SOFTWARE SYSTEMS USED FOR UNSTRUCTURED GRID GENERATION AT NASA LANGLEY

MICHAEL J. BOCKELIE
COMPUTER SCIENCES CORPORATION
OVERVIEW

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

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

CRITERIA

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

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

- Most Widely Used System For 3D Configurations
  - User Support / Training + Expert Users Available Locally
  - Tested On Many Configurations

- NOT an Integrated System ==> Collection of Individual Codes
  - Requires User with CFD Training (Engineer)

- Surface Definition: NURBS !! NEW !!
  - INPUT: Point or NURBS Surface Data

- 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.

- Graphical User Interface ==> 111 NEW 111
  - Create Surface Patches, Source Terms, Flow Solver BC's
  - "T" Connections for Patches

- 100K Cell Grid => 12 CPUM
**FELISA**

- **Small User Base**
  - Limited User Support

- **NOT an Integrated System ==> Collection of Individual Codes**
  - Requires CFD Engineer

- **Surface Definition: Networks of Bi-Cubic Hermite Patches**
  - **Input**: Point Data

- **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

- **No Graphical User Interface ==> Difficult To Set Up Problems**
  - modify VGRID Interface To Output Required Data ?

- **100K Cell Grid => 25 CPUM**

---

**TETRA**

- **Very Small User Base for ICEM / TETRA Module**
  - Expert Users + Strong Support Locally for other ICEM Modules

- **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)

- **Surface Definition: NURBS**
  - **Input**: Point / CAD (IGES) / NURBS Data

- **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

- **User Interface ==> easy to use but can be confusing for non-CAD user**

- **100K Cell Grid => 17 CPUM**
DISPLAYING MENUS

Selecting a function button (a) displays the appropriate tablet icons (b) and the equivalent menu in the dialog window (c).
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: $M_{oo} = 0.84$, $\alpha = 3.04^\circ$  Solution Computed With USM3D
Displayed is Normalized Pressure ($P/P_{oo}$) on Wing Upper Surface (contours: $\Delta P/P_{oo} = 0.02$)

Grid Generated with VGRID
172K cells overall, 45K cells on wing

Grid Generated with ICEM / TETRA
185K cells overall, 58K cells on wing

$C_L = 0.2903$
$C_D = 0.0144$

NGP

- Very, Very Small User Base
  - Code Still In Development => next release in August 1993

- 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)

- Surface Definition: NURBS
  - INPUT: Point / CAD (IGES) / NURBS Data

- 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

- User Interface => very clean and easy to use

- 100K Problem => 2 CPUM (estimated from values reported in literature)
CONCLUSIONS

- Wide Variety Of Unstructured Grid Generation Tools Available and In Use At NASA/LaRC

- 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

- General Purpose Grid and Solution Visualization Tools
  - FAST
  - VPLOT3D
  - VISUAL3
  - TECPLLOT (surface grids only)
  - SURFACE (surface grids only)
  - DEMAC (surface grids and advancing front)

  **note:**
  FAST, VPLOT3D & SURFACE contain visualization tools for grid quality

- Special Purpose Grid and Solution Visualization Tools

SPECIAL PURPOSE GRID GENERATORS

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

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

- 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

- Small (?) User Base

- Not A Fully Integrated System
  - Module Within Creare / RAMPANT Flow Solver System

- Surface Definition : N / A
  - ONLY Generates Volume Grid

- 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

- User Interface => ?

- 100K Cell Grid => 4 (?) CPUM (estimated from values reported in literature)