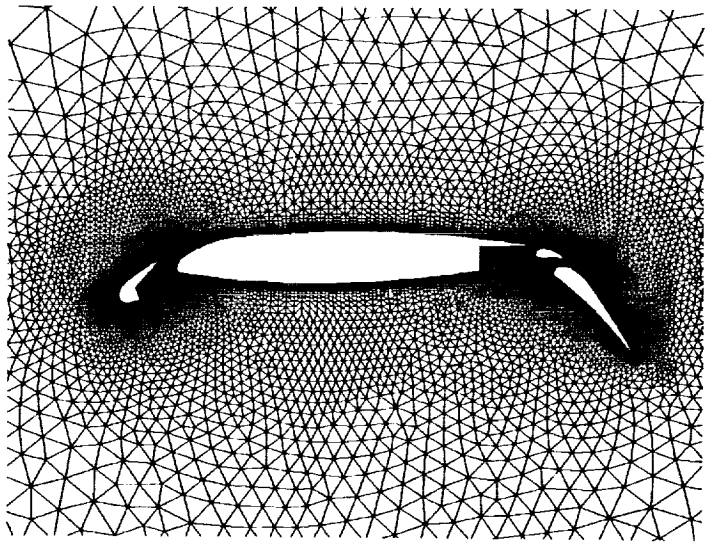
- An extension of Advancing-Front method to generate highly stretched cells
  - grid advances in the field one layer at a time
  - benefits from generality and flexibility of AFM
  - method is automatic, fast, self-sufficient, and robust
  - provides smooth and structured-looking viscous grids
  - practically, no limit to the extent of cell aspect ratio
  - minimal user's input data (uses same surface mesh and B.G.)
  - resolves many of shortcomings of the semi-structured methods
- Has been shown in 2D with good results (NASA CR 191449, 1993)
- Work in progress in 3D

**Viscous Grid around a Multi-element Airfoil**

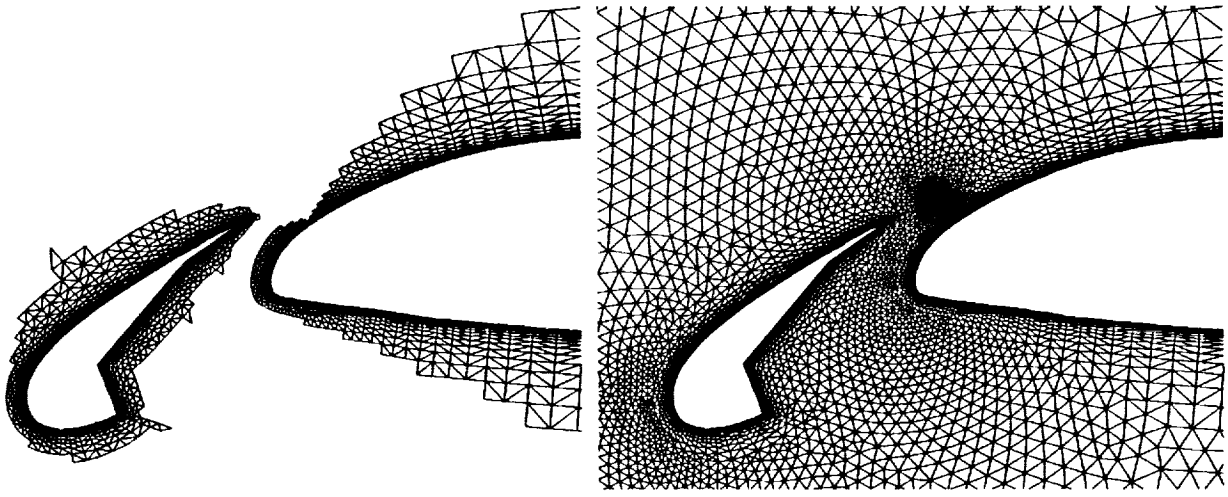
Partial grid



complete grid



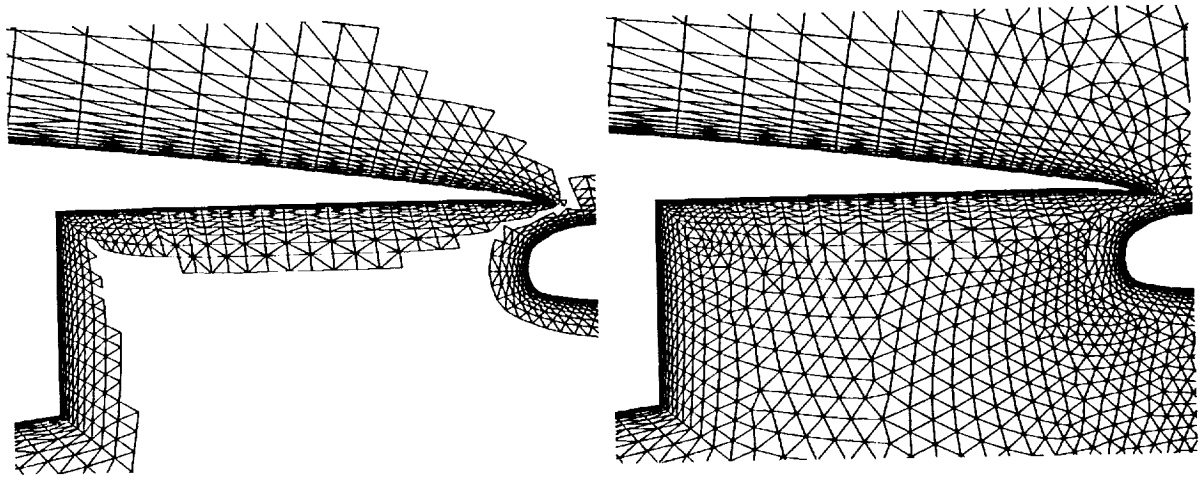
## Viscous Grid around a Multi-element Airfoil
(by Advancing Layers / Advancing Front Methods)



Partial grid

complete grid

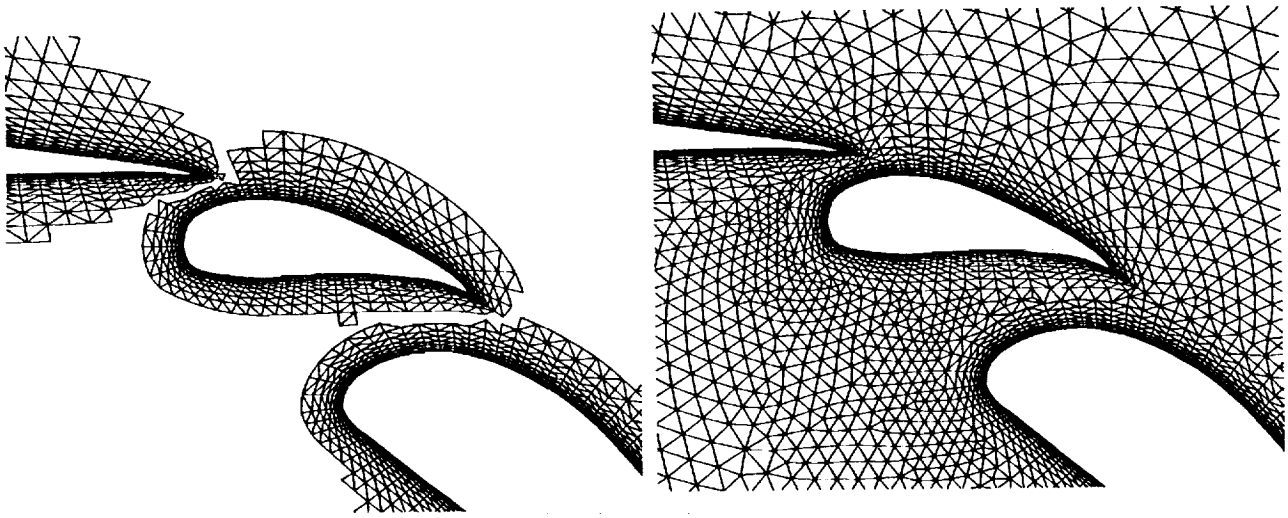
**Viscous Grid around a Multi-element Airfoil**
(by Advancing Layers / Advancing Front Methods)



Partial grid

complete grid

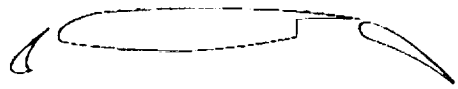
**Viscous Grid around a Multi-element Airfoil**
(by Advancing Layers / Advancing Front Methods)



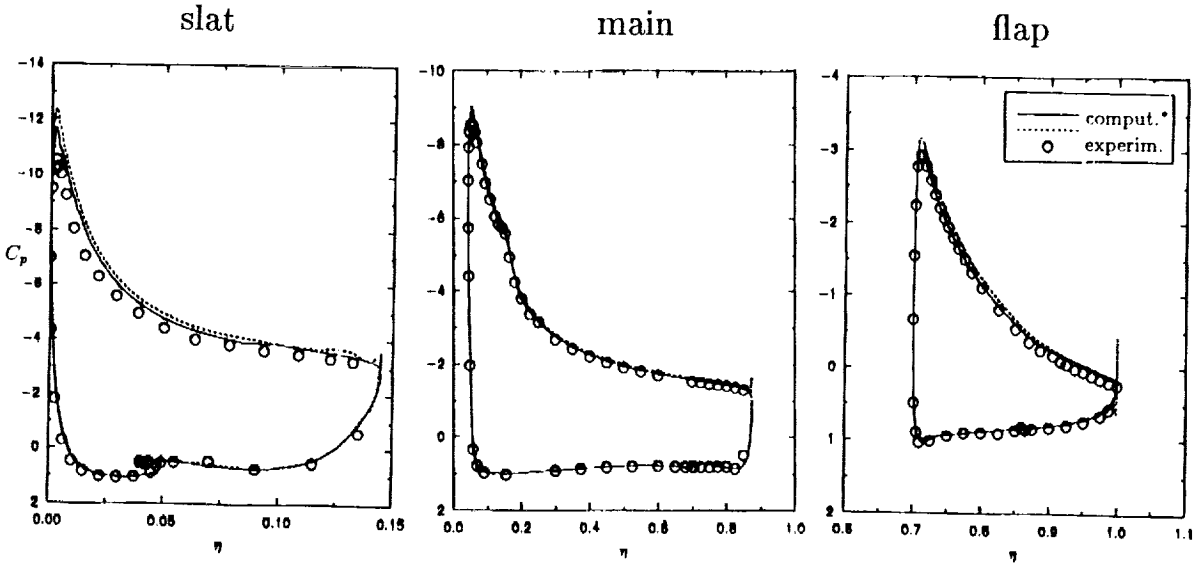
Partial grid

complete grid

## Surface Pressure on a Douglas Multi-element Airfoil



$M_\infty = 0.2$
$Re = 9 \times 10^6$
$\alpha = 16.30°$




## Concluding Remarks

- Routine generation of Euler grids around complex configurations now possible with VGRID as currently used by many users from NASA and industry
- Continuous enhancement of the technique is performed in response to the users' requirements and feedback
- The new method of 'Advancing Layers' has produced good unstructured viscous grids in 2D (extension to 3D in progress)
- Plan: a single robust code for generation of both Euler and viscous unstructured tetrahedral grids