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

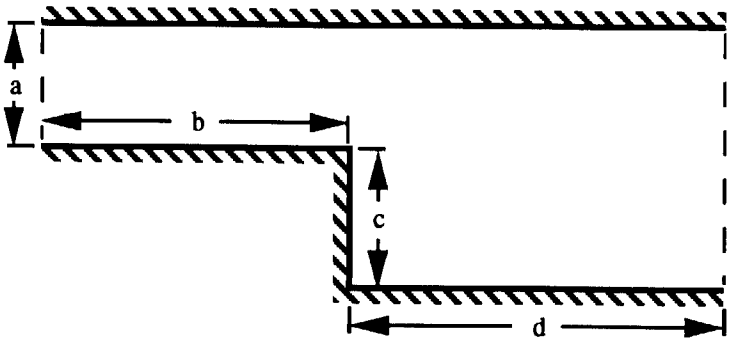
- **COSTS CATEGORY INCLUDES:**
  - SOURCE CODE AND ANNUAL MAINTENANCE
  - TRAINING
  - CONSULTING

- **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

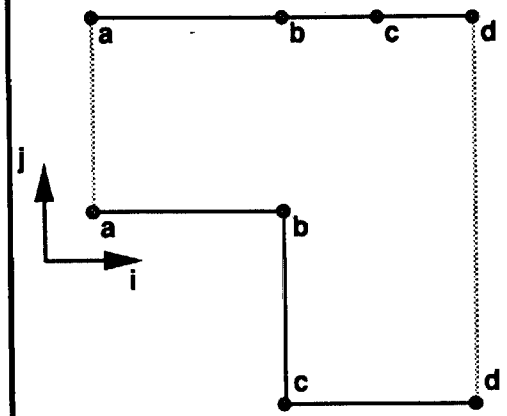


GEOMETRY 1: a=b=c=d=1
GEOMETRY 2: a=0.25, b=c=d=1
GEOMETRY 3: a=b=1, c=4, d=1

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

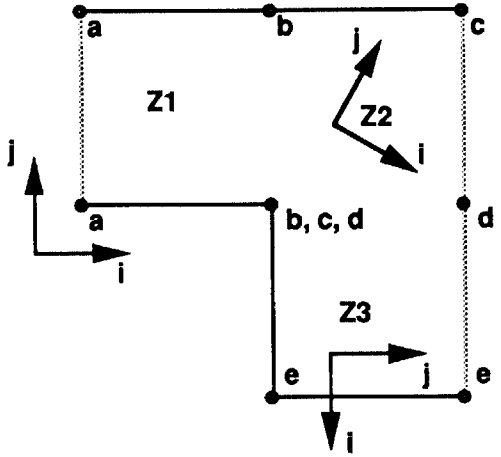


GEOM 1:
imax = 30, jmax = 20+18+20
(1740 grid points)

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

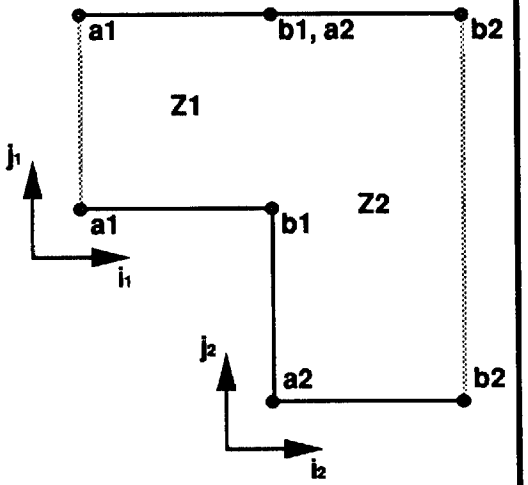


GEOM 1 Z1: imax = 41, jmax = 41
Z2: imax = 41, jmax = 41
Z3: imax = 41, jmax = 41
(5043 grid points)

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

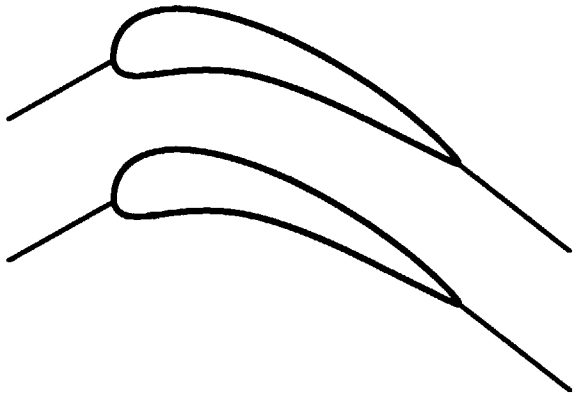


GEOM 1
Z1: imax = 41, jmax = 41
Z2: imax = 41, jmax = 81
(5002 grid points)

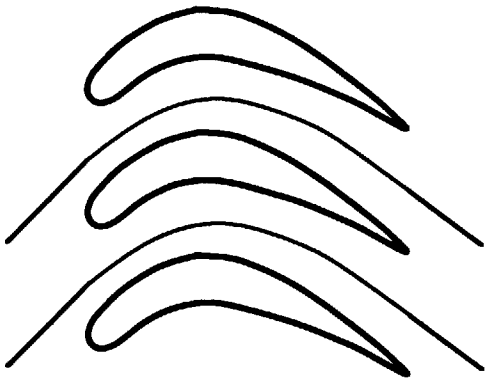
GEOM 2
Z1: imax = 41, jmax = 11
Z2: imax = 41, jmax = 51
(2542 grid points)

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

BENCHMARK CASES - SET 2



GEOMETRY 1 - REACTION TYPE

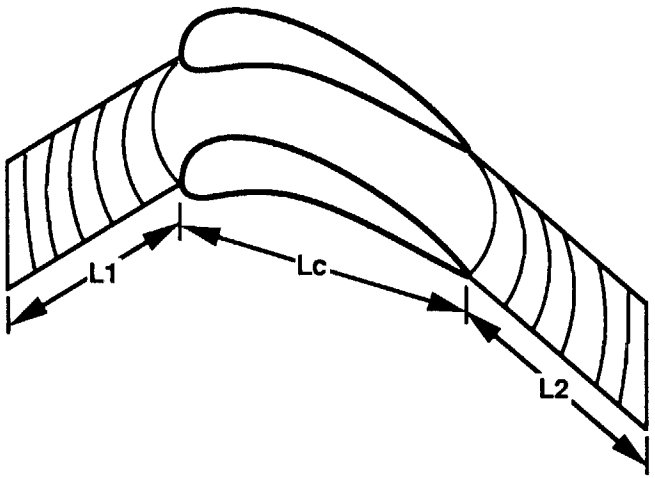


GEOMETRY 2 - IMPULSE TYPE

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

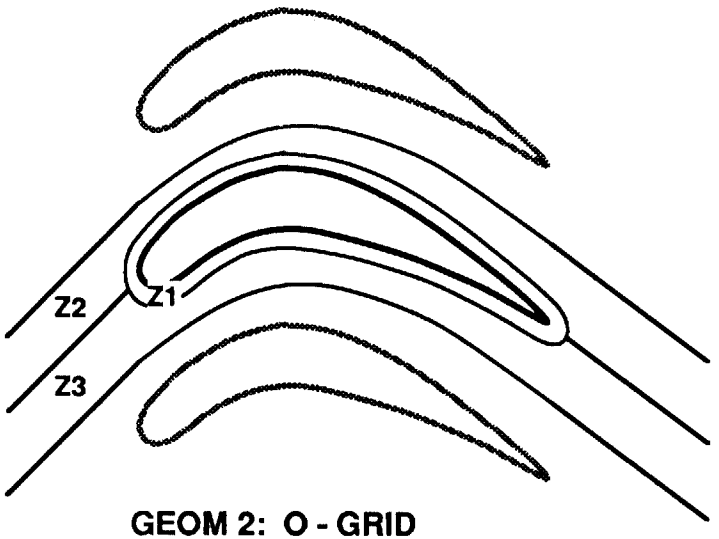
BENCHMARK CASES - SET 2 (CONT'D)

TOPOLOGY 1: H-GRID, PERIODIC



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

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



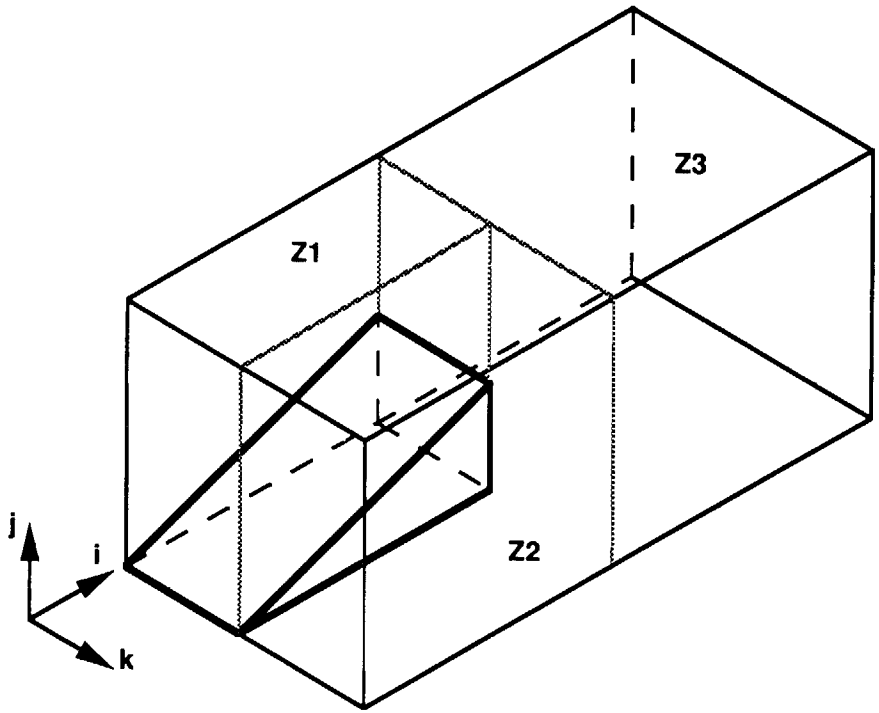
GEOM 2: O - GRID

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



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

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

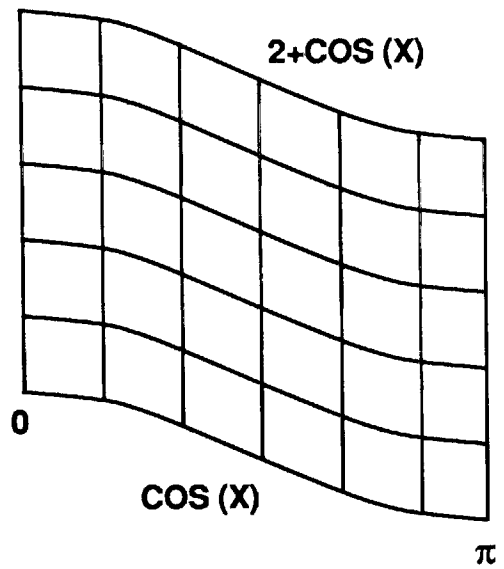
$H_{Z1} = H_{Z2} = H_{Z3} = 1.0$
$W_{Z1} = W_{WEDGE} = 0.25$
$W_{Z2} = 0.75,\ W_{Z3} = 1.0$
$L_{Z1} = L_{Z2} = L_{Z3} = 1.0$

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

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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**