N94-22354

# GRID GENERATION REQUIREMENTS AT MARSHALL SPACE FLIGHT CENTER

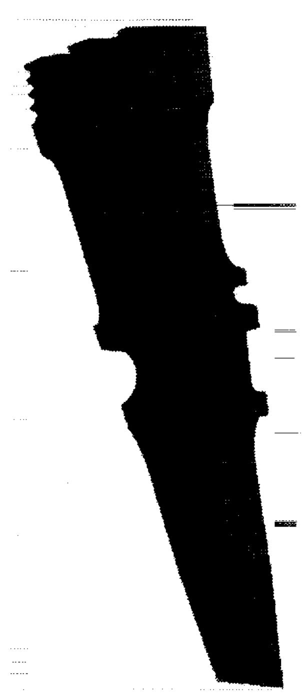
LARRY KIEFLING
MARSHALL SPACE FLIGHT CENTER

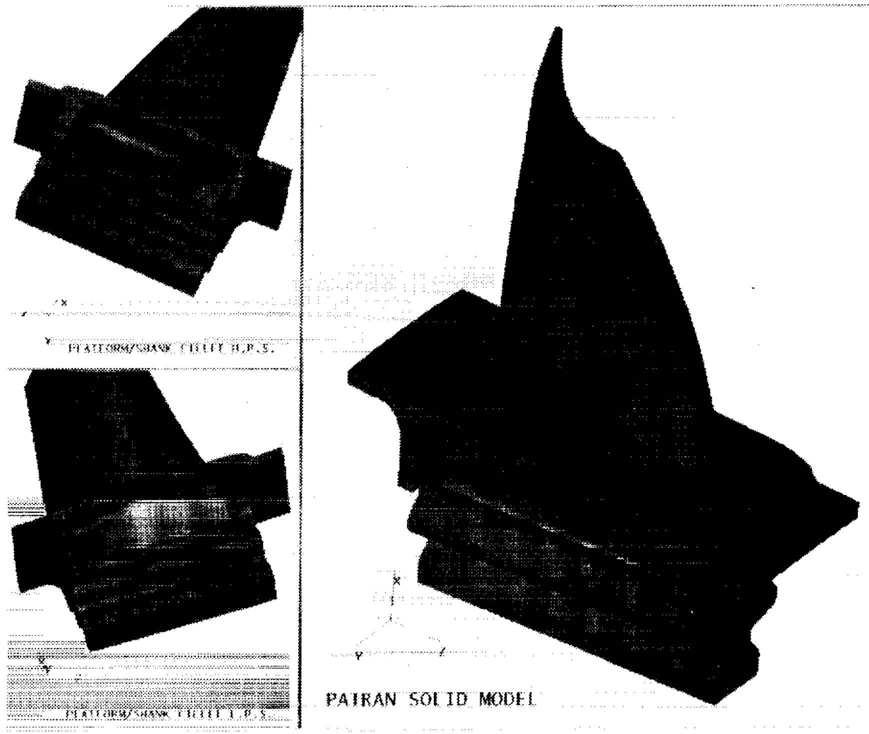
| ORGANIZATION: MSFC | MARSHALL SPACE FLIGHT CENTER | NAME: LARRY KIEFLING |
|---|---|---|
| CHART NO: | SOME EXAMPLES OF STRUCTURAL GRID GENERATION | DATE: 4/27/93 |

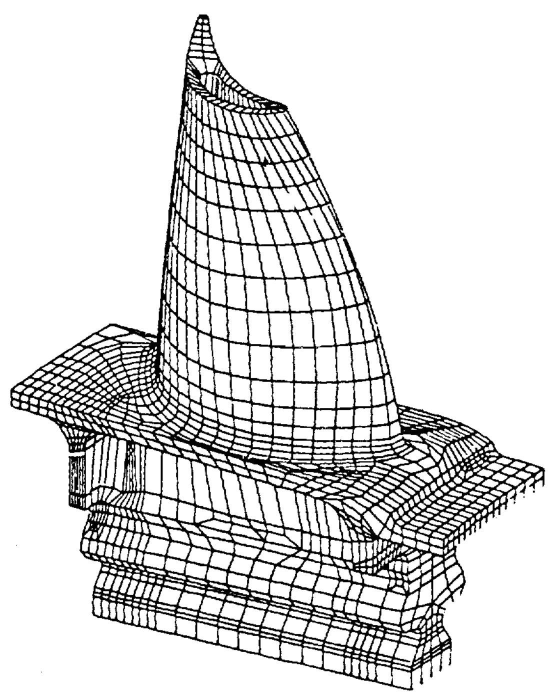
- THREE EXAMPLES FROM MSFC ANALYSTS

- PROPULSION SYSTEMS COMPONENTS
  - HIGH PERFORMANCE REQUIREMENTS
  - MULTI-CURVED SURFACES

- SUMMARY OF NEEDS





**Sverdrup Technology, Inc. Blade Model**

Attachment I

Model Summary

| | |
|---|---|
| Quadrilateral Elements | none |
| Triangular Elements | none |
| Tetrahedral Elements | none |
| Pentahedral Elements | 14 |
| Hexahedral Elements | 7123 |
| Nodes | 9478 |
| Duplicate Nodes | 24 |

Element Shape Summary

Pentahedral Elements

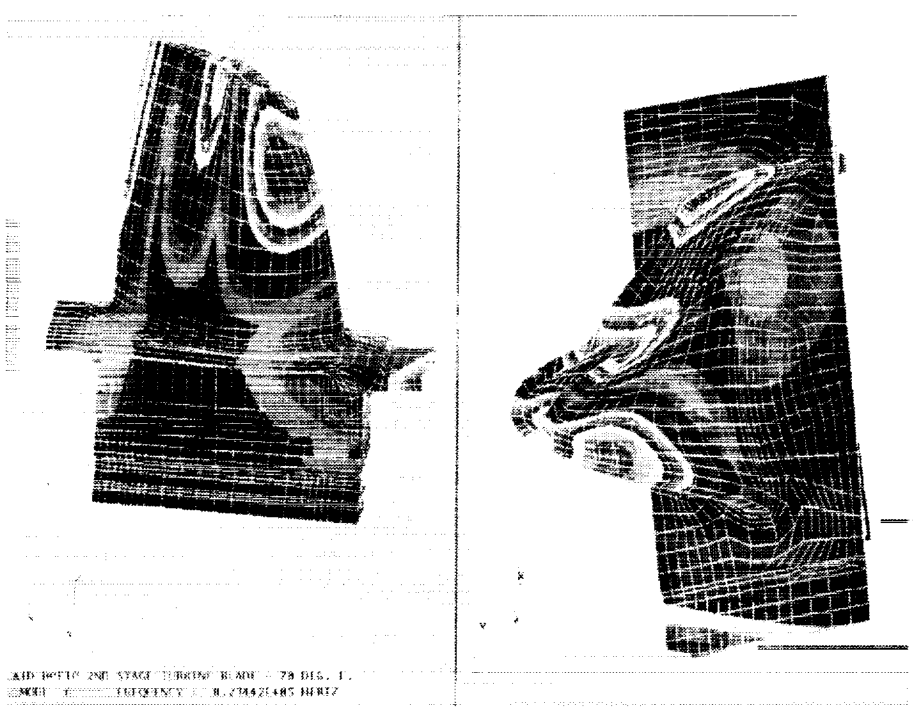
| | |
|---|---|
| Aspect Ratio | 1.4 - 4.2 |
| Face Skew | 32.0 - 61.0 |
| Face Warp | 2.3 - 14.0 |
| Face Taper | 0.53 - 0.91 |
| Twist Angle | 1.1 - 34.0 |
| Edge Angle | 21.0 - 75.0 |
| Jacobian Ratio | 1.1 - 2.3 |

Hexahedral Elements

| | |
|---|---|
| Aspect Ratio | 1.0 - 27.0 |
| Face Skew | 0.90 - 83.0 |
| Face Warp | 0.0 - 59.0 |
| Face Taper | 0.16 - 1.0 |
| Twist Angle | 0.0 - 132.0 |
| Edge Angle | 1.8 - 90.0 |
| Jacobian Ratio | 1.0 - 19.0 |

General

| | |
|---|---|
| Duplicate Elements | None |
| Element Volume | All positive |
| Unconnected Nodes | None |
| Boundary Check | Good |
| Free Face Check | Good |
| Free Edge Check | Good |
| Connectivity | Complete |
| Optimization | PATRAN |



**23480 Hz**

## MSFC GRID GENERATION EXAMPLE

Terry Prickett
Rockwell, International

GRID GENERATION OR FINITE ELEMENT MESHING FOR STRUCTURAL AND THERMAL ANALYSIS MODELS IS CURRENTLY ACCOMPLISHED USING INTERACTIVE GRAPHICS BASED SOFTWARE ON PERSONAL WORKSTATIONS. THE TWO SOFTWARE PACKAGES USED MOST OFTEN ARE INTERGRAPH'S I/FEM AND PDA ENGINEERING'S PATRAN. THE TWO PROGRAMS EACH HAVE THEIR STRONG POINTS AND WEAK POINTS, THEREFORE MANY USERS WILL USE BOTH PACKAGES DURING THEIR MODEL CONSTRUCTION.

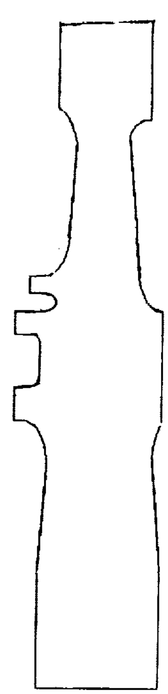
I/FEM IS AN ADD ON PACKAGE THAT WORKS WITH INTERGRAPH'S I/EMS, WHICH IS A NURBS (NON-UNIFORM RATIONAL B-SPLINE) BASED CAD PACKAGE. MOST ENGINEERING DRAWINGS PREPARED ON-SITE AT MSFC ARE PRODUCED WITH I/EMS. THE MODELER USES BOTH I/EMS CAD COMMANDS AND I/FEM COMMANDS TO BUILD HIS MESH. THIS METHOD WORKS WELL FOR GENERATING MODELS WITH COMPLICATED GEOMETRY.

PATRAN IS A FINITE ELEMENT GENERATION PROGRAM THAT IS BASED ON PARAMETRIC CUBIC GEOMETRY. GENERATING COMPLICATED GEOMETRY IN PATRAN IS MORE TIME CONSUMING THAN I/FEM, BUT MODIFICATIONS TO THE MESH ARE MORE EASILY MADE THAN IN I/FEM. ONE OF THE MOST ATTRACTIVE FEATURES OF PATRAN IS THAT IT ALLOWS YOU TO MODIFY NODE AND ELEMENT ATTRIBUTES BY THEIR ASSOCIATION WITH ANOTHER ENTITY, THEIR INDIVIDUAL ID, PROPERTY ID, MATERIAL ID, OR LOCATION IN SPACE. PATRAN CAN BE CUSTOMIZED USING PCL(PATRAN COMMAND LANGUAGE). PCL IS A HIGH LEVEL BLOCK STRUCTURED PROGRAMMING LANGUAGE DESIGNED TO FIT AROUND THE USER INTERFACE OF PATRAN. IT CAN BE USED TO CREATE SPECIFIC COMMANDS, CREATE TRANSLATORS, PERFORM REPEATED STEPS, etc..

## MSFC GRID GENERATION EXAMPLE

- THE HPOTP FIRST STAGE TURBINE DISC FEA MODEL IS A GOOD EXAMPLE OF OF A MODELING EFFORT WHICH USED BOTH SOFTWARE PACKAGES.
- A 2D DRAWING OF THE DISC WAS LOCATED ON THE INTERGRAPH SYSTEM (Fig 1).
- A 3D SOLID CAD MODEL WEDGE SECTION WAS CREATED FROM THE 2D DRAWING (Fig 2).
- THE SOLID MODEL WAS NEXT BROKEN DOWN INTO LINES THAT COULD BE TRANSLATED TO PATRAN THROUGH IGES (Fig 3).
- THE LINES IN PATRAN WERE USED TO CREATE HYPER-PATCHES, A 3D PARAMETRIC CUBIC SOLID REGION TO WHICH A MESH CAN BE MAPPED (Fig 4).
- GENERATION OF THE FINITE ELEMENT MESH WAS NEXT PERFORMED USING THE HYPERPATCHES. MESH DENSITY WAS CHANGED SEVERAL TIMES, WITHOUT MUCH TIME OR EFFORT, UNTIL AN ACCEPTABLE MESH WAS CREATED (Fig 5).

THE MODEL WAS TRANSFERRED TO ANOTHER ANALYSIS PACKAGE WHERE LOADS AND BOUNDARY CONDITIONS WERE APPLIED AND THE MODEL WAS SOLVED.



ATD HPFTP 2ND STAGE TURBINE BLADE MODAL ANALYSIS
JOHN BERNOT, SVERDRUP CORPORATION

•A THREE DIMENSIONAL SOLID FINITE ELEMENT MODEL WAS GENERATED USING PATRAN. THE PATRAN SOLID MODEL, PRIOR TO GENERATION OF THE FINITE ELEMENT MESH, IS SHOWN IN FIGURE 5.

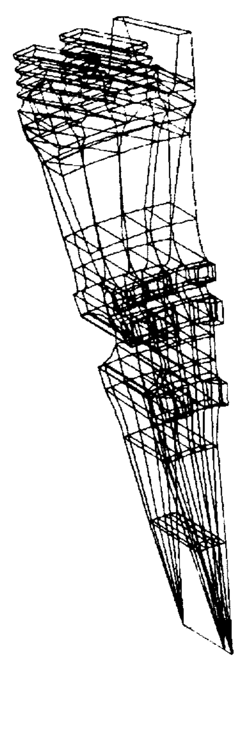
•ALL MAJOR FILLET RADII IN THE BLADE SYSTEM WERE MODELED. WHERE A TOLERANCE WAS SPECIFIED FOR THE BLADE SYSTEM FILLET RADII, MINIMUM VALUES WERE CHOSEN.

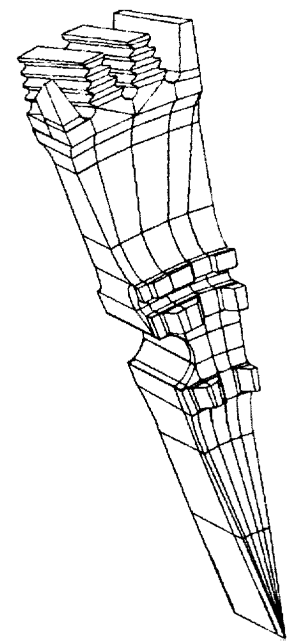
•THE MODEL IS ALMOST ENTIRELY COMPOSED OF HEXAHEDRAL BRICK ELEMENTS IN ORDER TO TAKE ADVANTAGE OF THE BRICK ELEMENT GENERALLY BETTER PERFORMANCE OVER PENTAHEDRAL AND TETRAHEDRAL ELEMENTS.

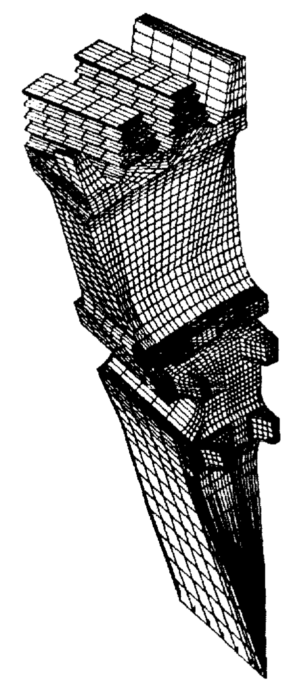
•HIGHER QUALITY ELEMENTS WERE USED IN AREAS OF ANTICIPATED INTEREST, SUCH AS THE BLADE ATTACHMENT RADIUS TO THE PLATFORM, FOR ANY SUBSEQUENT STRESS ANALYSIS WHICH MIGHT LATER BE PERFORMED.

•LOWER QUALITY ELEMENTS, WHOSE GEOMETRIC DISTORTION IS TOO SEVERE TO ACCURATELY PREDICT REALISTIC STRESSES, ETC., WERE RESTRICTED IN THE INTERIOR OF THE BLADE SYSTEM VOLUME AND/OR WHERE RESULTS WERE NOT ANTICIPATED TO BE OF ANY SIGNIFICANT INTEREST.

•THE FINITE ELEMENT MODEL WAS CHECKED BY SVT PERSONNEL AS PART OF ROUTINE QUALITY CONTROL PROCEDURES. MODEL GEOMETRY, CONSTRAINTS, ETC., WERE INDEPENDENTLY EVALUATED AGAINST THE DRAWINGS, ETC. THESE CHECKS ARE SUMMARIZED IN ATTACHMENT 1.



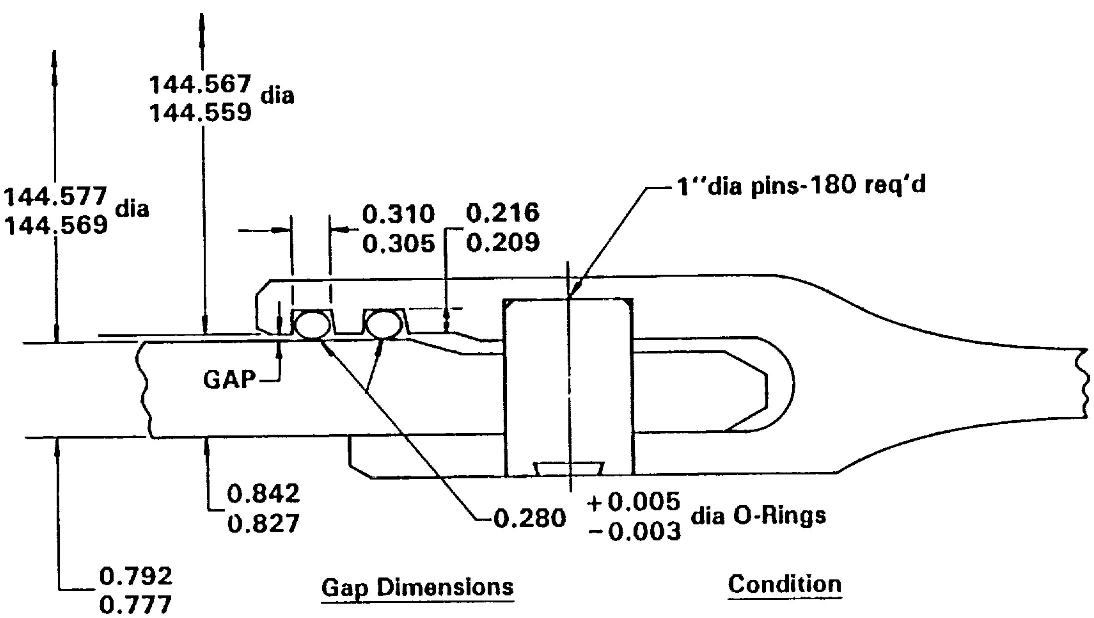




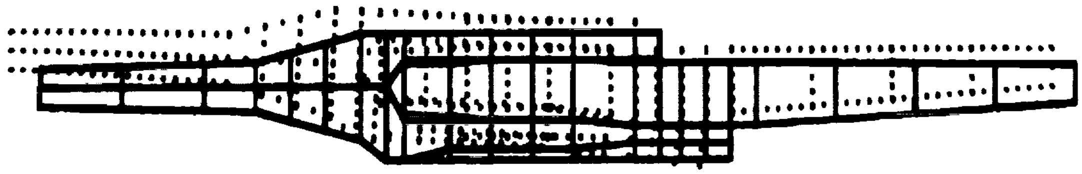
SPACE SHUTTLE SOLID ROCKET MOTOR FIELD JOINT (OLD)

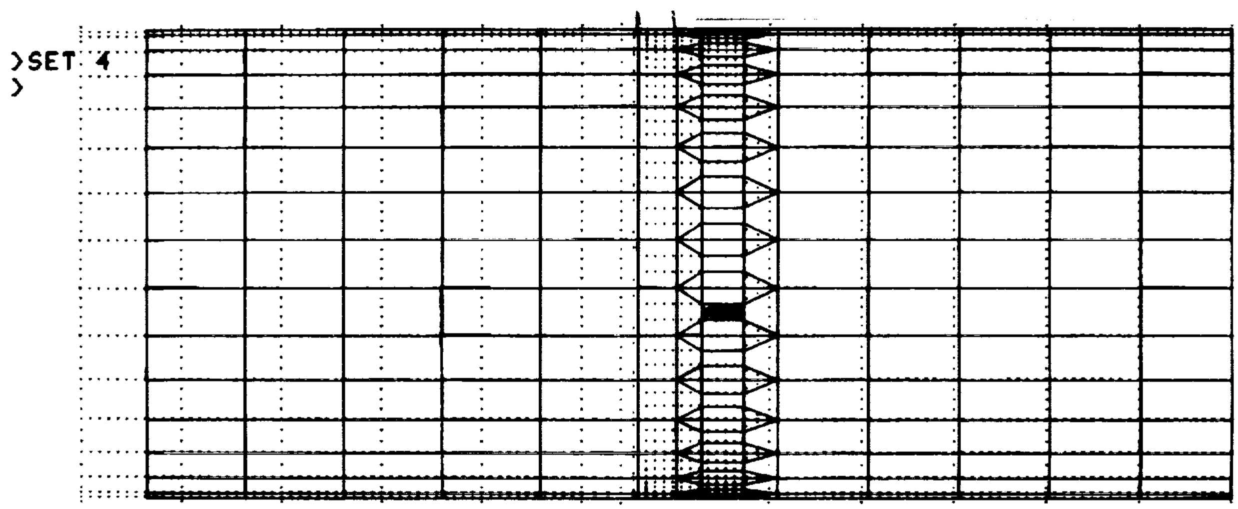
- USED TO USCCESSFULLY MODEL CHALLENGER FAILURE
- SELECTED TO DEMONSTRATE LARGE RANGE OF SCALING

## Space Shuttle SRM Segment Joint




| Gap Dimensions | Condition | |
|---|---|---|
| 0.005 ± 0.004 | Concentric | Diameter Basis |
| 0.010 ± 008 | Non-symmetric | Diameter Basis |
| 0.033 Max | Non-symmetric - | Gathering |




>SET 4
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## SOME SPECIFIC NEEDS

- NEED TO HAVE JOINTS AND ELEMENTS IN A RATIONAL ORDER. NEED TO VISUALIZE LOCATION OF MAX STRESS, ETC.
- NEED TO USE QUADS FOR SHELLS AND HEXAHEDRAL SOLIDS AS MUCH AS PRACTICABLE, ESPECIALLY HIGH STRESS AREAS.
- NEED TO KEEP ELEMENT SURFACES FLAT. MOST IMPORTANT FOR SHELLS.
- NEED TO MATE SOLIDS WITH SHELLS AND BEAMS.
- ABILITY TO SELECT NODES AND ELEMENTS MANY WAYS.
- NEED TO DEVELOP MULTISCALE GRIDS.
- NEED TO VISUALIZE BEAM CROSS-SECTION ORIENTATIONS.
- NEED TO MODEL THEORETICAL POINTS SUCH AS A HINGE CENTERLINE (WITH COINCIDENT NODES).
- NEED TO INPUT NONGEOMETRIC DATA.