# Criteria for Evaluation of Grid Generation Systems

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Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion

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## Abstract

Many CFD grid generation systems are in use nationally, but few comparative studies have been performed to quantify their relative merits. A study was undertaken to systematically evaluate and select the best CFD grid generation codes available. Detailed evaluation criteria were established as the basis for the evaluation conducted. Descriptions of thirty four separate criteria, grouped into eight general categories are provided. Benchmark test cases, developed to test basic features of selected codes, are described in detail. Scoring guidelines were generated to establish standards for measuring code capabilities, ensure uniformity of ratings, and minimize personal bias among the three code evaluators. Ten candidate codes were identified from government, industry, universities, and commercial software companies. A three phase evaluation was conducted. In Phase 1, ten codes identified were screened through conversations with code authors and other industry experts. Seven codes were carried forward into a Phase 2 evaluation in which all codes were scored according to the predefined criteria. Two codes emerged as being significantly better than the others; RAGGS and GRIDGEN. Finally, these two codes were carried forward into a Phase 3 evaluation in which complex 3-D multizone grids were generated to verify capability.

# CRITERIA FOR EVALUATION OF GRID GENERATION SYSTEMS

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# EVALUATION OF GRID GENERATION SYSTEMS

- **BACKGROUND**
  - MANY GRID GENERATION CODES CURRENTLY AVAILABLE
  - VARIOUS SYSTEMS EMPLOY DIFFERENT APPROACHES AND CODE FEATURES
  - NEED EXISTS TO CONDUCT SYSTEMATIC REVIEW OF GRID GENERATION CODES CURRENTLY AVAILABLE

- **OBJECTIVES**
  - IDENTIFY CANDIDATE GRID GENERATION CODES
  - SYSTEMATICALLY EVALUATE IDENTIFIED CODES
  - INTEGRATE BEST CODES WITH ROCKETDYNE ADVANCED COMPUTATIONAL ENGINEERING SYSTEM (RACES) FOR INCREASED PRODUCTIVITY



# APPROACH

- **DETAILED EVALUATION CRITERIA ESTABLISHED**
- **BENCHMARK CASES DEVELOPED**
- **SCORING GUIDELINES GENERATED**
- **CANDIDATE CODES IDENTIFIED**
- **THREE PHASE EVALUATION CONDUCTED**
  - PHASE 1 - SCREEN POTENTIAL CODES
  - PHASE 2 - PRELIMINARY EVALUATION
  - PHASE 3 - FINAL EVALUATION

# EVALUATION CRITERIA

- **34 SEPARATE CRITERIA DEFINED**
- **GROUPED INTO 8 GENERAL CATEGORIES**
  - GEOMETRY DEFINITION
  - SURFACE / VOLUME GRIDS
  - GRID TYPES SUPPORTED
  - GRID CONTROL
  - USABILITY
  - SUPPORT SERVICES
  - PORTABILITY
  - COSTS

# EVALUATION CRITERIA

## GEOMETRY DEFINITION

- **GEOMETRY DEFINITION CATEGORY INCLUDES:**
  - ABILITY TO I/O VARIOUS FORMATS (e.g., CAD/CAE VIA DIRECT, IGES, OTHERS)
  - CREATION CAPABILITY WITHIN GRID GENERATION CODE
  - SURFACE ACCURACY (AS CREATED, AS IMPORTED)

- **KEY CRITERIA (HIGHEST WEIGHTING)**
  - IGES INPUT (9/10)
    - POINTS
    - LINES
    - SURFACES
  - INTERNAL GEOMETRY CREATION CAPABILITY (5/10)

# EVALUATION CRITERIA

## SURFACE / VOLUME GRID

- **SURFACE / VOLUME GRID CATEGORY INCLUDES:**
  - ACCURACY ISSUES
    - CONSTRUCTION OF ENTITIES ON GEOMETRIC SURFACE
    - POINTS ON GEOMETRIC SURFACE
  - RANGE OF METHODOLOGIES AVAILABLE AND THEIR EFFECTIVENESS
    - ALGEBRAIC
    - ELLIPTIC
    - HYPERBOLIC
- **KEY CRITERIA (HIGHEST WEIGHTING)**
  - METHODOLOGIES AVAILABLE
    - ALGEBRAIC (10/10)
    - ELLIPTIC (9/10)

# EVALUATION CRITERIA

## GRID TYPES SUPPORTED

- **GRID TYPES SUPPORTED CATEGORY INCLUDES:**
  - MULTIZONE
  - PERIODIC
  - H-TYPE
  - C- AND O-TYPES
  - FAN (DEGENERATE CELLS)
  - 2-D AND 3-D

- **KEY CRITERIA (HIGHEST WEIGHTING)**
  - MULTIZONE (10/10)
  - H-TYPE (1010)
  - 2-D AND 3-D (10/10)

# EVALUATION CRITERIA

## GRID CONTROL

- **GRID CONTROL CATEGORY INCLUDES:**
  - CLUSTERING OPTIONS (e.g., LINEAR, GEOMETRIC, EXPONENTIAL, etc.)
  - LOCAL CONTROL
    - EDITING
    - INTERACTIVE
    - SMOOTHING

- **KEY CRITERION (HIGHEST WEIGHTING)**
  - CLUSTERING (10/10)

# EVALUATION CRITERIA

## USABILITY

- **USABILITY CATEGORY INCLUDES:**
  - LEARNABILITY
  - USER INTERFACE
  - EASY TO MODIFY (PARAMETRICS)
  - SPECIALIZE (TEMPLATES)
  - SAVE INTERMEDIATE STATE
  - GRID DIAGNOSTICS
  - ERROR HANDLING
  - SIZE LIMITATIONS

- **KEY CRITERIA (HIGHEST WEIGHTING)**
  - USER INTERFACE (10/10)
  - LEARNABILITY (10/10)
  - SAVE INTERMEDIATE STATE (10/10)

# EVALUATION CRITERIA

## SUPPORT SERVICES

- **SUPPORT SERVICES CATEGORY INCLUDES:**
  - SUPPORT SERVICES AVAILABLE (e.g., DOCUMENTATION, TRAINING, HOT LINE, etc.)
  - SOURCE CODE AVAILABILITY
  - AUTHOR/VENDOR RESPONSIVENESS

- **KEY CRITERIA (HIGHEST WEIGHTING)**
  - SUPPORT SERVICES AVAILABLE (10/10)
  - SOURCE CODE AVAILABILITY (10/10)
  - AUTHOR/VENDOR RESPONSIVENESS (10/10)

# EVALUATION CRITERIA

## PORTABILITY

- **PORTABILITY CATEGORY INCLUDES:**
  - RANGE OF COMPUTING PLATFORMS SUPPORTED
  - NOTE: ALL CODES EXCEPT PATRAN REQUIRE SGI
    - GL OR OPEN GL
    - FEW OPTIONS

- **KEY CRITERION (HIGHEST WEIGHTING)**
  - PORTABILITY (5/10)
  - NOT A DISTINGUISHING FACTOR

# EVALUATION CRITERIA

## COSTS

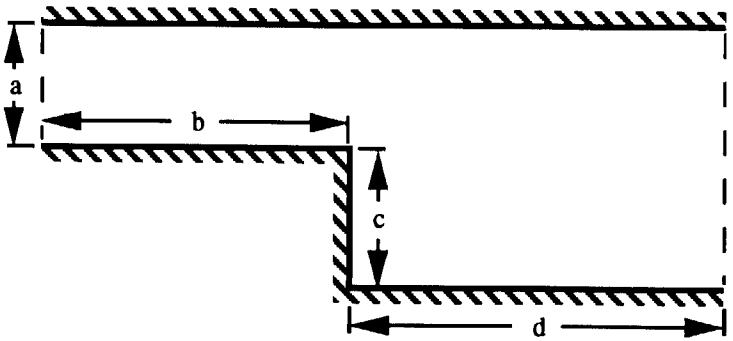
- **COSTS CATEGORY INCLUDES:**
  - SOURCE CODE AND ANNUAL MAINTENANCE
  - TRAINING
  - CONSULTING

- **KEY CRITERION (HIGHEST WEIGHTING)**
  - SOURCE CODE AND ANNUAL MAINTENANCE (10/10)

# BENCHMARK CASES DEVELOPED

- **SERIES OF TEST CASES DEVISED TO TEST BASIC CODE FEATURES**
  - MANY SIMPLE CASES
  - ISOLATE SINGLE GRID GENERATION ISSUE
  - TYPICAL OF PROBLEMS ENCOUNTERED DURING CFD GRID GENERATION
  - THREE SETS OF 2-D CASES, ONE SET OF 3-D CASES
- **ALL CODES TESTED THROUGH EXECUTION OF BENCHMARK CASES**
- **AS MANY CASES EXECUTED AS PRACTICAL FOR EACH CODE**
  - CODE LIMITATIONS
  - LIMITED LEARNING VALUE
  - TIME LIMITATIONS

# BENCHMARK CASES - SET 1

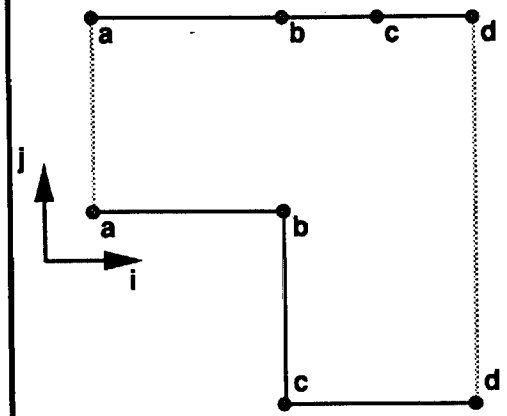



GEOMETRY 1: a=b=c=d=1
GEOMETRY 2: a=0.25, b=c=d=1
GEOMETRY 3: a=b=1, c=4, d=1

| SUBSET | GEOMETRY | TOPOLOGY | GRID TYPE | CLUSTERING |
|---|---|---|---|---|
| A | 1, 2, 3 | SINGLE ZONE | H | NONE |
| B | 1, 2, 3 | SINGLE ZONE | A+ELLIPTIC | NONE |
| C | 1, 2, 3 | SINGLE ZONE | H | 2-3 OPTIONS |
| D | 1, 2, 3 | SINGLE ZONE | A+ELLIPTIC | 1 OPTION-FINE GRID |
| E | 1 | SINGLE ZONE | H-FAN-H | NONE |
| F | 1 | SINGLE ZONE | H-FAN-H | 1 OPTION |
| G | 1 | MULTI-ZONE | H-H | NONE |
| H | 1 | MULTI-ZONE | H-H | ALL OPTIONS |
| I | 1 | MULTI-ZONE | E+ELLIPTIC | NONE |
| J | 1 | MULTI-ZONE | E+ELLIPTIC | 1 OPTION-FINE GRID |

# BENCHMARK CASES - SET 1 (CONT'D)

## TOPOLOGY 1: H-GRID

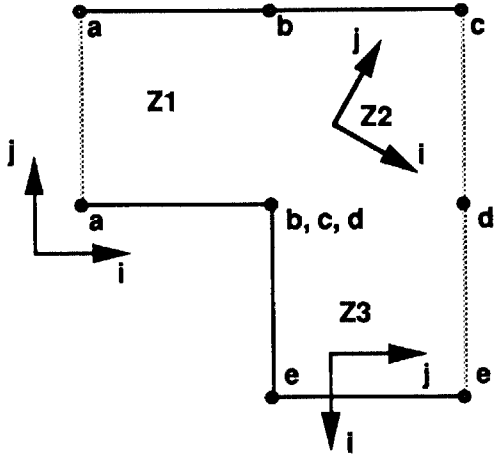



**GEOM 1:**
imax = 30, jmax = 20+18+20
(1740 grid points)

**GEOM 2:**
imax = 30, jmax = 20+18+20
(1740 grid points)

**GEOM 3:**
imax = 30, jmax = 10+38+10
(1740 grid points)

## TOPOLOGY 2: H-FAN-H

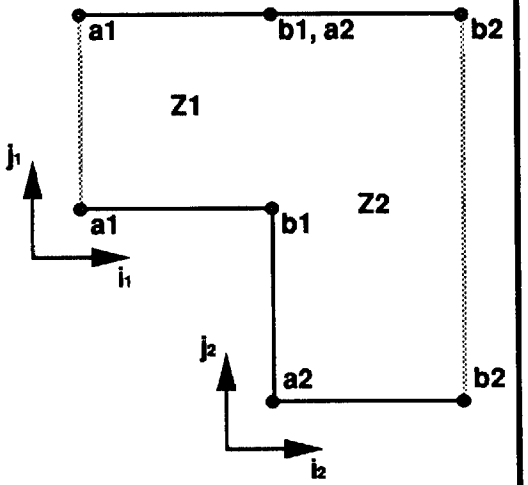



**GEOM 1** Z1: imax = 41, jmax = 41
Z2: imax = 41, jmax = 41
Z3: imax = 41, jmax = 41
(5043 grid points)

**GEOM 2** Z1: imax = 41, jmax = 11
Z2: imax = 31, jmax = 11
Z3: imax = 41, jmax = 11
(1243 grid points)

**GEOM 3** Z1: imax = 41, jmax = 41
Z2: imax = 41, jmax = 41
Z3: imax = 161, jmax = 41
(9963 grid points)

## TOPOLOGY 3: H-H

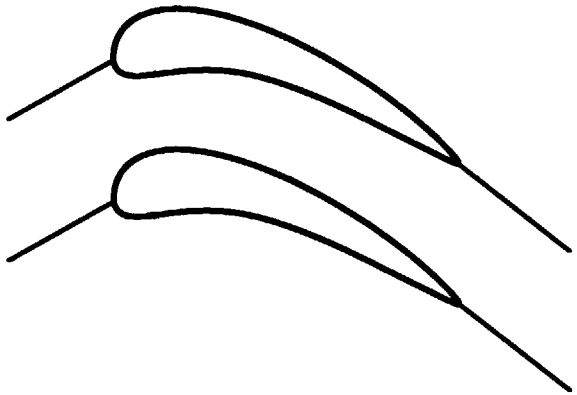



**GEOM 1**
Z1: imax = 41, jmax = 41
Z2: imax = 41, jmax = 81
(5002 grid points)

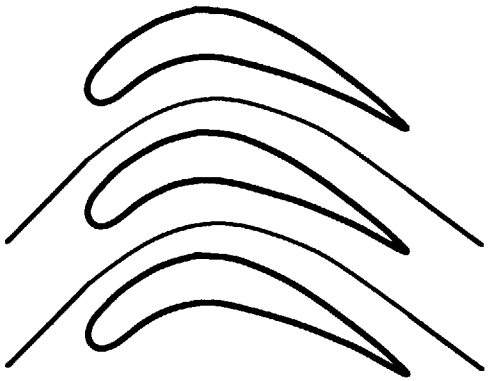
**GEOM 2**
Z1: imax = 41, jmax = 11
Z2: imax = 41, jmax = 51
(2542 grid points)

**GEOM 3**
Z1: imax = 41, jmax = 41
Z2: imax = 41, jmax = 161
(8282 grid points)

# BENCHMARK CASES - SET 2



GEOMETRY 1 - REACTION TYPE

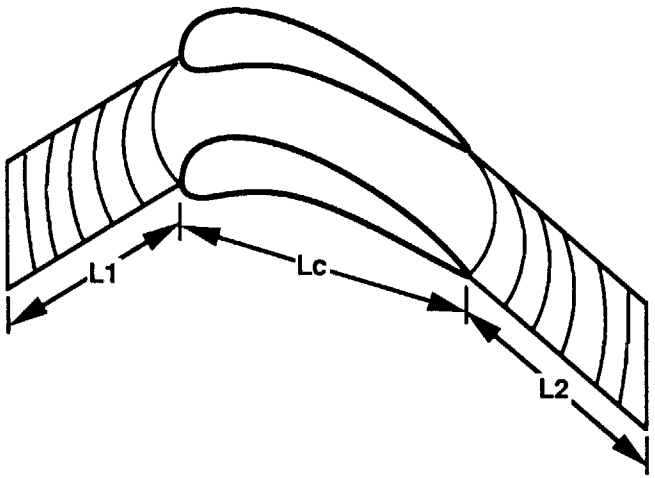


GEOMETRY 2 - IMPULSE TYPE

| SUBSET | GEOMETRY | TOPOLOGY | GRID TYPE | CLUSTERING |
|---|---|---|---|---|
| A | 1 | SINGLE ZONE - PASSAGE | H-PERIODIC | NONE |
| B | 1 | SINGLE ZONE - PASSAGE | H-PERIODIC | 1-2 OPTIONS |
| C | 2 | MULTI-ZONE OBSTRUCTION | H-O | NONE |
| D | 2 | MULTI-ZONE OBSTRUCTION | H-C | NONE |
| E | 2 | MULTI-ZONE OBSTRUCTION | H-O OR H-C | 1-2 OPTIONS |

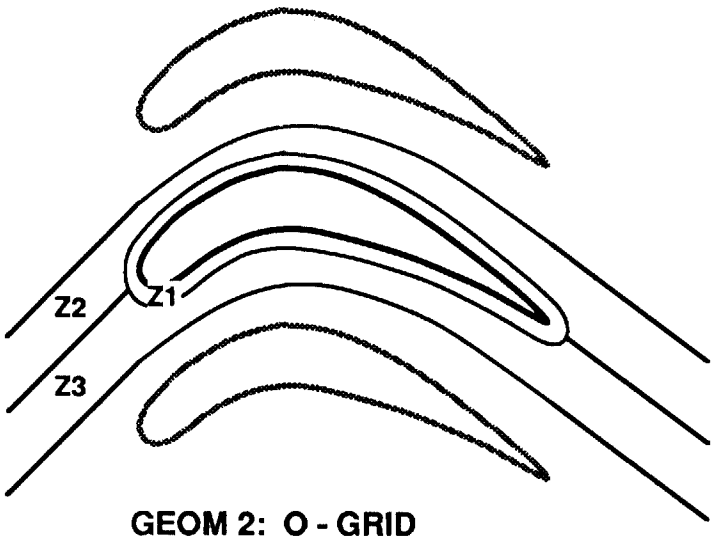
# BENCHMARK CASES - SET 2 (CONT'D)

TOPOLOGY 1: H-GRID, PERIODIC




GEOM 1: imax = 100+100+100, jmax = 50

TOPOLOGY 2&3: C & O - GRIDS, PERIODIC



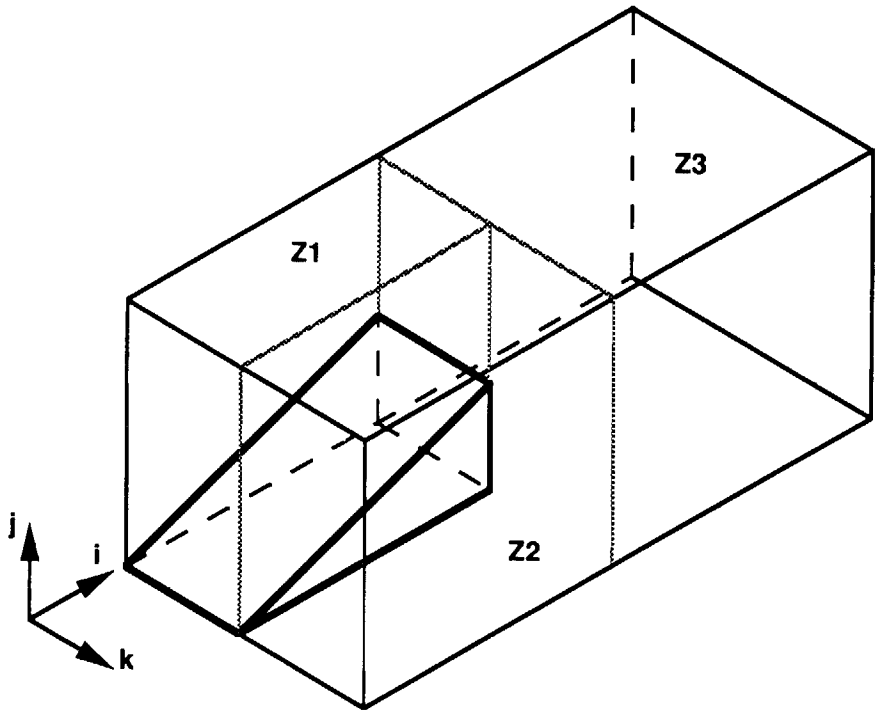

GEOM 2: O - GRID

Z1: imax = 200, jmax = 11
Z2: imax = 300, jmax = 25
Z3: imax = 300, jmax = 25

GEOM 2: C - GRID

Z1: imax = 200, jmax = 11
Z2: imax = 300, jmax = 25
Z3: imax = 300, jmax = 25

# BENCHMARK CASES - SET 3




$W_{wedge} = 0.25$
$L_{wedge} = 1.0$

$\alpha_{wedge} = 15°$
$H_{wedge} = 0.2679$

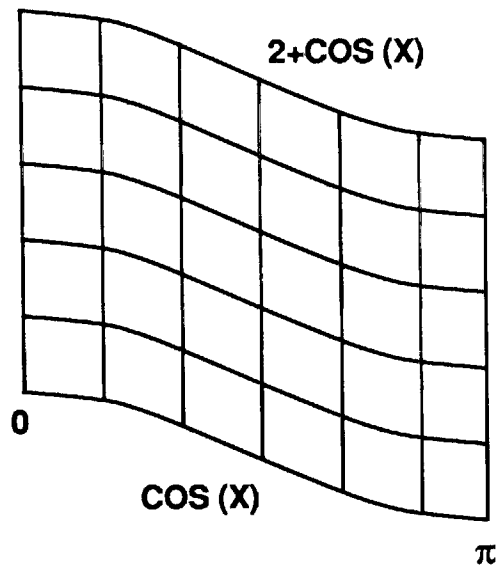
$H_{Z1} = H_{Z2} = H_{Z3} = 1.0$
$W_{Z1} = W_{WEDGE} = 0.25$
$W_{Z2} = 0.75,\ W_{Z3} = 1.0$
$L_{Z1} = L_{Z2} = L_{Z3} = 1.0$

ZONE 1: $i_{max} = 21$, $j_{max} = 16$, $k_{max} = 6$
ZONE 2: $i_{max} = 21$, $j_{max} = 21$, $k_{max} = 16$
ZONE 3: $i_{max} = 21$, $j_{max} = 21$, $k_{max} = 21$

(2016 + 7056 + 9261 = 18333 grid points)

| SUBSET | GEOMETRY | TOPOLOGY | GRID TYPE | CLUSTERING |
|---|---|---|---|---|
| A | 1 | MULTI-ZONE | H-FAN | NONE |
| B | 1 | MULTI-ZONE | H-FAN | 1-2 OPTIONS |

# BENCHMARK CASES - SET 4




**GEOMETRY:**

TOP: $2+\cos(X)$, $0 \le X \le \pi$
BOTTOM: $\cos(X)$, $0 \le X \le \pi$

$H = 5$

**GRIDS**

1: $i_{max} = 10$, $j_{max} = 10$
2: $i_{max} = 100$, $j_{max} = 100$
3: $i_{max} = 1000$, $j_{max} = 1000$

| SUBSET | GRID | TOPOLOGY | GRID TYPE | CLUSTERING |
|---|---|---|---|---|
| A | 1 | SINGLE ZONE | H | NONE |
| B | 1 | SINGLE ZONE | H + ELLIPTIC | NONE |
| C | 2 | SINGLE ZONE | H | NONE |
| D | 2 | SINGLE ZONE | H + ELLIPTIC | NONE |
| E | 3 | SINGLE ZONE | H | NONE |
| F | 3 | SINGLE ZONE | H + ELLIPTIC | NONE |

# SCORING GUIDELINES DEVELOPED

- **OBJECTIVES**
  - ESTABLISH STANDARDS FOR SCORING CODE CAPABILITIES
  - ENSURE UNIFORMITY OF RATINGS (SHARED WORKLOAD)
  - MINIMIZE PERSONAL BIAS

- **APPROACH**
  - REVIEW EACH CRITERION
  - CONSIDER POSSIBLE RANGE OF ATTRIBUTES
  - ASSIGN SCORES ACCORDINGLY USING POINT SYSTEM

# SCORING GUIDELINES

## EXAMPLES

- **GEOMETRY DEFINITION, INPUT FORMATS, CAD**
  - ACCEPTS IGES FORMAT = 7 PTS
  - EACH ADDITIONAL CAD STANDARD = +1 PT
  - MAXIMUM SCORE = 10 PTS

- **SCORING**
  - ICEM: ACCEPTS IGES AND 2 EUROPEAN CAD STANDARDS (SCORE = 7 + 1 + 1 = 9 PTS)
  - RAGGS: ACCEPTS IGES ONLY (SCORE = 7 PTS)

# SCORING GUIDELINES

## EXAMPLES (CONT'D)

- **SURFACE/VOLUME GRIDS, METHODOLOGIES, ALGEBRAIC**
  - BASIC LINEAR INTERPOLATION = 1 PT
  - BASIC TRANSFINITE INTERPOLATION (TFI) = 4 PTS
  - ADVANCED TFI = 7 PTS
  - ADDITIONAL POINTS FOR EXTENT OF CONTROL AND DEGREE OF AUTOMATION
  - MAXIMUM SCORE = 10 PTS
- **SCORING**
  - PATRAN: BASIC LINEAR INTERPOLATION AND SOME ADDITIONAL CONTROL FEATURES (SCORE = 1 + 1 = 2 PTS)
  - EAGLEVIEW, ICEM, IGB, RAGGS: TFI (SCORE = 7 PTS)
  - GRIDGEN: TFI AND EXTENSIVE OPTIONS (SCORE = 7 + 2 = 9 PTS)

# CANDIDATE CODES IDENTIFIED

- **GRID GENERATION CODES CONSIDERED FROM MANY SOURCES**
  - GOVERNMENT
  - INDUSTRY
  - UNIVERSITY
  - COMMERCIAL

- **10 CODES IDENTIFIED AS CANDIDATES FOR EVALUATION**
  - EAGLE (MSU)
  - EAGLEVIEW MSU)
  - GENIE (MSU)
  - GRAPE (NASA AMES)
  - GRIDGEN (GD/MDA/NASA)
  - ICEM (CDC)
  - IGB (NASA LEWIS)
  - PATRAN (PDA)
  - RAGGS (RI NAA)
  - TIGER (MSU)

# CODE EVALUATION

## PHASE 1 PRE-SCREEN

- **OBJECTIVES**
  - IDENTIFY MOST PROMISING CODES
  - REDUCE LIST OF CODES TO PRACTICAL SIZE
  - IDENTIFY PHASE 2 EVALUATION CODES

- **APPROACH: SURVEY CODE AUTHORS AND INDUSTRY EXPERTS**
  - GENERAL CAPABILITY (IGES, GEOMETRY, ALGORITHMS)
  - UNIQUE ASPECTS
  - USE IN, AND ACCEPTANCE BY COMMUNITY
  - NEAR-TERM UPGRADES PLANNED (IGES, INTERACTIVE)
  - USABILITY (SCRIPTS, BATCH VS INTERACTIVE)
  - AVAILABILITY (FOR EVALUATION)
  - DOCUMENTATION AND TRAINING AVAILABLE

# CODE EVALUATION

## PHASE 1 PRE-SCREEN RESULTS (CONT'D)

- **CODES RANKED BASED ON TECHNICAL CAPABILITY AND OTHER CONSIDERATIONS***

1. **GRIDGEN**
2. **RAGGS**
3. **CDC**
4. / **5.** EAGLE / **EAGLEVIEW**
6. **GENIE**
7. **PATRAN**
8. **IGB**
9. GRAPE
10. TIGER

* **OTHER CONSIDERATIONS**

- BENCHMARK CODES
  - NASA MSFC EXPERIENCE WITH GENIE
  - ROCKETDYNE EXPERIENCE WITH PATRAN AND IGB
- AVAILABILITY DURING PLANNED EVALUATION TIMEFRAME
- AVAILABLE VERSIONS "FROZEN" FOR PHASE 2 EVALUATION

1080

# PHASE 2 - PRELIMINARY EVALUATION MATRIX DEVELOPED

- **CRITERIA GROUPED INTO LOGICAL CATEGORIES**
- **WEIGHTING FACTORS ASSIGNED**
  - EACH CRITERION WEIGHS EQUALLY
  - FACTOR RANGE FROM 1-10
    - 1 - LOW IMPORTANCE
    - 10 - HIGH IMPORTANCE
- **SPREADSHEET DEVELOPED TO AUTOMATE EVALUATION**
  - SCORING GUIDELINES APPLIED
  - EACH CODE SCORED FROM 1-10 BASED ON CAPABILITY IN EACH AREA
- **AVAILABLE VERSIONS "FROZEN" FOR PHASE 2 EVALUATION**

# PHASE 2 - PRELIMINARY EVALUATION MATRIX
## (Page 1 of 2)

| CRITERIA | WEIGHT | CDC | EAGLE-VIEW | IGB | GENIE | GRIDGEN | PATRAN | RAGGS |
|---|---|---|---|---|---|---|---|---|
| GEOMETRY DEFINITION | | | | | | | | |
| • INPUT FORMATS | | | | | | | | |
| • CAD | 9.000 | 9 | 0 | 0 | 0 | 0 | 9 | 7 |
| • OTHER | 6.000 | 6 | 4 | 1 | 6 | 6 | 6 | 6 |
| • OUTPUT CAPABILITY | 2.000 | 10 | 2 | 1 | 1 | 2 | 10 | 1 |
| • CREATION CAPABILITY | 5.000 | 10 | 5 | 0 | 5 | 5 | 9 | 5 |
| • ACCURACY OF SURFACE | | | | | | | | |
| • AS CREATED (IN GG) | | NA | NA | NA | NA | NA | NA | NA |
| • AS TRANSLATED (TO GG) | | NA | NA | NA | NA | NA | NA | NA |
| SURFACE / VOLUME GRIDS | | | | | | | | |
| • ACCURACY (PTS. ON SURFACE) | | NA | NA | NA | NA | NA | NA | NA |
| • METHODOLOGIES | | | | | | | | |
| • ALGEBRAIC | 10.000 | 7 | 7 | 7 | 7 | 9 | 2 | 7 |
| • ELLIPTIC | 9.000 | 6 | 0 | 7 | 9 | 10 | 1 | 8 |
| • HYPERBOLIC | 2.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GRID TYPES SUPPORTED | | | | | | | | |
| • MULTIZONE | 10.000 | 5 | 5 | 1 | 3 | 6 | 1 | 6 |
| • PERIODIC | 6.000 | 5 | 5 | 10 | 5 | 5 | 1 | 5 |
| • H | 10.000 | 7 | 5 | 7 | 5 | 5 | 3 | 5 |
| • C AND/OR O | 6.000 | 4 | 4 | 0 | 4 | 5 | 4 | 4 |
| • FAN (DEGENERATE CELLS) | 6.000 | 7 | 5 | 0 | 5 | 5 | 1 | 5 |
| • 2D/3D | 10.000 | 10 | 3 | 5 | 7 | 10 | 10 | 10 |

# PHASE 2 - PRELIMINARY EVALUATION MATRIX
## (Page 2 of 2)

| CRITERIA | WEIGHT | CDC | EAGLE-VIEW | IGB | GENIE | GRIDGEN | PATRAN | RAGGS |
|---|---|---|---|---|---|---|---|---|
| GRID CONTROL | | | | | | | | |
| • CLUSTERING | 10.000 | 4 | 3 | 2 | 5 | 7 | 2 | 9 |
| • LOCAL CONTROL | 5.000 | 0 | 0 | 7 | 7 | 9 | 7 | 5 |
| USABILITY | | | | | | | | |
| • LEARNABILITY | 10.000 | 3 | 2 | 4 | 4 | 6 | 3 | 5 |
| • USER INTERFACE | 10.000 | 6 | 7 | 4 | 1 | 5 | 3 | 8 |
| • MODIFY (PARAMETRICS) | 4.000 | 6 | 5 | 5 | 5 | 1 | 5 | 1 |
| • SPECIALIZE (TEMPLATE) | 4.000 | 2 | 5 | 9 | 5 | 1 | 4 | 1 |
| • SESSION HISTORY | 8.000 | 6 | 9 | 5 | 7 | 0 | 7 | 0 |
| • SAVE INTERMEDIATE STATE | 10.000 | 5 | 4 | 4 | 4 | 5 | 7 | 5 |
| • GRID DIAGNOSTICS | 7.000 | 5 | 0 | 4 | 4 | 3 | 4 | 2 |
| • ERROR HANDLING | 8.000 | 4 | 1 | 4 | 2 | 8 | 4 | 3 |
| • SIZE LIMITATIONS | 8.000 | 5 | 8 | 7 | 7 | 9 | 2 | 8 |
| VENDOR SUPPORT | | | | | | | | |
| • SERVICES | 10.000 | 7 | 5 | 6 | 1 | 8 | 9 | 7 |
| • SOURCE CODE | 10.000 | 0 | 7 | 6 | 5 | 9 | 0 | 8 |
| • RESPONSIVE TO NEEDS | 10.000 | 6 | 7 | 9 | 2 | 7 | 5 | 10 |
| PORTABILITY | 5.000 | 2 | 1 | 1 | 1 | 2 | 10 | 1 |
| COST OF SERVICES | | | | | | | | |
| • CODE/MAINTENANCE | 10.000 | 1 | 10 | 10 | 10 | 10 | 7 | 10 |
| • TRAINING | 6.000 | 1 | 5 | 7 | 7 | 5 | 7 | 10 |
| • CONSULTING | 6.000 | 5 | 5 | 10 | 10 | 5 | 5 | 10 |
| TOTALS | | 1180.0 | 1036.0 | 1135.0 | 1106.0 | 1395.0 | 1072.0 | 1442.0 |

# PHASE 2 - PRELIMINARY EVALUATION

## SUMMARY

- **SEVEN CODES RANKED ACCORDING TO PHASE 2 EVALUATION**

| RANK | CODE | SCORE |
|---|---|---|
| 1. | RAGGS | 1442 |
| 2. | GRIDGEN | 1395 |
| 3. | ICEM (CDC) | 1180 |
| 4. | IGB * | 1135 |
| 5. | GENIE | 1106 |
| 6. | PATRAN | 1072 |
| 7. | EAGLEVIEW | 1036 |

- **SCORE DIFFERENCES OF 50-100 POINTS AND GREATER CONSIDERED TO BE SIGNIFICANT**

* **IGB WORKS WELL FOR INTENDED PURPOSE, BUT IS NOT A GENERAL USE CODE**

# PHASE 2 - PRELIMINARY EVALUATION

## CONCLUSIONS

- **TOP THREE GRID GENERATION CODES WORTHY OF CONSIDERATION**
- **SELECTION DEPENDS ON FUNCTIONAL REQUIREMENTS**
- **RAGGS AND GRIDGEN ARE BOTH GOOD GENERIC CFD GRID GENERATION SYSTEMS**
  - RAGGS PRIMARY ADVANTAGES
    - ABILITY TO IMPORT IGES FILES
    - MORE INTERACTIVE GRAPHICAL USER INTERFACE
  - GRIDGEN PRIMARY ADVANTAGES
    - MORE MATURE, ROBUST, WELL DOCUMENTED CODE
    - EXTENSIVE GRID GENERATION ALGORITHMS, OPTIONS
- **ICEM CODE PRIMARY STRENGTH IN EXTENSIVE CAD IMPORT/EXPORT CAPABILITY**
  - LIMITED GRID GENERATION FEATURES
  - THIRD PARTY CODE (NO SOURCE CODE, SIGNIFICANT COST)



# PHASE 3 - FINAL EVALUATION COMPLETED

- **TOP TWO CODES (RAGGS, GRIDGEN) FROM PRELIMINARY (PHASE 2) EVALUATION CARRIED FORWARD TO FINAL EVALUATION (PHASE 3)**

- **COMPLEX 3-D CASE SELECTED TO VERIFY PHASE 2 RESULTS**
  - NLS 1.5 STAGE BASE REGION GEOMETRY
    - 8 ZONES
    - 638,000 GRID POINTS IN ONE QUADRANT
  - FULLY GENERATED WITH RAGGS
  - PARTIALLY GENERATED WITH GRIDGEN (SUFFICIENT FOR COMPARISON)

- **SPREADSHEET REVISED TO EXTEND EVALUATION**
  - COMPARISONS EXPANDED
  - MOST RECENT VERSIONS EVALUATED
  - RELATIVE ADJUSTMENTS MADE TO SCORES

# PHASE 3 - FINAL EVALUATION MATRIX
## (Page 1 of 2)

| CRITERIA | WEIGHT | GRIDGEN | RAGGS |
|---|---|---|---|
| GEOMETRY DEFINITION | | | |
| • INPUT FORMATS | | | |
| • CAD | 9.000 | 5 | 7 |
| • OTHER | 6.000 | 6 | 6 |
| • OUTPUT CAPABILITY | 2.000 | 2 | 1 |
| • CREATION CAPABILITY | 5.000 | 5 | 5 |
| • ACCURACY OF SURFACE | | | |
| • AS CREATED (IN GG) | | NA | NA |
| • AS TRANSLATED (TO GG) | | NA | NA |
| SURFACE / VOLUME GRIDS | | | |
| • ACCURACY (PTS. ON SURFACE) | | NA | NA |
| • METHODOLOGIES | | | |
| • ALGEBRAIC | 10.000 | 8 | 9 |
| • ELLIPTIC | 9.000 | 9 | 9 |
| • HYPERBOLIC | 2.000 | 0 | 0 |
| GRID TYPES SUPPORTED | | | |
| • MULTIZONE | 10.000 | 6 | 7 |
| • PERIODIC | 6.000 | 5 | 5 |
| • H | 10.000 | 5 | 5 |
| • C AND/OR O | 6.000 | 5 | 4 |
| • FAN (DEGENERATE CELLS) | 6.000 | 5 | 5 |
| • 2D/3D | 10.000 | 10 | 10 |

# PHASE 3 - FINAL EVALUATION MATRIX
## (Page 2 of 2)

| CRITERIA | WEIGHT | GRIDGEN | RAGGS |
|---|---|---|---|
| GRID CONTROL | | | |
| • CLUSTERING | 10.000 | 8 | 9 |
| • LOCAL CONTROL | 5.000 | 9 | 9 |
| USABILITY | | | |
| • LEARNABILITY | 10.000 | 6 | 5 |
| • USER INTERFACE | 10.000 | 6 | 8 |
| • MODIFY (PARAMETRICS) | 4.000 | 1 | 3 |
| • SPECIALIZE (TEMPLATE) | 4.000 | 1 | 3 |
| • SESSION HISTORY | 8.000 | 0 | 6 |
| • SAVE INTERMEDIATE STATE | 10.000 | 5 | 5 |
| • GRID DIAGNOSTICS | 7.000 | 6 | 2 |
| • ERROR HANDLING | 8.000 | 8 | 4 |
| • SIZE LIMITATIONS | 8.000 | 9 | 8 |
| VENDOR SUPPORT | | | |
| • SERVICES | 10.000 | 8 | 7 |
| • SOURCE CODE | 10.000 | 9 | 8 |
| • RESPONSIVE TO NEEDS | 10.000 | 7 | 10 |
| PORTABILITY | 5.000 | 2 | 1 |
| COST OF SERVICES | | | |
| • CODE/MAINTENANCE | 10.000 | 10 | 10 |
| • TRAINING | 6.000 | 5 | 10 |
| • CONSULTING | 6.000 | 5 | 10 |
| TOTALS | | 1462.0 | 1573.0 |

# PHASE 3 - FINAL EVALUATION

## SUMMARY AND CONCLUSIONS

- **SIGNIFICANT CHANGES IN LATEST VERSIONS**
  - RAGGS
    - HAS ENHANCED TFI OPTIONS, AUTOMATION
    - MORE AUTOMATED MULTIZONE CAPABILITY (FACE/SEGMENT SORTERS)
    - EXTENDED LOCAL CONTROL OPTIONS
    - EXTENDED HELP FACILITY
    - "SHORTCUT" SINGLE KEY COMMANDS
    - IMPROVED PARAMETRIC AND TEMPLATE CAPABILITIES
    - NEW SESSION HISTORY CAPABILITY
  - GRIDGEN v8.0
    - NOW ACCEPTS IGES INPUT
    - ADDITIONAL CLUSTERING OPTIONS
    - TRANSITIONING TOWARD MORE UNIFIED APPROACH
    - REAL TIME COLOR CODED GRID DIAGNOSTICS

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# PHASE 3 - FINAL EVALUATION

## SUMMARY AND CONCLUSIONS (CONT'D)

- **RELATIVE RANKINGS OF TOP TWO CODES REMAINS UNCHANGED**

| RANK | CODE | SCORE |
|---|---|---|
| 1. | RAGGS | 1573 |
| 2. | GRIDGEN | 1462 |

- **RAGGS AND GRIDGEN BOTH CAPABLE OF GENERATING COMPLEX 3-D GRIDS**