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**SOFTWARE SYSTEMS USED FOR
UNSTRUCTURED GRID GENERATION
AT NASA LANGLEY**

**MICHAEL J. BOCKELIE
COMPUTER SCIENCES CORPORATION**

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OVERVIEW

- o **Grid Generation Systems For 3D Configurations (Euler Grids)**
 - o **VGRID** (NASA / LaRC)
 - o **FELISA** (Swansea College, UK)
 - o **TETRA** (CDC / ICEM)
 - o **NGP** (National Grid Project / Mississippi State University)
 - o **TGRID** (Create / RAMPANT)

- o **Special Purpose (Research) Grid Generators**
 - o Viscous and Inviscid
 - o Solution Adaptive For Steady and Unsteady Flows

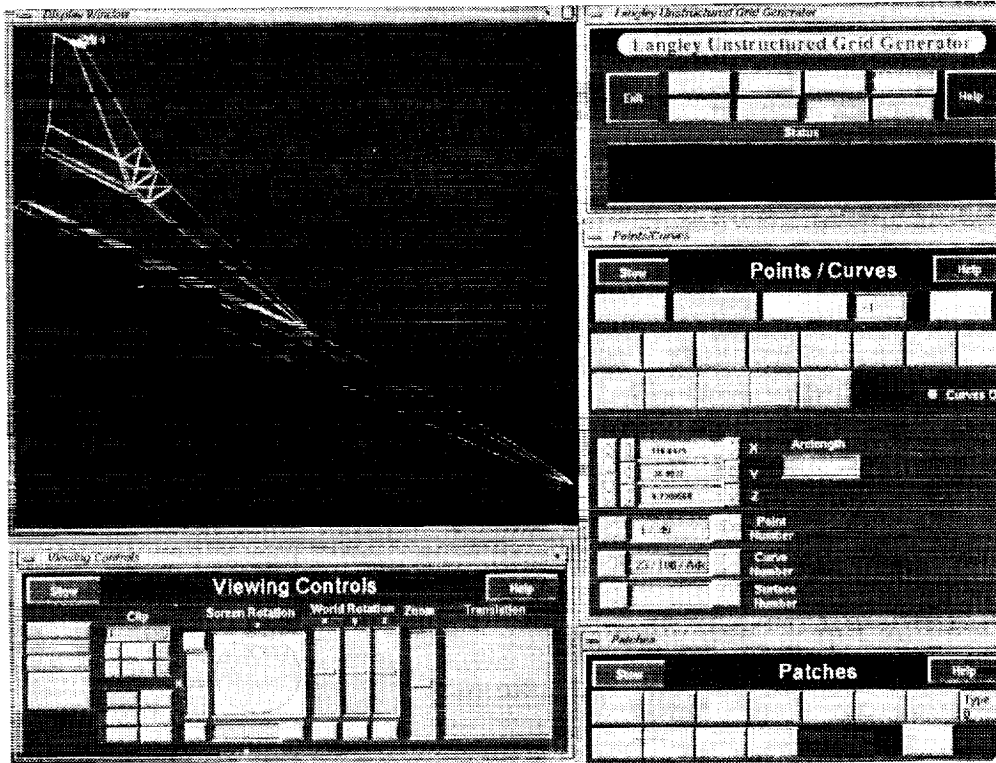
CRITERIA

- o **User Orientation**
- o **Type of Software System**
- o **Surface Definition**
- o **Grid Generation Method**
- o **User Interface**

- o **" Computational Time " to generate 100K Cell Grid**
 - SGI IRIS / 4D with 50 MHz R4000 64 Bit CPU + 128 MB

NEW VGRID

- o **Most Widely Used System For 3D Configurations**
 - User Support / Training + Expert Users Available Locally
 - Tested On Many Configurations
- o **NOT an Integrated System ==> Collection of Individual Codes**
 - Requires User with CFD Training (Engineer)
- o **Surface Definition : NURBS !! NEW !!**
 - INPUT : Point or NURBS Surface Data
- o **Grid Generation Method : Advancing Front (Lohner, Parikh, Pirzadeh)**
 - Node Spacing Data : Point / Line Sources
 - Surface Grid : Generated on Bi - Linear Surface Patch Approximation of Object and then Projected to NURBS Surface.
- o **Graphical User Interface ==> !!! NEW !!!**
 - Create Surface Patches, Source Terms, Flow Solver BC's
 - "T" Connections for Patches
- o **100K Cell Grid => 12 CPUM**

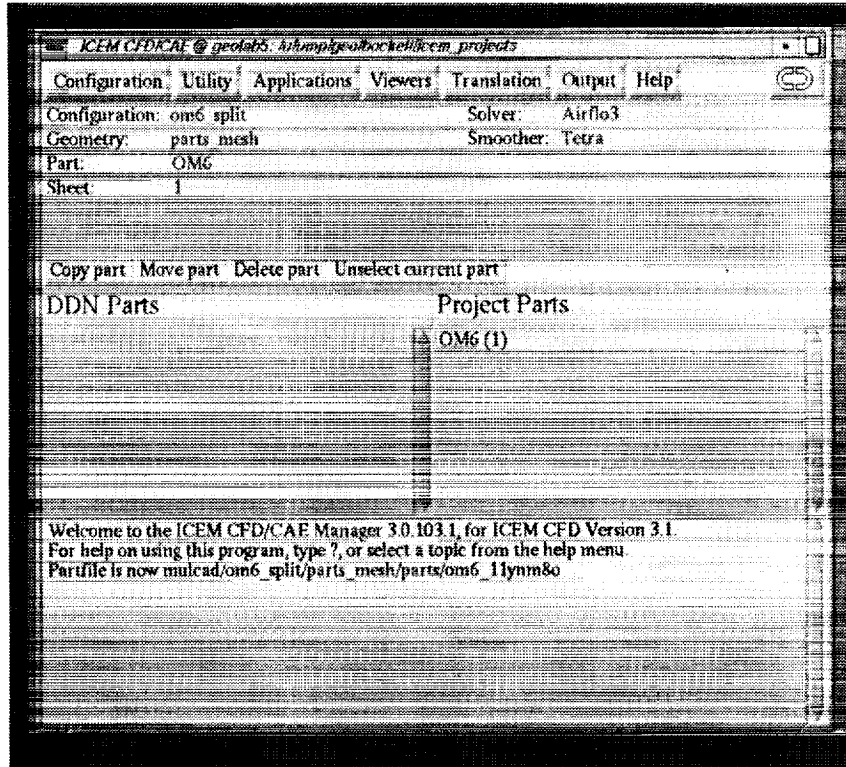


FELISA

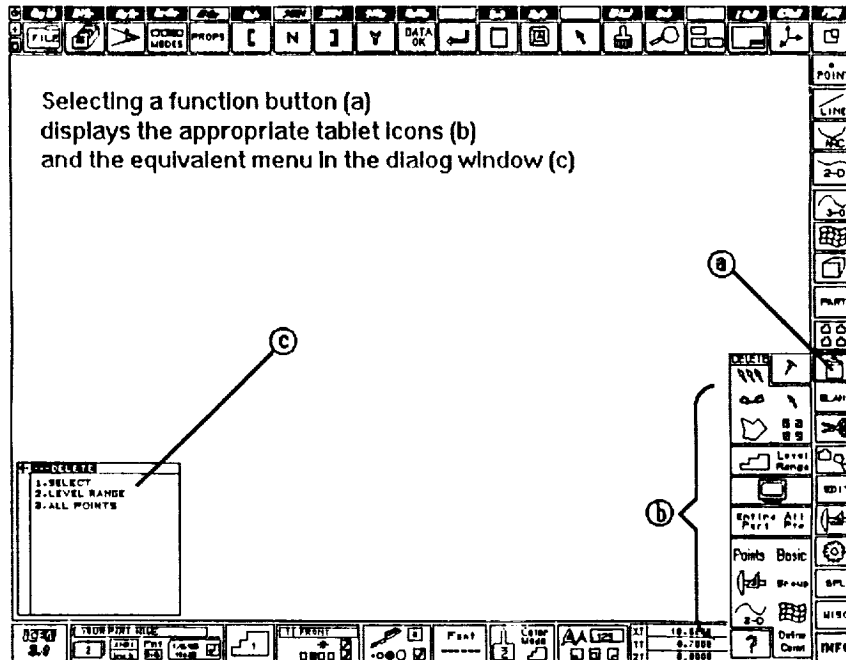
- o **Small User Base**
 - Limited User Support
- o **NOT an Integrated System ==> Collection of Individual Codes**
 - Requires CFD Engineer
- o **Surface Definition : Networks of Bi-Cubic Hermite Patches**
 - INPUT : Point Data
- o **Grid Generation Method : Advancing Front (Morgan & Peraire)**
 - Node Spacing Data : Point / Line / Triangle Sources
 - Surface Grid : Generated on Bi-Cubic Surface in Uniform Parameter Space
best looking (prettiest) surface grids in open literature
- o **No Graphical User Interface ==> Difficult To Set Up Problems**
 - modify VGRID Interface To Output Required Data ?
- o **100K Cell Grid => 25 CPUM**

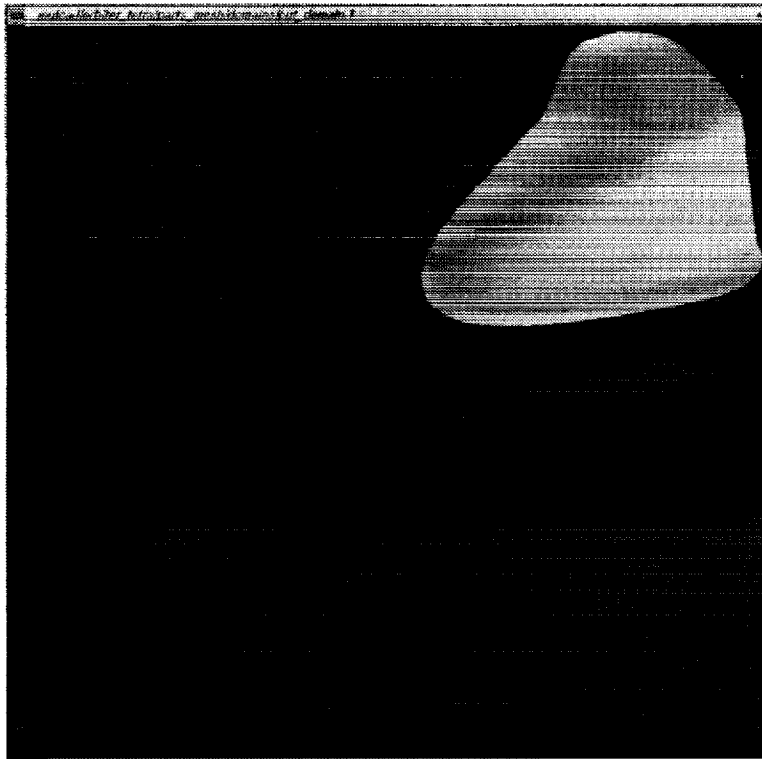
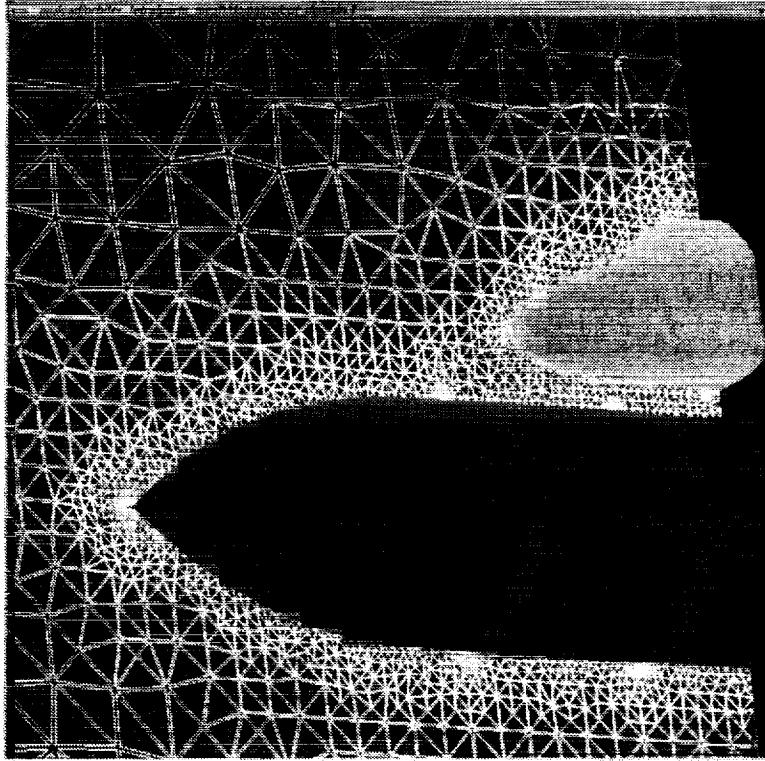
TETRA

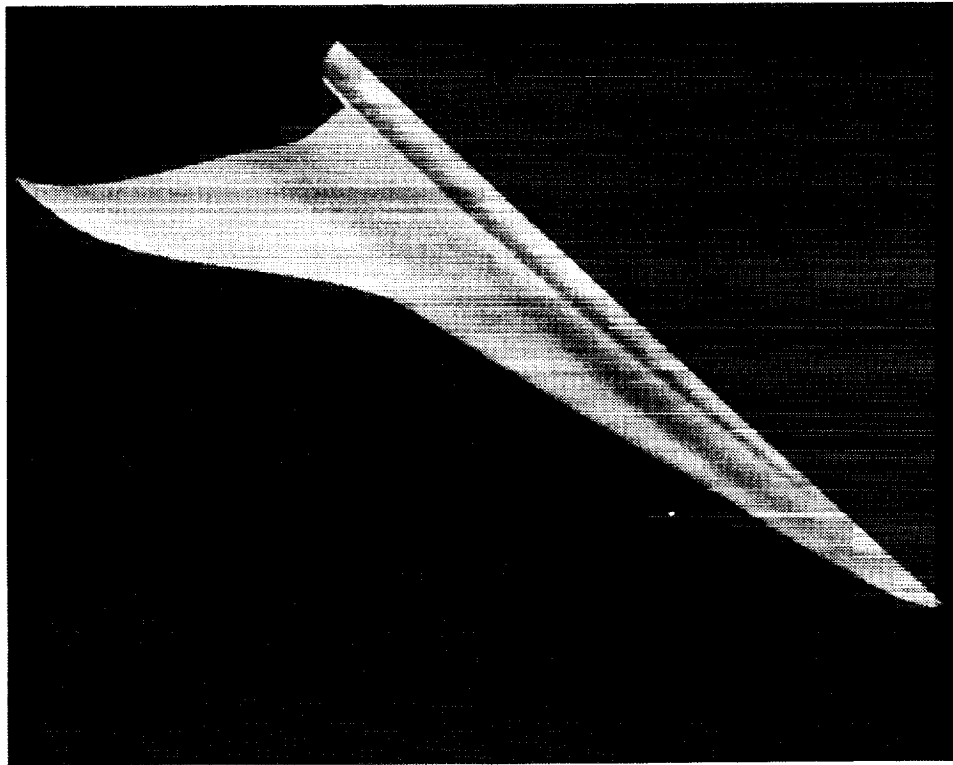
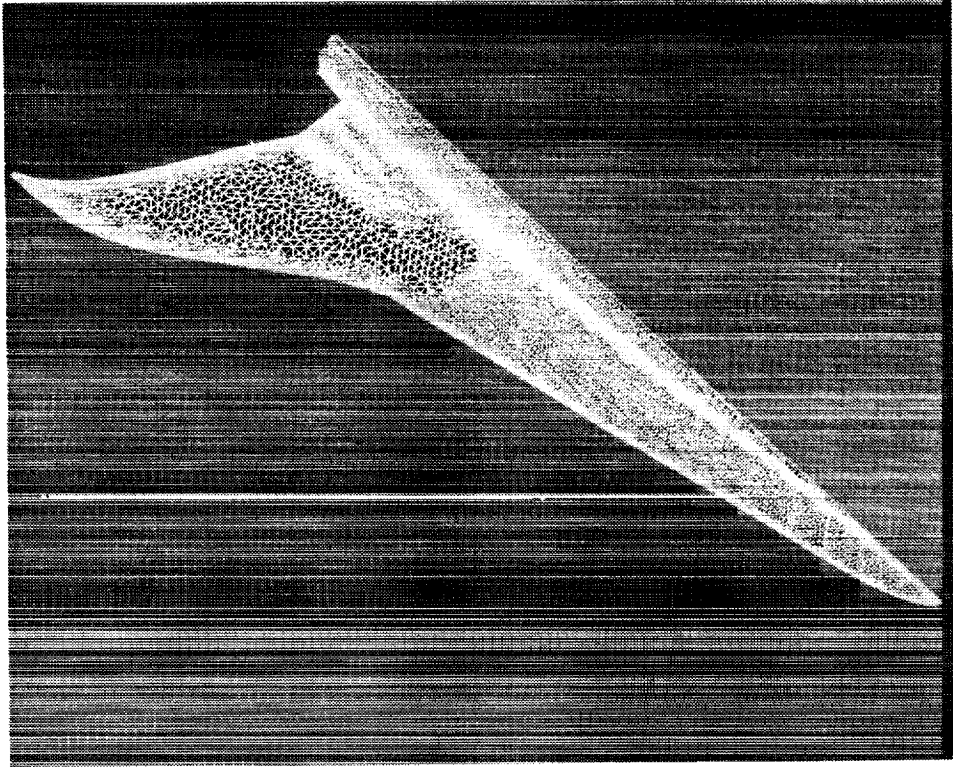
- o **Very Small User Base for ICEM / TETRA Module**
 - Expert Users + Strong Support Locally for other ICEM Modules
- o **Grid Generator Fully Integrated Into CAD / CAE Environment**
 - *Grid Generator Sits On Top Of Full CAD*
 - Commercial Grade Software System With Good Customer Support
 - Grid Topologies : Unstructured / Structured / Cartesian / Body Fitted Cartesian
 - Grid Smoothing, Visualization and Flow Solver Output Modules
 - *Oriented For Engineering Technician (CFD training useful - NOT required)*
- o **Surface Definition : NURBS**
 - INPUT : Point / CAD (IGES) / NURBS Data
- o **Grid Generation Method : Octree**
 - Node Spacing Data : specify values for surfaces / curves
 - Surface Grid : must be cut out of volume grid => "noisy" surface grids
need to assess if grid quality is adequate for Aerospace CFD
- o **User Interface => easy to use but can be confusing for non - CAD user**
- o **100K Cell Grid => 17 CPUM**

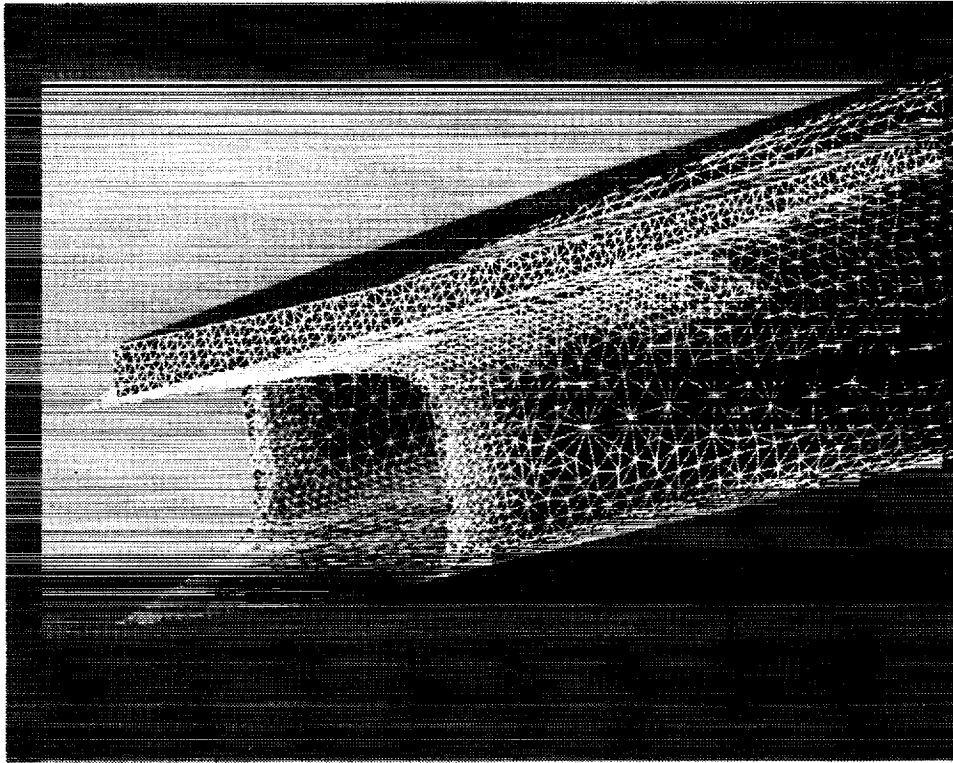
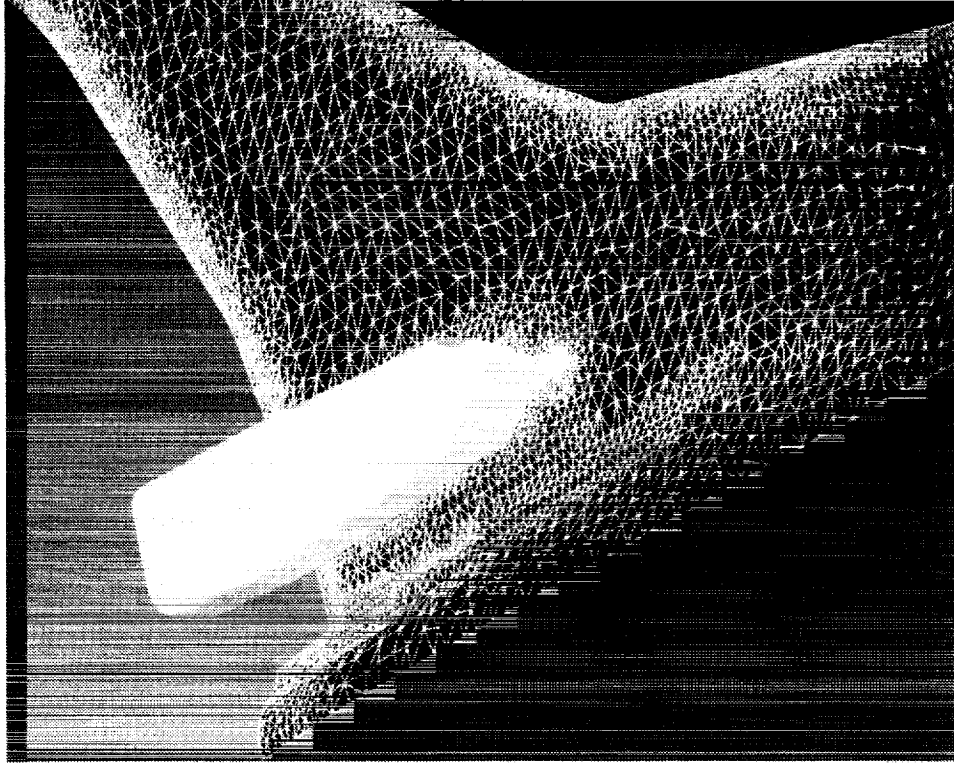


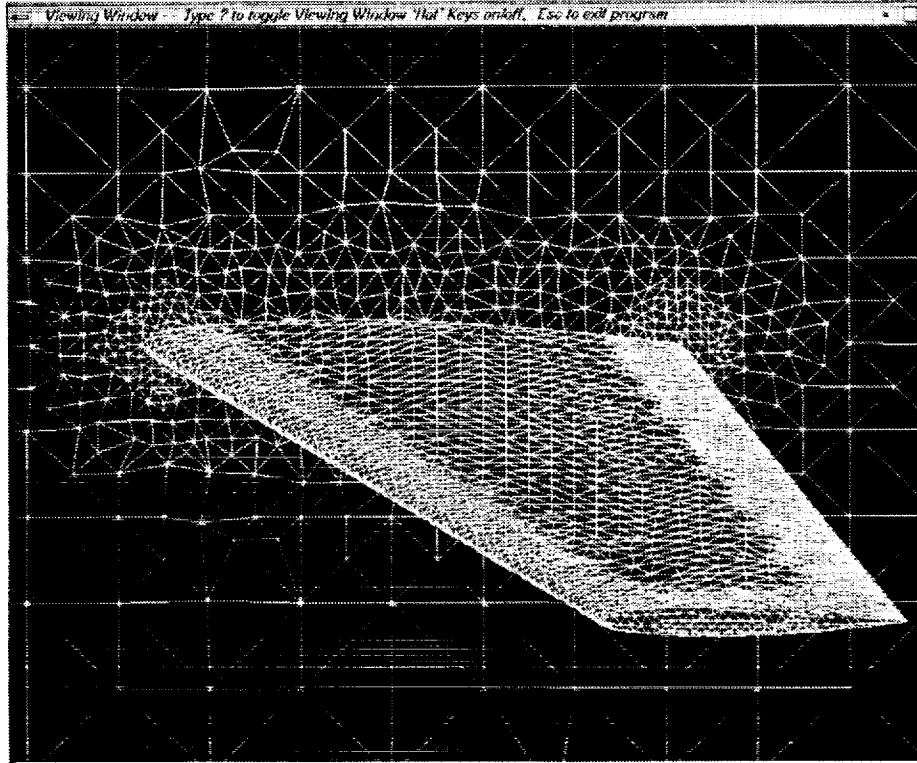
DISPLAYING MENUS







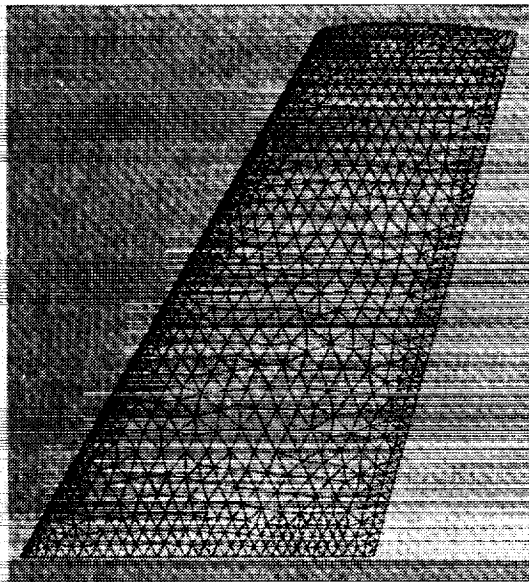




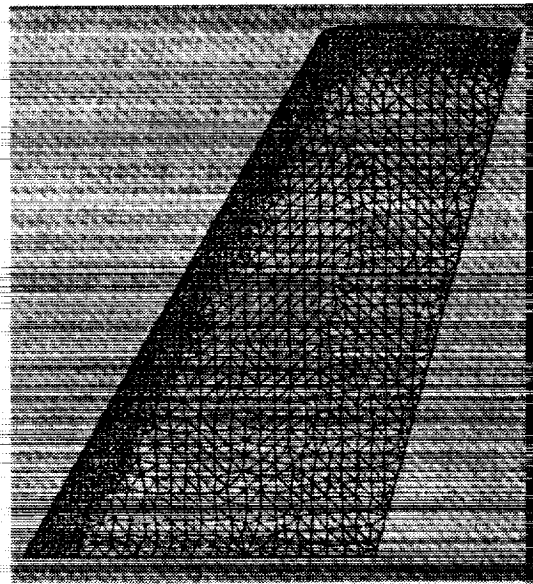
ONERA M6 WING

Flow Conditions : $M_{\infty} = 0.84$, $\alpha = 3.04^\circ$ Solution Computed With USM3D
Displayed Is Grid On Wing Upper Surface

Grid Generated with VGRID
172K cells overall, 4.5K cells on wing



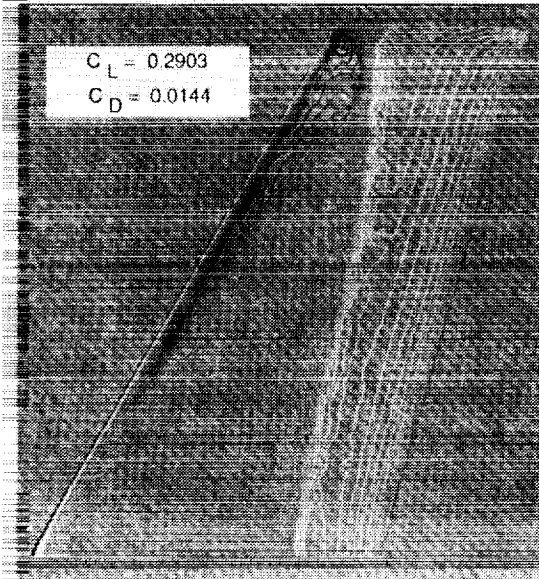
Grid Generated with ICEM / TETRA
185K cells overall, 5.8K cells on wing



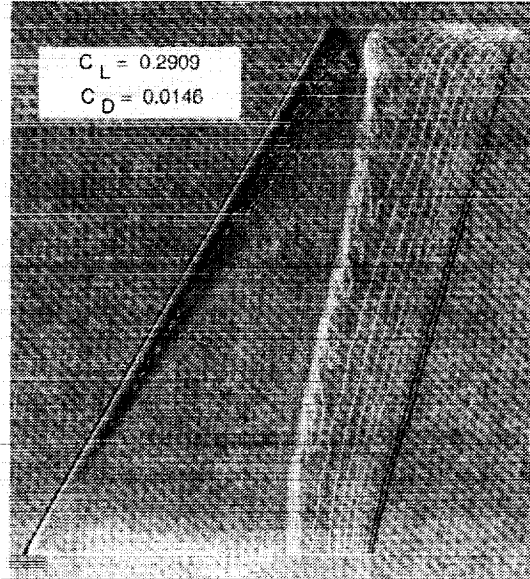
ONERA M6 WING

Flow Conditions : $M_{\infty} = 0.84$, $\alpha = 3.04^\circ$ Solution Computed With USM3D
Displayed Is Normalized Pressure (P/P_{∞}) On Wing Upper Surface (contours: $\Delta P/P_{\infty} = 0.02$)

Grid Generated with VGRID
172K cells overall, 4.5K cells on wing

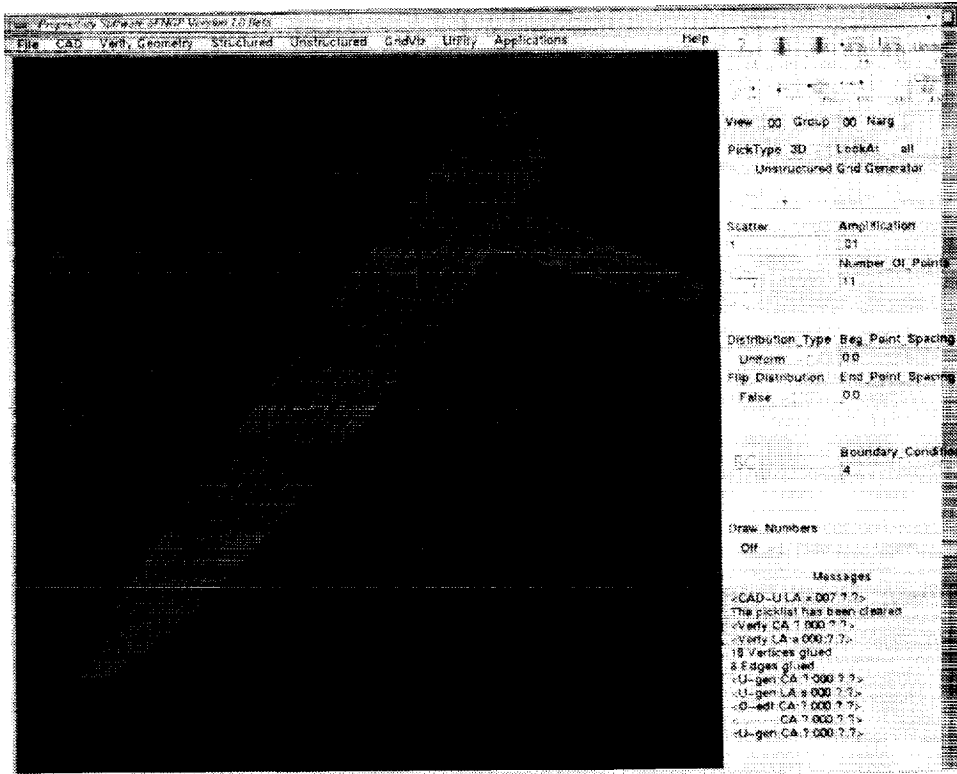


Grid Generated with ICEM / TETRA
185K cells overall, 5.8K cells on wing



NGP

- o **Very, Very Small User Base**
 - Code Still In Development => next release in August 1993
- o **Fully Integrated Into CAD / CAE Environment**
 - *Sits On Top of "mini" CAD System*
 - Grid Topologies : Unstructured / Structured (automatic blocking)
 - Grid Visualization and Flow Solver Output Modules
 - *Oriented For Engineering Technician* (CFD training useful - NOT required)
- o **Surface Definition : NURBS**
 - INPUT : Point / CAD (IGES) / NURBS Data
- o **Grid Generation Method : Delaunay (Weatherill)**
 - Node Spacing : Now => specify distributions on curves, Future => sources (?)
 - Surface Grid : a) generate on NURBS surface using combination of data in physical and uniform parameter space
b) surface grid must be recovered in final volume grid
- o **User Interface => very clean and easy to use**
- o **100K Problem => 2 CPUM** (estimated from values reported in literature)



CONCLUSIONS

- o Wide Variety Of Unstructured Grid Generation Tools Available and In Use At NASA / LaRC
- o VGRID Is Clearly The Most Widely Used Code For 3D Applications

WHY?

- customer oriented user support available on site
- can generate CFD quality grids in "reasonable" time
- graphical interface available
 - => new interface and improved surface definition will increase use

FUTURE

Tool Requirements :

- integrated into NURBS based CAD / CAE environment
- customer oriented and have local support
- designed for use by non - CFD expert (e.g., engineering tech)
- simple to use and have user friendly graphical interface
- provide fast turnaround :
 - => reduce / automate data required for grid generation module
 - => improve grid generation algorithms

VISUALIZATION

- o **General Purpose Grid and Solution Visualization Tools**

- FAST
- VPLOT3D
- VISUAL3
- TECPLOT (surface grids only)
- SURFACE (surface grids only)
- DEMAC (surface grids and advancing front)

note :

FAST, VPLOT3D & SURFACE contain visualization tools for grid quality

- o **Special Purpose Grid and Solution Visualization Tools**

SPECIAL PURPOSE GRID GENERATORS

- o **Inviscid**

- 2D => several codes in use
- 3D => research codes in development

- o **Viscous**

- 2D => couple research codes in use
- 3D => "in development"
prismatic element grids being investigated

- o **Solution Adaptive**

- several research codes available for 2D / 3D steady and unsteady flow
primarily h refinement and redistribution methods
- general purpose (production) codes not yet available

TGRID

- o **Small (?) User Base**
- o **Not A Fully Integrated System**
 - Module Within Create / RAMPANT Flow Solver System
- o **Surface Definition : N / A**
 - ONLY Generates Volume Grid
- o **Grid Generation Method : Delaunay (Blake & Spragle)**
 - Node Spacing : computed from given surface grid
 - Surface Grid :
 - a) must be computed in another software package
 - b) surface grid must be recovered from final volume grid
 - c) volume grid highly dependent on quality of surface grid
- o **User Interface => ?**
- o **100K Cell Grid => 4 (?) CPUM (estimated from values reported in literature)**

