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CAE Partner Business Unit



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The
MacNeal-Schwendler
Corporation

Bob Gilliver
MSC/ARIES European Product
Marketing and Support
Manager



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AGENDA

- **Geometry**
- **FE Analysis**
- **Optimization**
- **Mechanisms**
- **Plastics**
- **MSC/ARIES**
Positioning

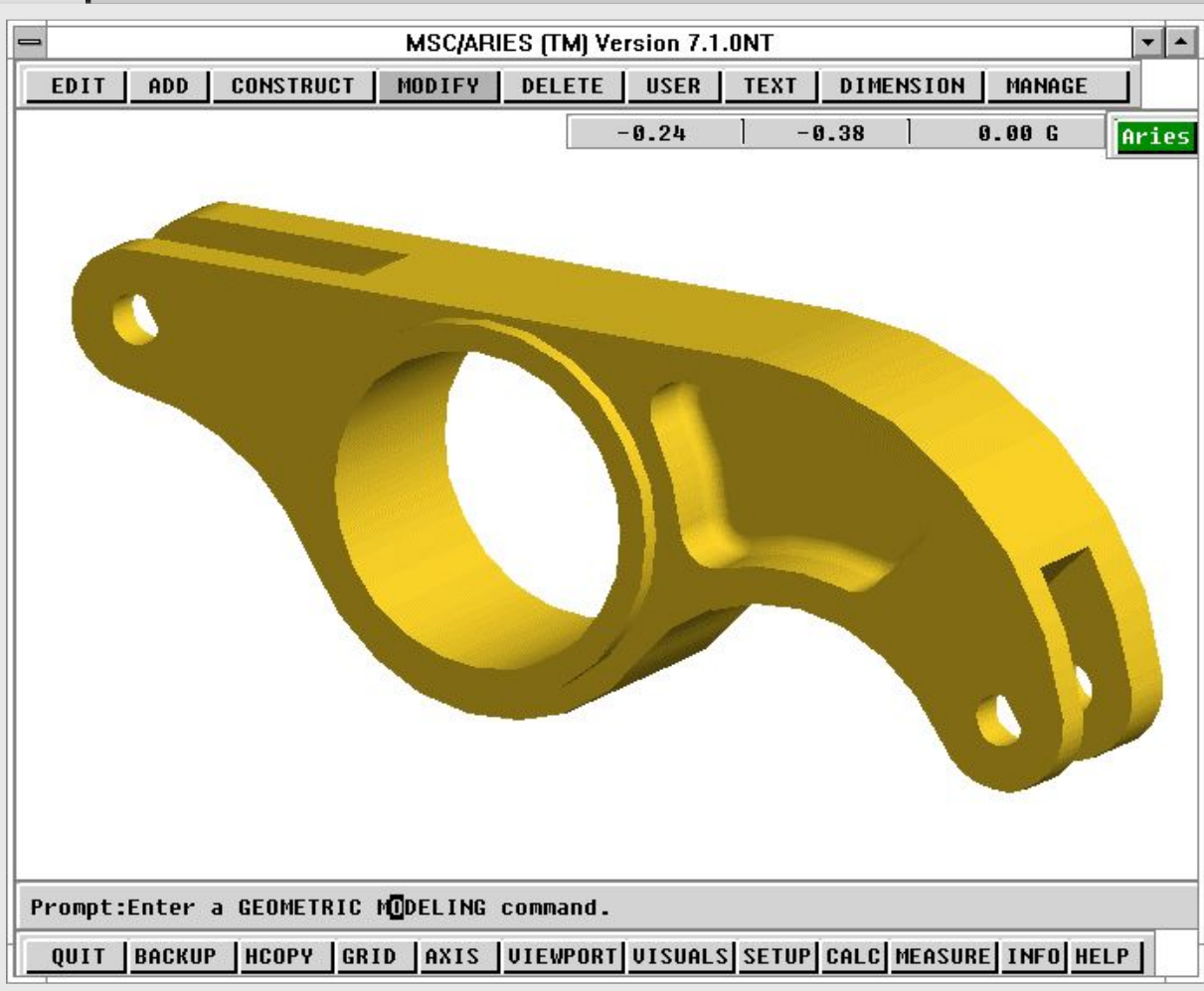


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Geometry



- **Full function ACIS based modeler**
- **Constraints**
 - full
 - partial
 - none
- **ACIS data exchange**
 - AutoCAD
 - Bentley
 - Integraph
 - HP

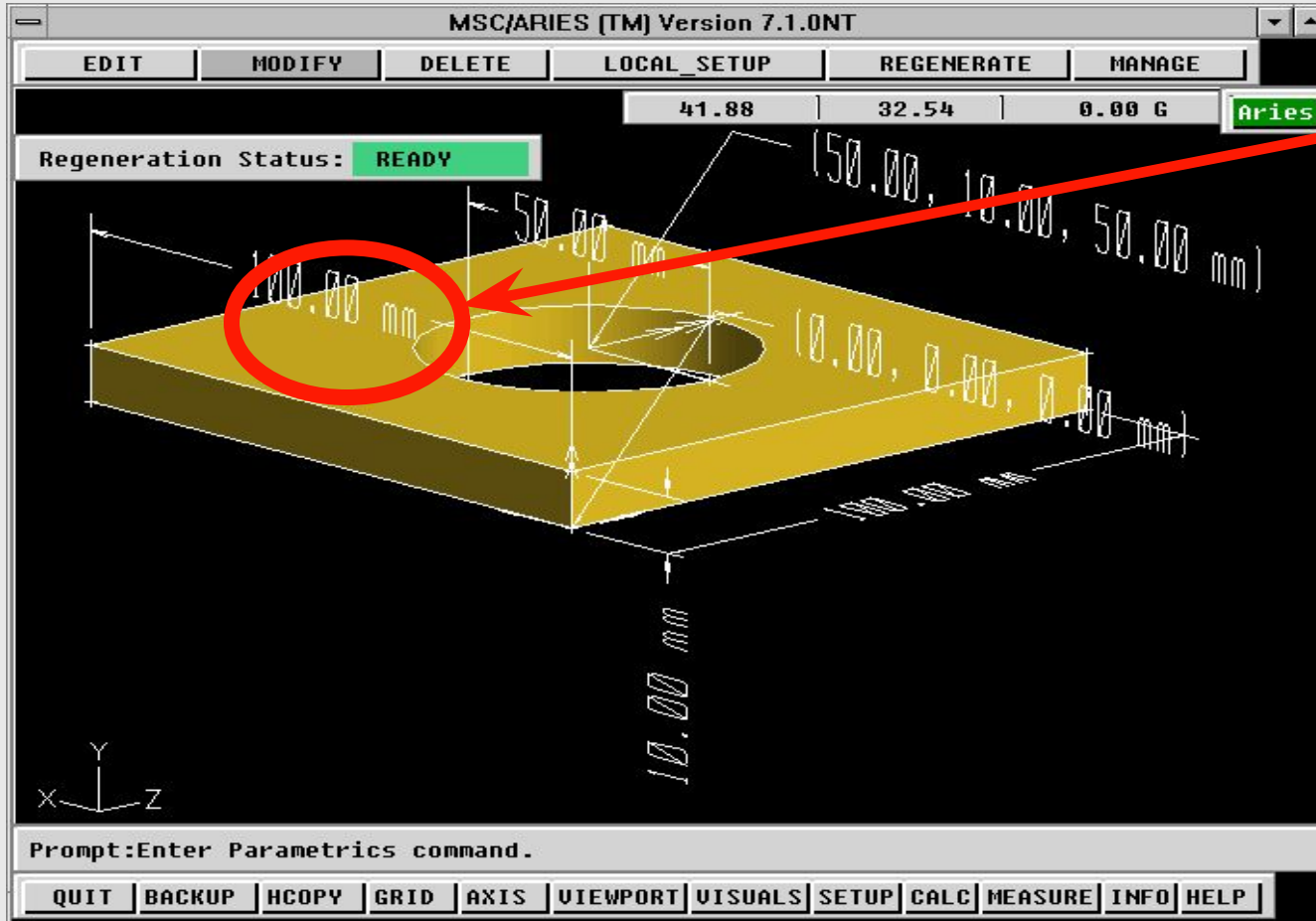


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Geometry



Modify
dimensions



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Geometry

The screenshot displays the MSC/ARIES (TM) Version 7.1.0NT interface. A red circle highlights the Rule List, which contains the following parametric relationships:

- S Length = 2*Width
- S OriginX = Length/ 2`mm`
- S OriginZ = Width/ 2`mm`
- S Dia1 = Length/ 2.5`mm`

A blue arrow points from the text "Parametric relationships" to the Rule List. Below the Rule List is a 3D model of a part. At the bottom, the Variable List table is shown:

VARIABLE	SCOPE	TYPE	STATUS	VALUE	UNITS	DESCRIPTION
Dia1	GLOBAL	DEPENDENT	SOLVED	32	1/(mm)	
Length	GLOBAL	DEPENDENT	SOLVED	80		
OriginX	GLOBAL	DEPENDENT	SOLVED	40	1/(mm)	
OriginZ	GLOBAL	DEPENDENT	SOLVED	20	1/(mm)	
Width	GLOBAL	INDEPENDENT		40		

Buttons at the bottom of the Variable List include: SCOPE..., TYPE..., CLEAR_STATUS, VALUE..., UNITS..., UPDATE_UNITS, DESCRIPTION..., SELECT ALL, and DESELECT ALL.



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Geometry

- **Complex solids**
 - Skin operator
 - Sweep operator
 - Extensive blending and chamfering
- **Region operator to sub-divide geometry**
 - Map meshing
 - Load footprint areas
 - Symmetry

MSC/ARIES Base - Assemblies



- Visualization
- Packaging
 - Clearance
 - Interference
- Mass properties



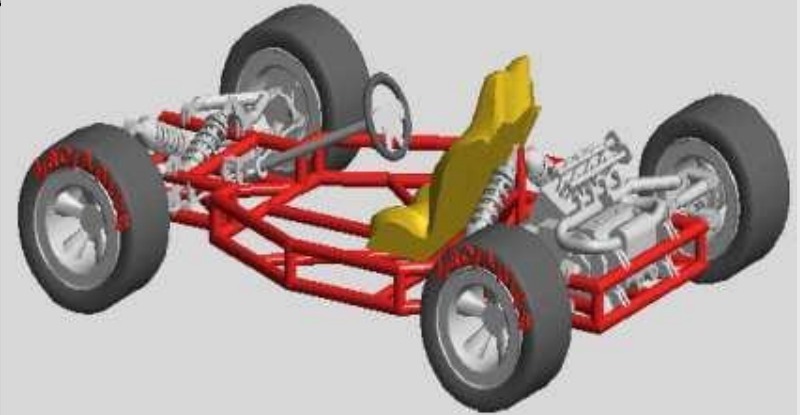
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MSC/ARIES Base - Mass Properties

Entity information			
Mass Properties of Selected Entities			
VOLUME	=	1.16677e+007	mm ³
DENSITY	=	7.7504e-006	kg/(mm ³)
MASS	=	90.4297	kg
WEIGHT	=	886.812	N
SURFACE AREA	=	503505	mm ²
MASS MOMENTS OF INERTIA :			
IX	=	935469	kg*mm ²
IY	=	2.43862e+006	kg*mm ²
IZ	=	3.31991e+006	kg*mm ²
MASS PRODUCTS OF INERTIA :			
IXY	=	0	kg*mm ²
IYZ	=	0	kg*mm ²
IZX	=	0	kg*mm ²
RADII OF GYRATION :			
K	=	101.709 164.216 191.605	mm
CENTER OF GRAVITY			
	=	0 0 0	mm
PRINCIPAL AXES ORIENTATION (DIRECTION COSINES) :			
X-AXIS	=	1 0 0	mm/mm
Y-AXIS	=	0 1 0	mm/mm
Z-AXIS	=	0 0 1	mm/mm
PRINCIPAL MASS MOMENTS OF INERTIA :			
IXP	=	935469	kg*mm ²
IYP	=	2.43862e+006	kg*mm ²
IZP	=	3.31991e+006	kg*mm ²
PRINCIPAL RADII OF GYRATION :			
KP	=	101.709 164.216 191.605	mm

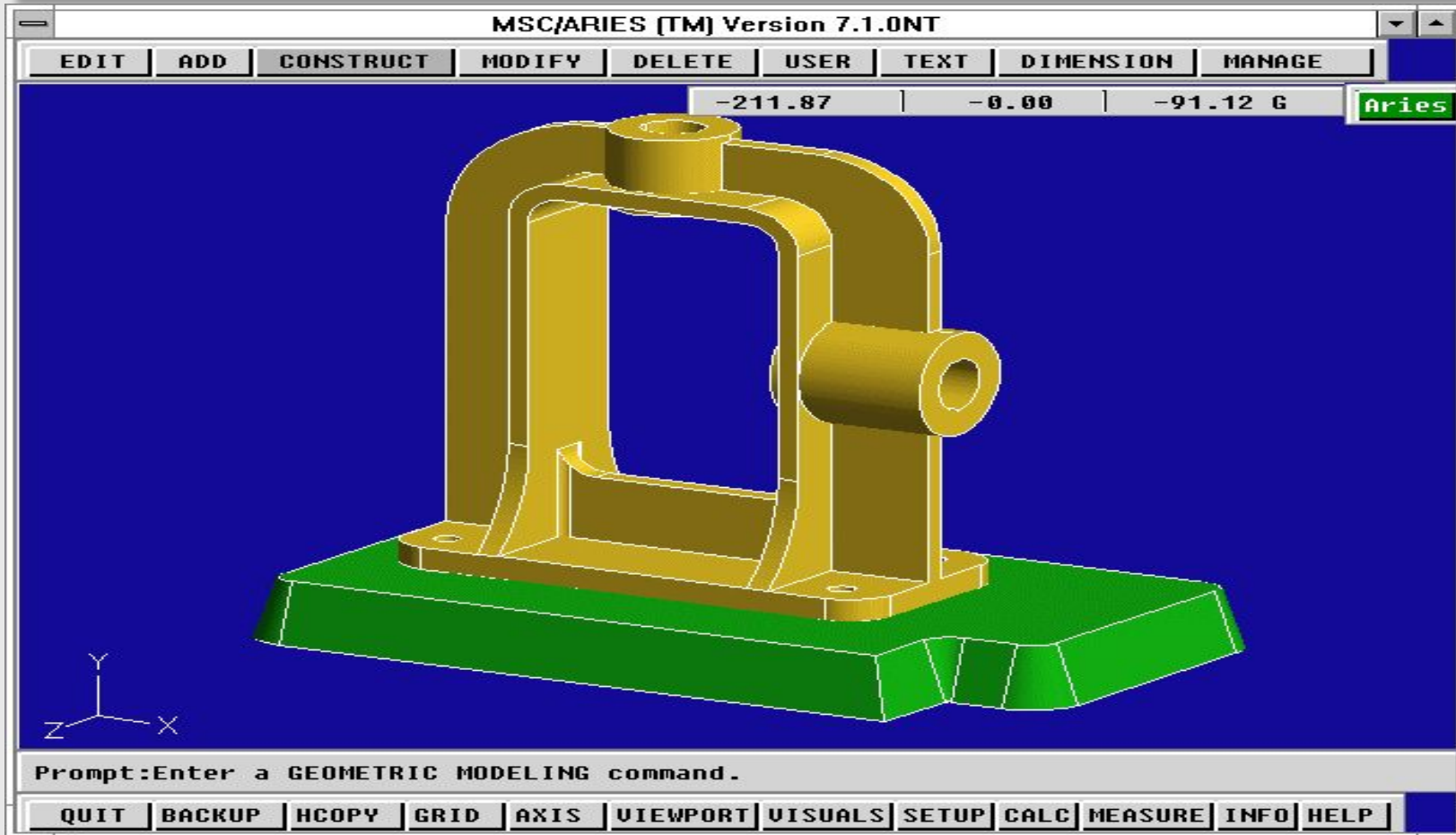


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Geometry - Regioning

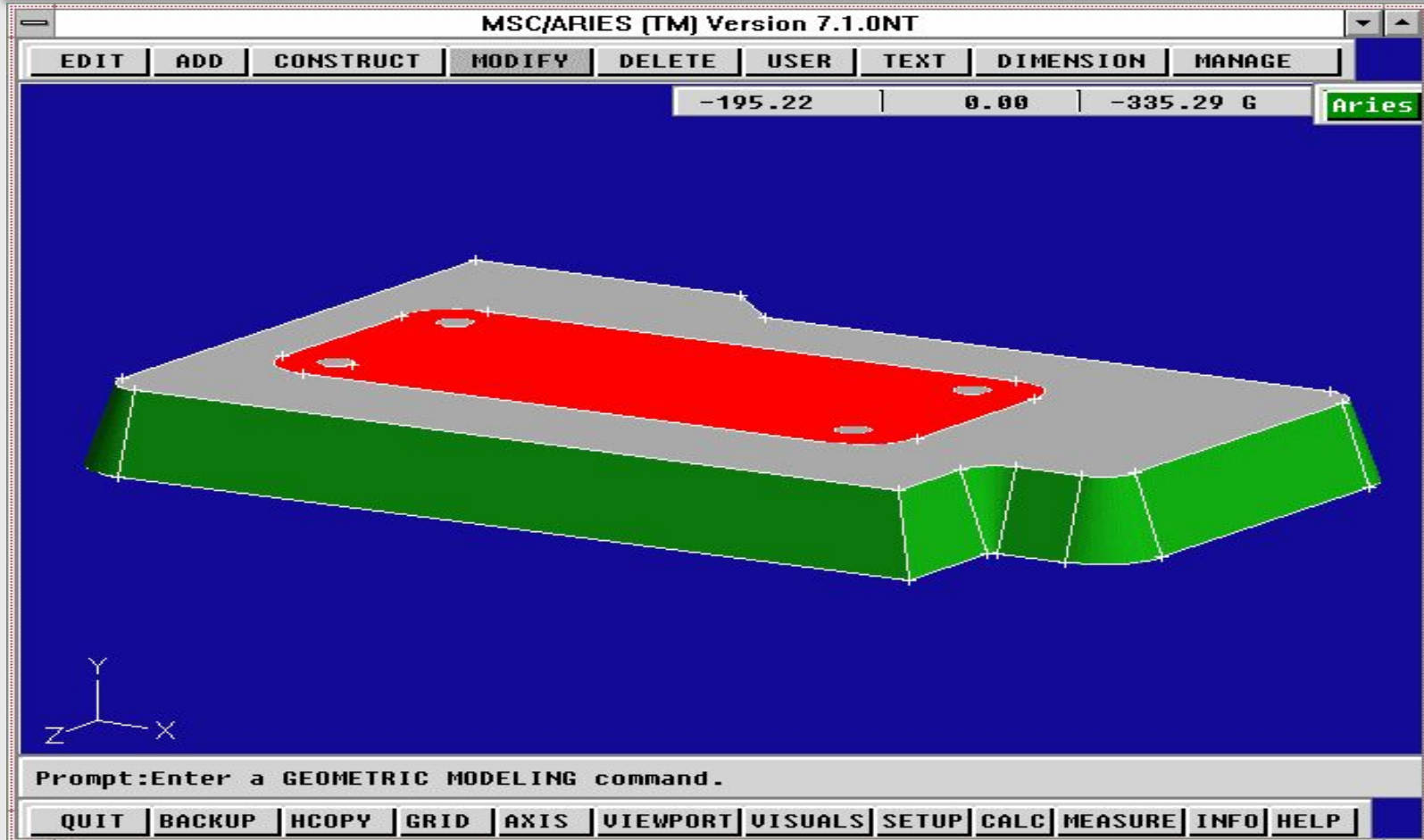


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Geometry - Regioning

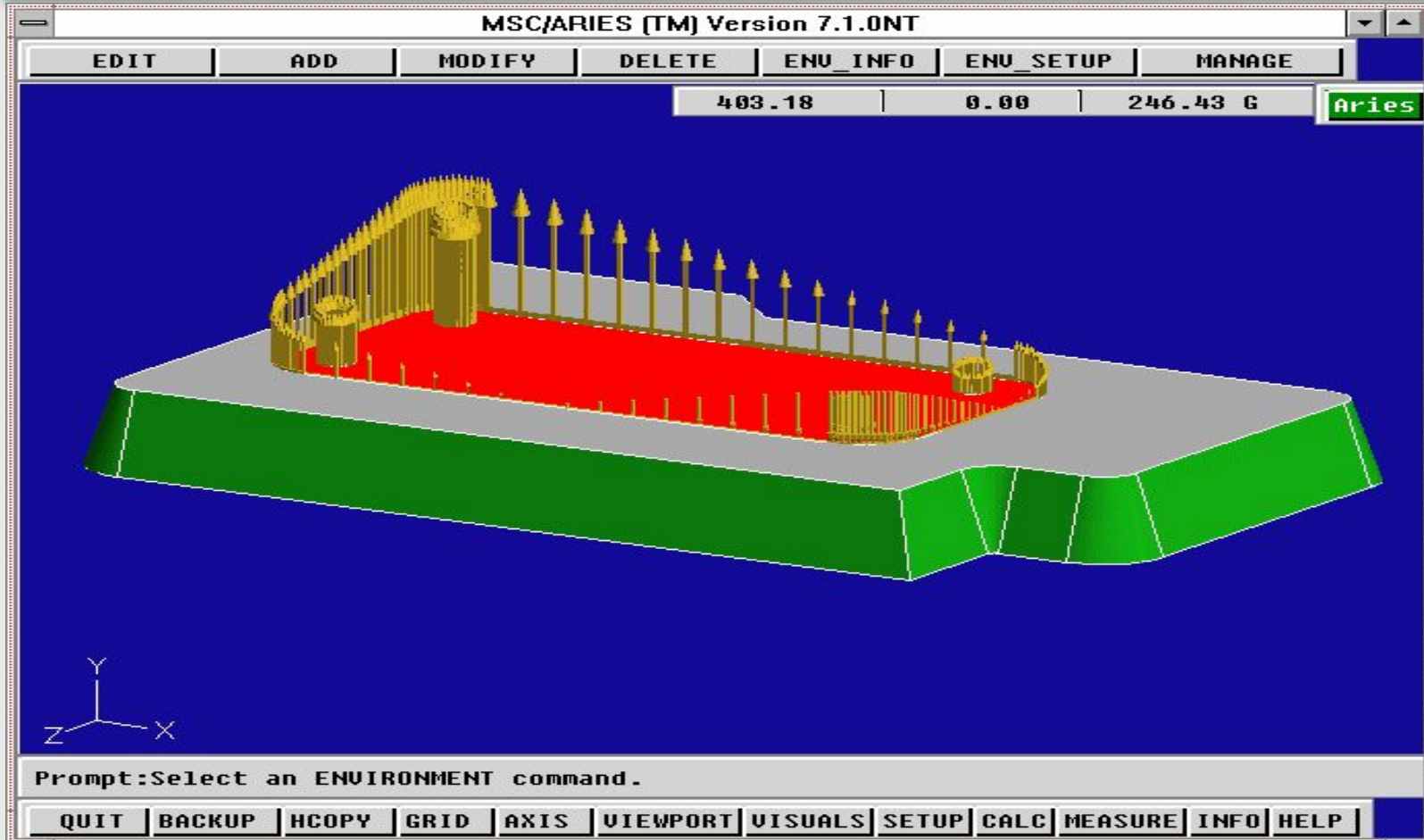


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Geometry - Regioning

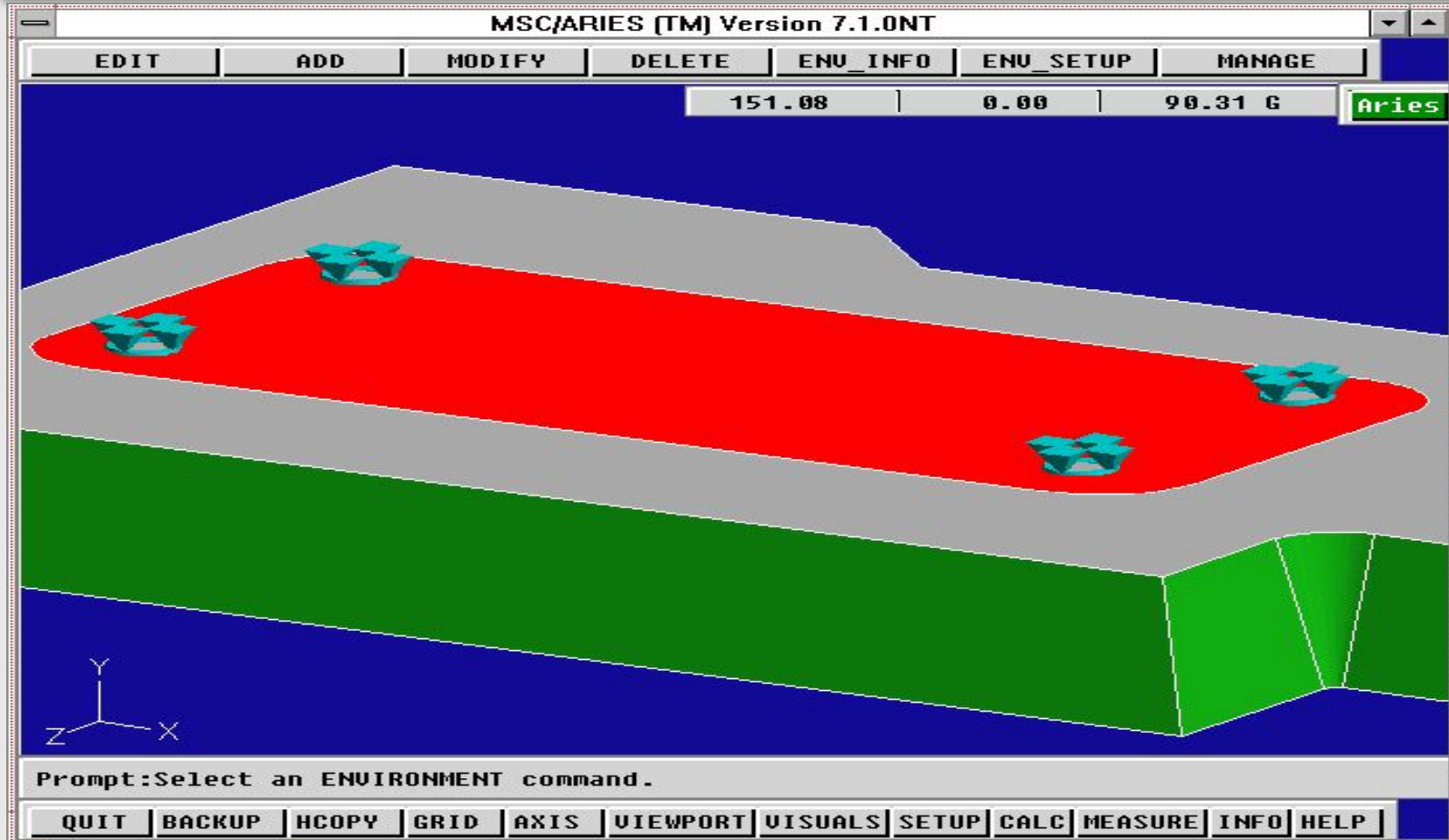


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Geometry - Regioning



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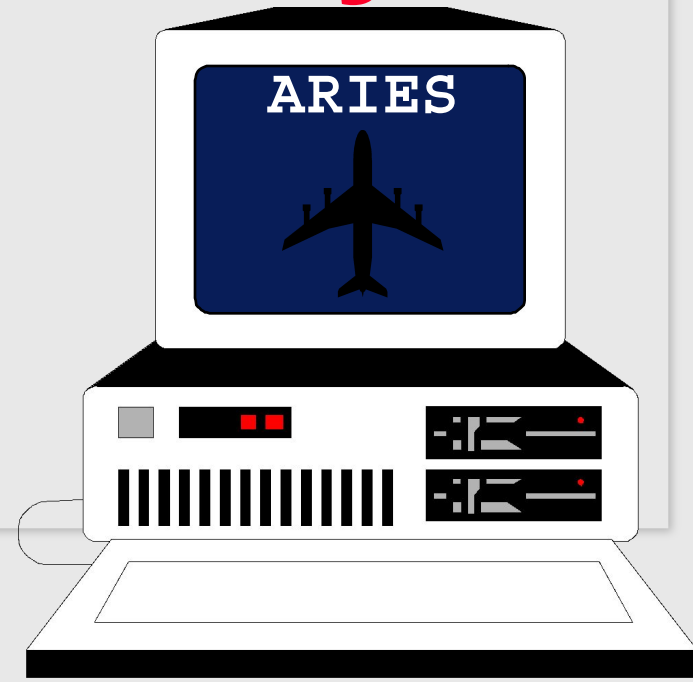
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Pre Release Solids Shelling

- ❑ **Shelling of solids to thin walled solids**
- ❑ **Per face (uniform) thickness control**
- ❑ **Face exclusion to create “open” solids**
- ❑ **Full Parametrics support**
- ❑ **Not supported**
 - **Spline faces (fillet, sweep, skin, spline segments in curve based primitives, extrude with draft <arc segment>)**

Analysis Of ACIS & Imported Geometry



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Geometry Interface - ACIS

- ❑ Support for ACIS sat (ASCII) and sab (binary) file formats
- ❑ Allows bi-directional exchange of solids, surface and wireframe
- ❑ Currently the most reliable solids data exchange format
- ❑ Transfers geometry only
 - No feature or history information

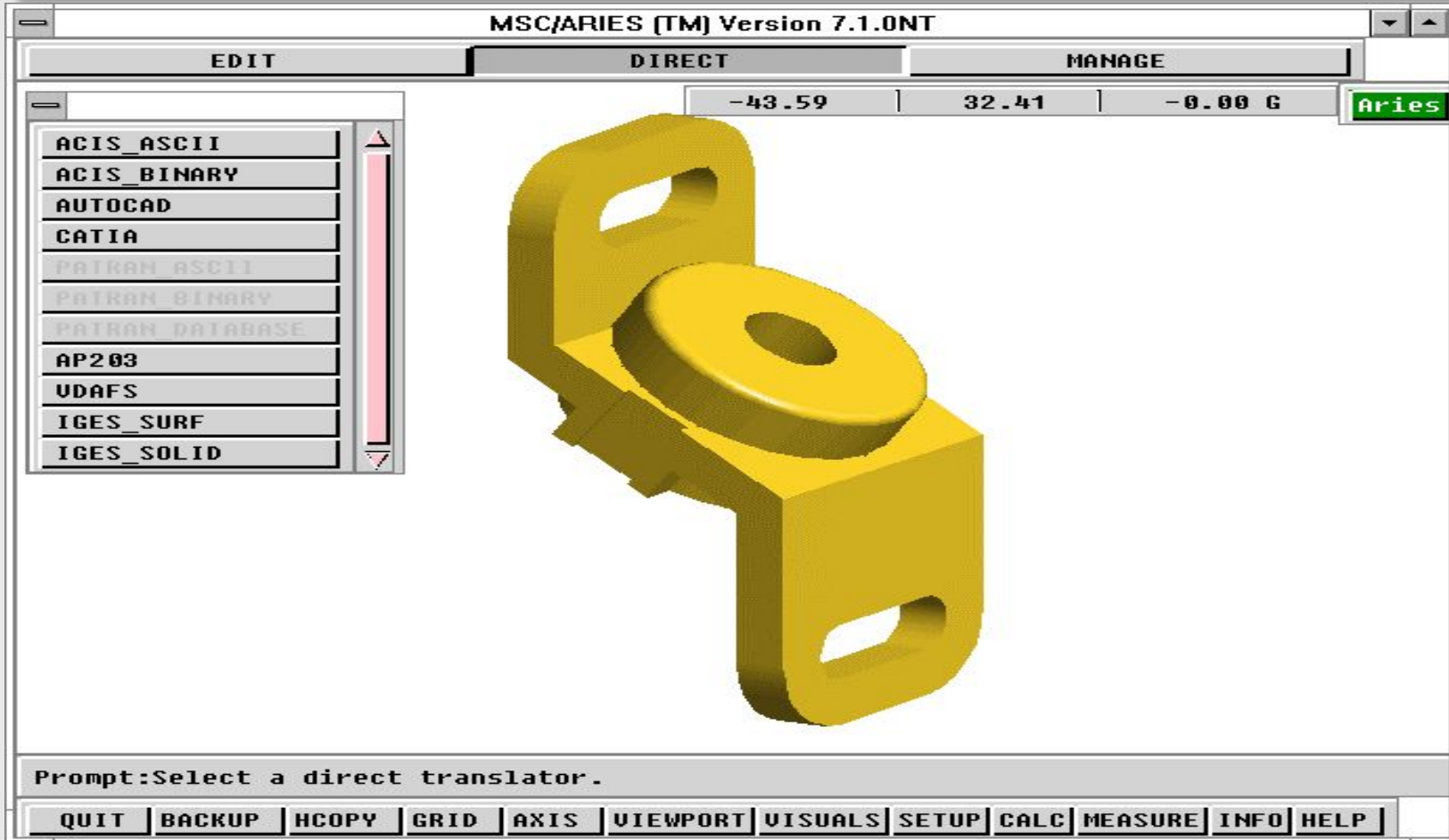


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Geometry Interface - Autocad Import

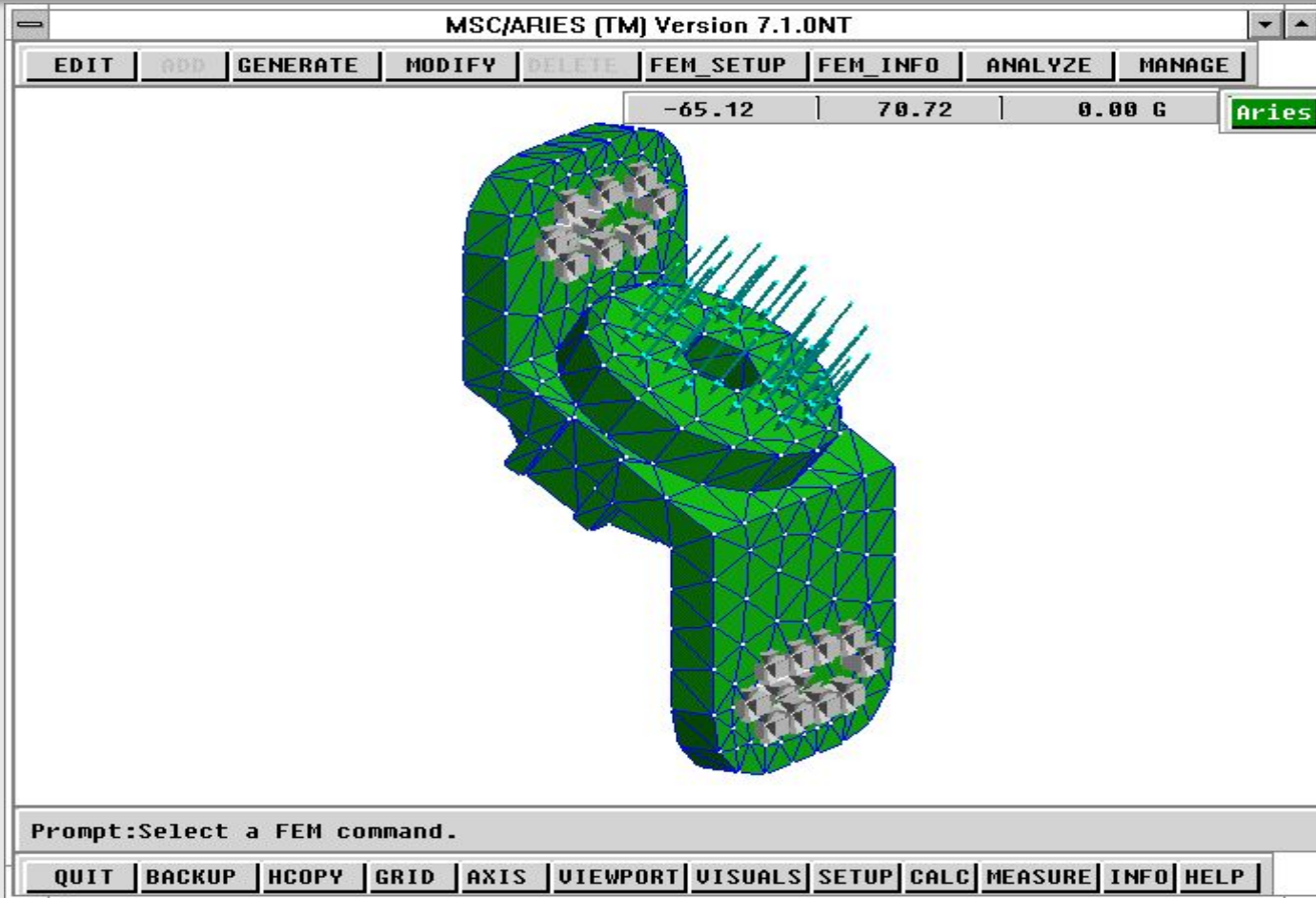


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Geometry Interface - Autocad Import

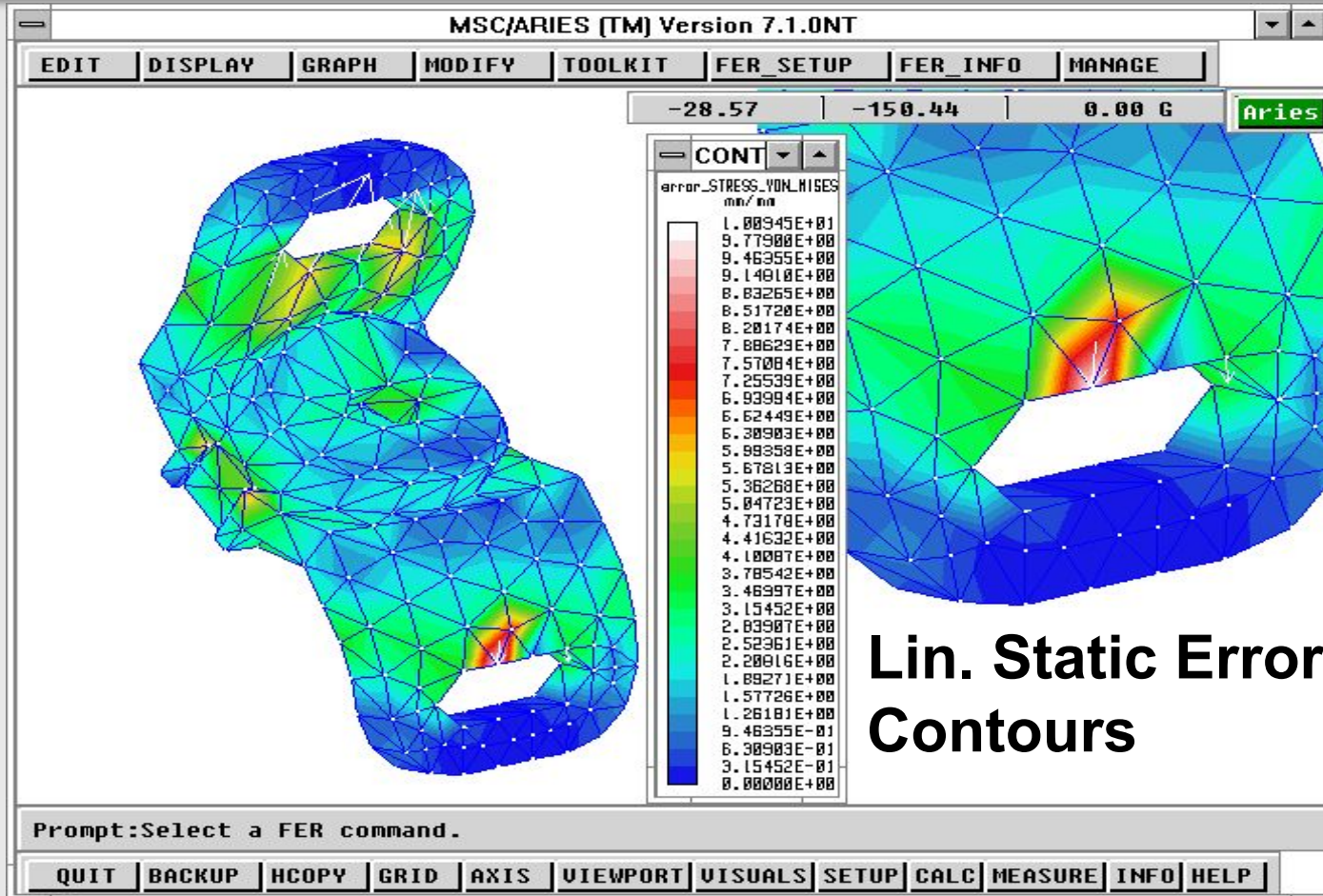


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Geometry Interface - Autocad Import

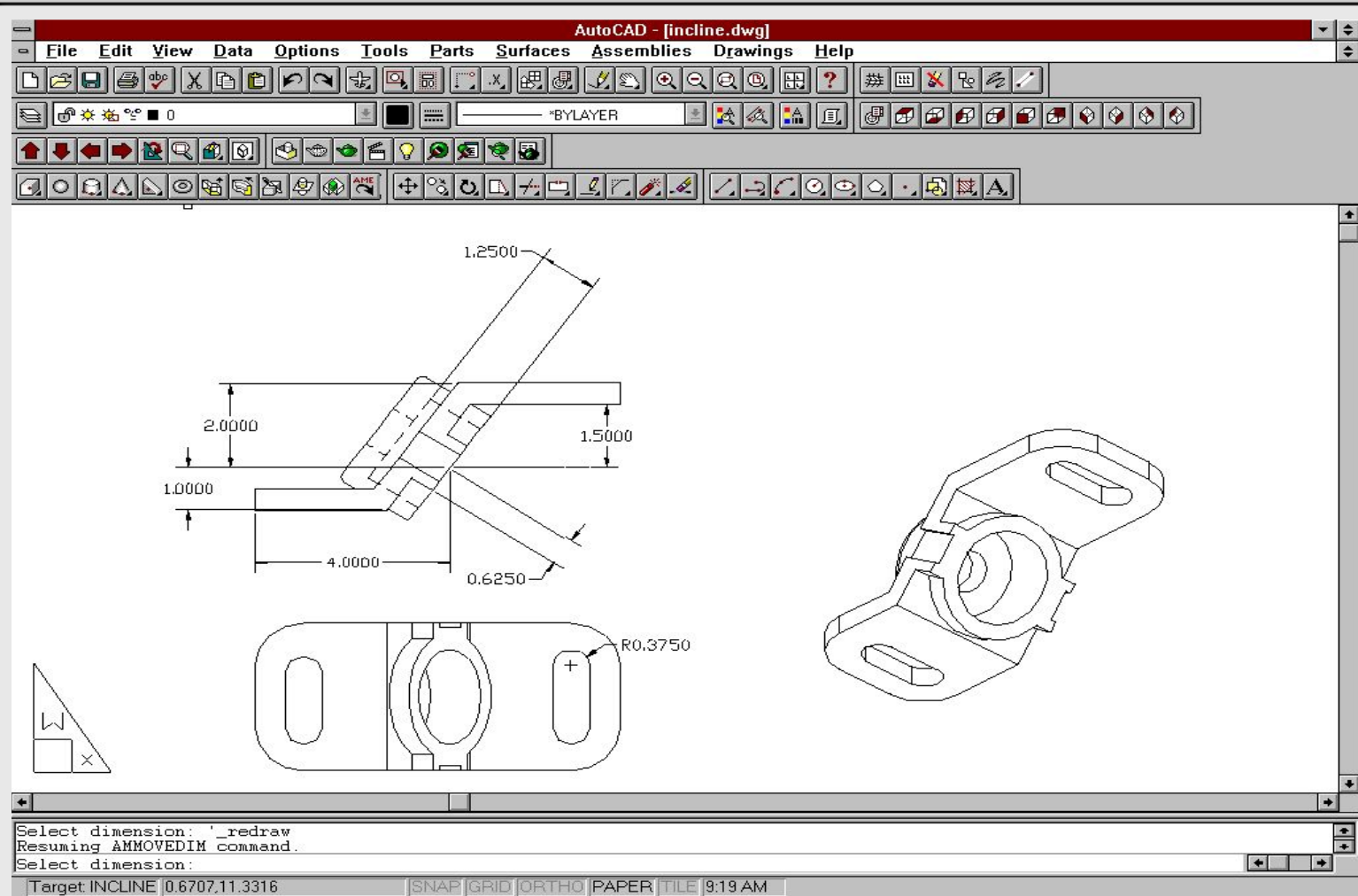


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Geometry Interface - Autocad Export



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Geometry Interface - IGES Import

□ Supports

- **Wireframe**
 - Point, line, arc, composite curve, spline (112,126), conics (104), copious data (106)
- **Surface**
 - Untrimmed (118, 120, 122, 128)
 - Trimmed (144)
- **Solid**
 - Solid BREP (186, 514, 510, 508, 504, 502,)

Geometry Interface - IGES Export

□ Supports

- **Wireframe**
 - Point, line, arc, composite curve, spline (112,126), conics (104)
- **Solid/surface**
 - Decomposed to precise wireframe BREP
 - Decomposed to surface collection (trimmed or untrimmed - 128, 142, 144)
- **Text**
- **Hidden line removal**
- **Silhouette edge generation**

Geometry Interface - DXF Import

- **Wireframe**
 - Point, line, arc, polyline
- **Text**



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Geometry Interface - DXF Export

□ Supports

- **Wireframe**
 - **Point, line, arc, composite curve, spline**
- **Solid/surface**
 - **Decomposed to precise wireframe BREP**
- **Text**
- **Hidden line removal**
- **Silhouette edge generation**



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Geometry Interfaces - STEP, VDAFS

- **PDES/STEP AP203**
 - **Import and export of solid/surface/wireframe data**
- **VDAFS**
 - **Import and export of surface/wireframe data**
 - **Data format that emphasizes surface transfer**
 - **Used predominantly by European automotive industry**

Geometry Interfaces -Stereolithography

- Translates solids into standard “stl” format
- Rapid manufacture for physical part prototyping



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- **MSC/ARIES**
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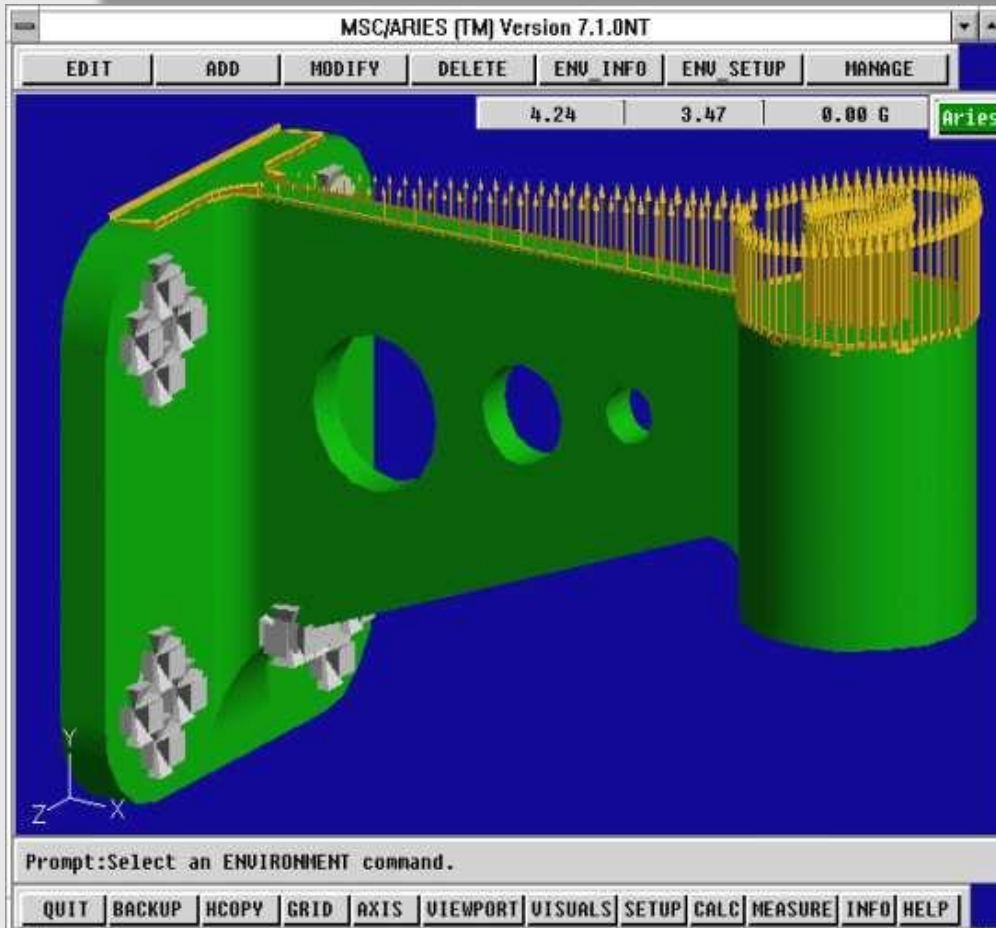


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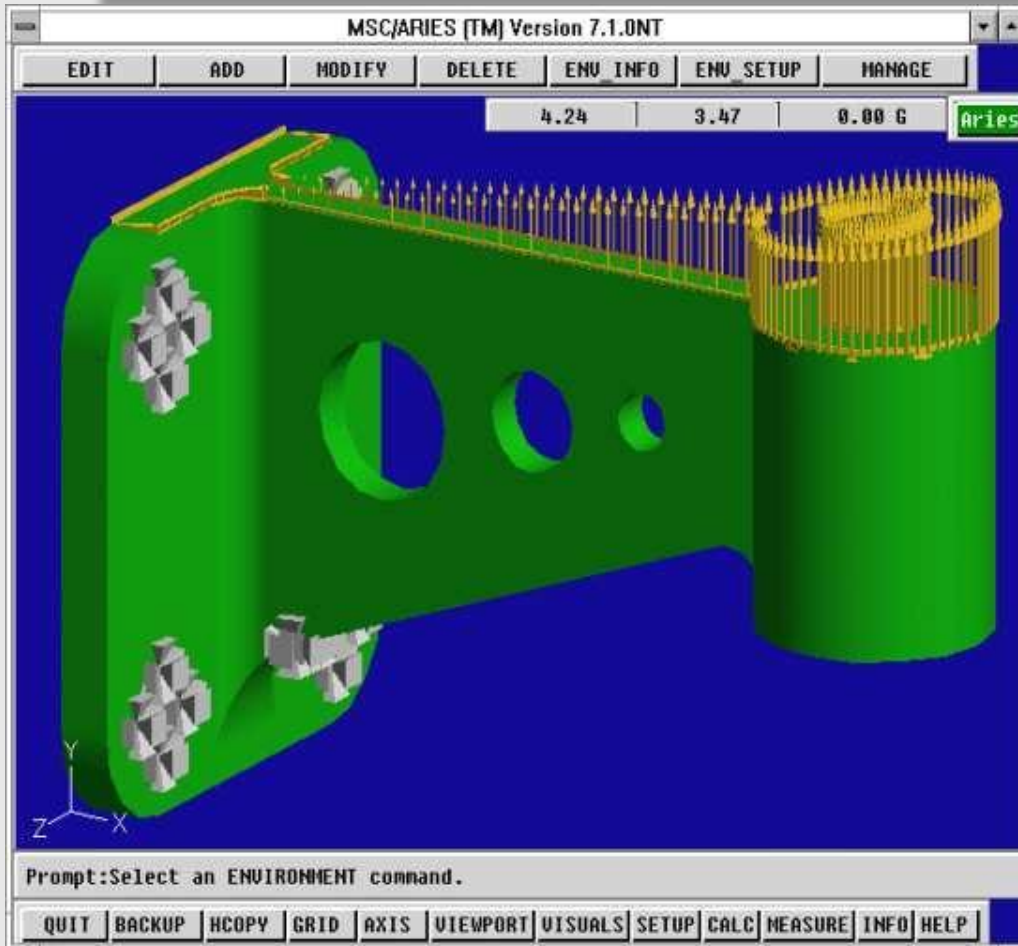


Load and Boundary Conditions



- LBC's applied to geometry or to nodes & elements
- Supported loads
 - Force, moment, pressure
 - Gravity
 - Velocity
 - Translational
 - Rotational
 - Acceleration
 - Translational

Load and Boundary Conditions



- Constant or functional varying magnitude
- Geometry based load and boundary conditions survive geometry change

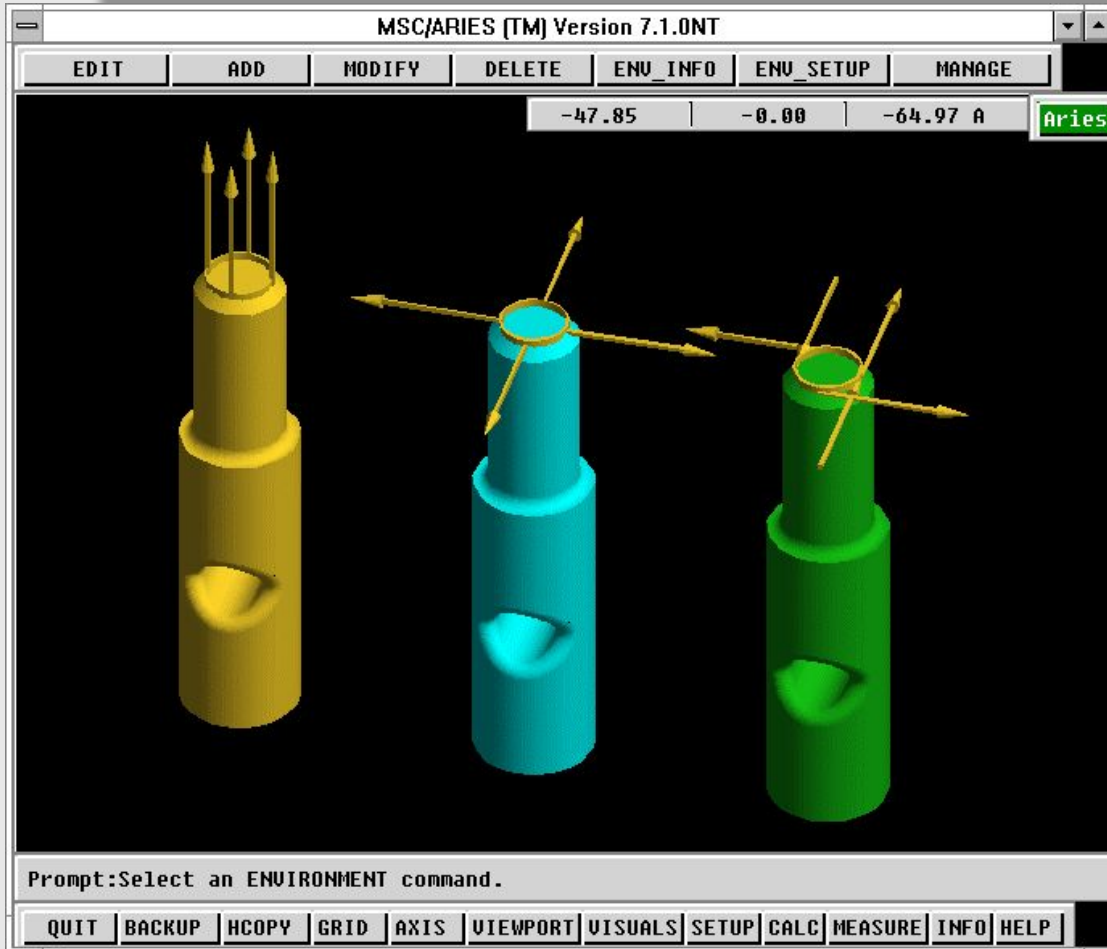


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Load and Boundary Conditions



□ Direction control for load/boundary conditions

- XYZ
- Radial
- Tangential

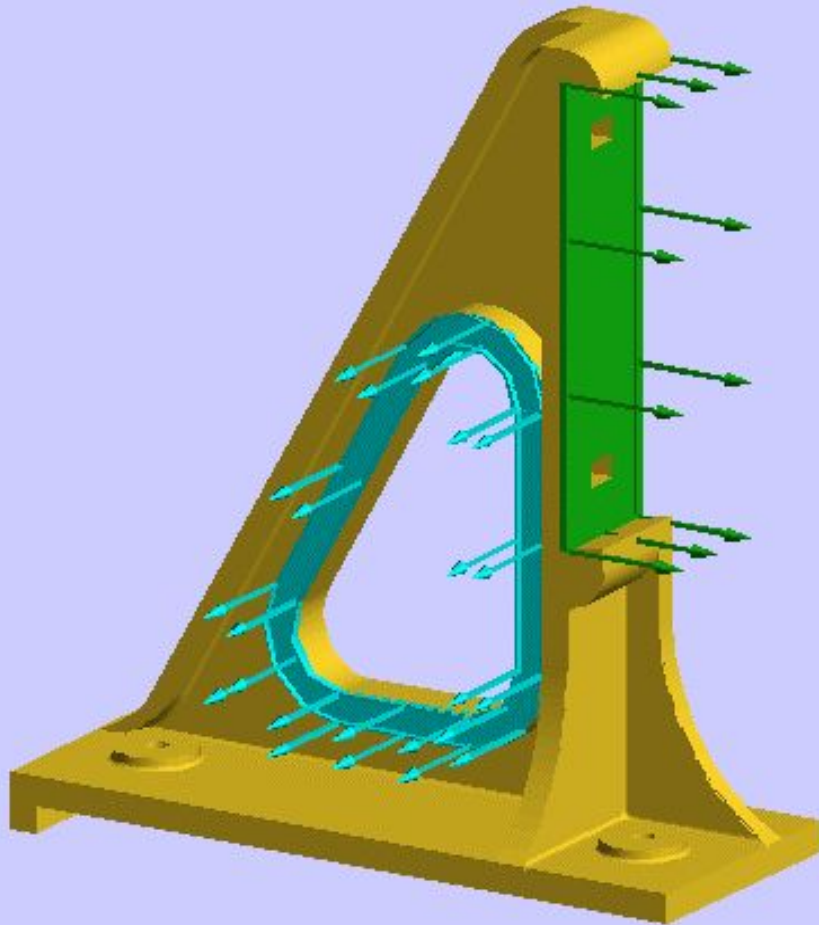


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Load and Boundary Conditions



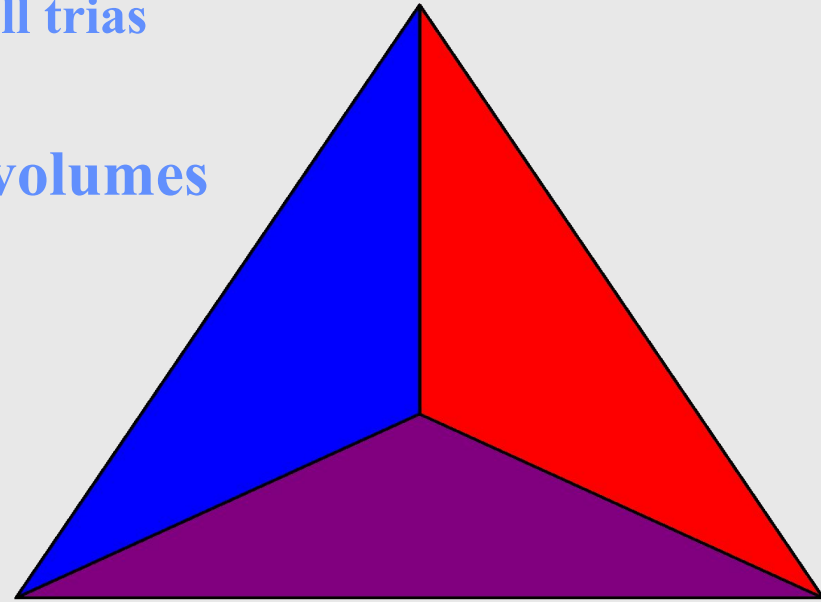
Load case combination

$(5 * \text{load_1}) +$

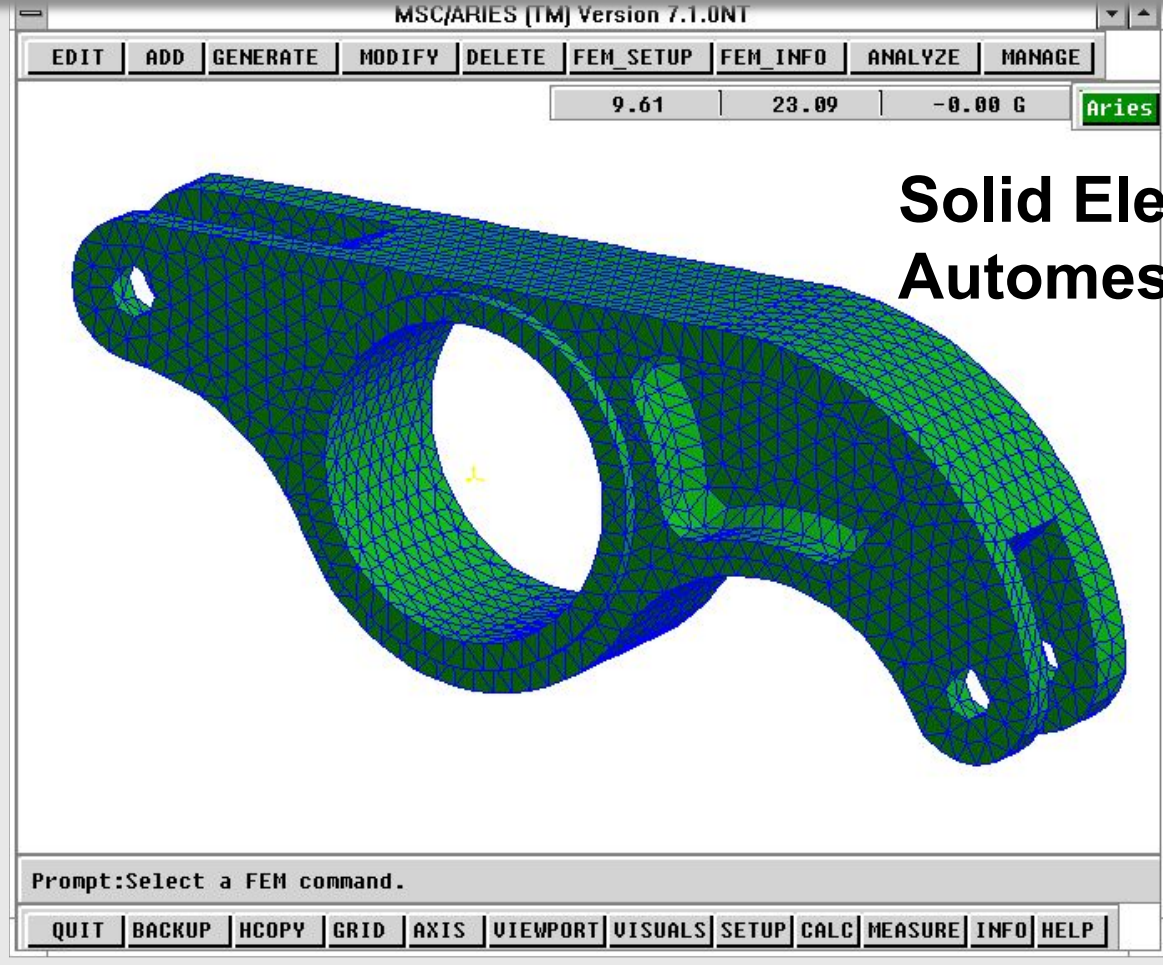
$(3 * \text{load_2})$

FE Meshing

- Automeshing technology
 - Edges -- 1D elements (beam, gap, rigid, spring)
 - Surfaces -- quad dominant or all trias
 - Volumes -- tets only
- Map meshing for surfaces and volumes
 - 3/4 side surfaces, 5/6 face volumes
 - Composite edge support



Auto Meshing



**Solid Element
Automesh**



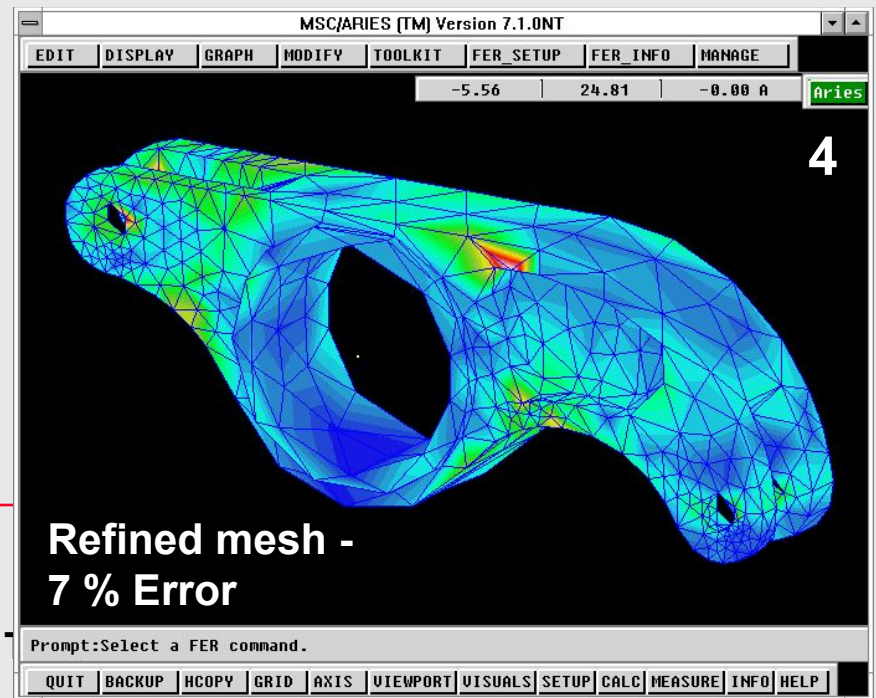
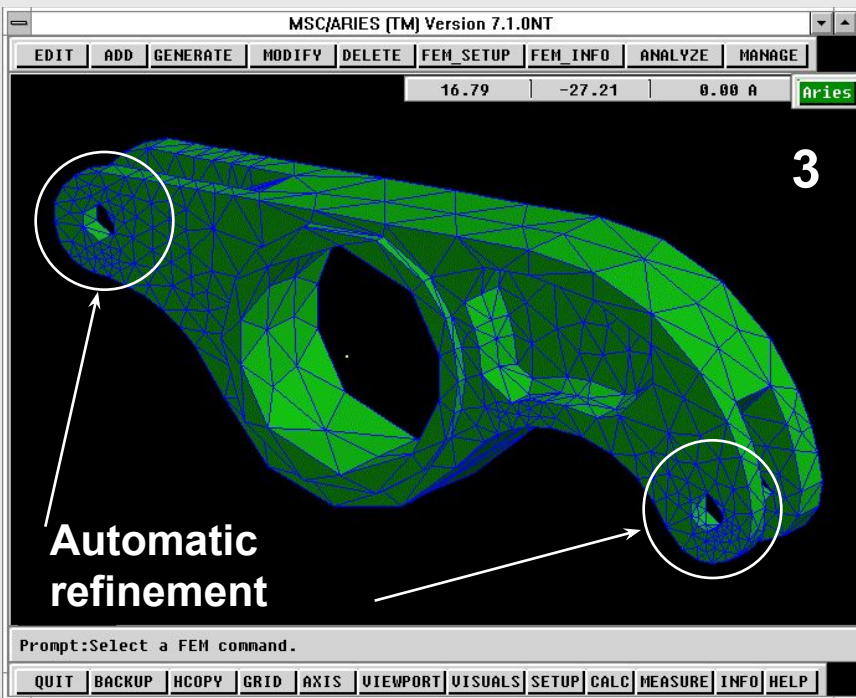
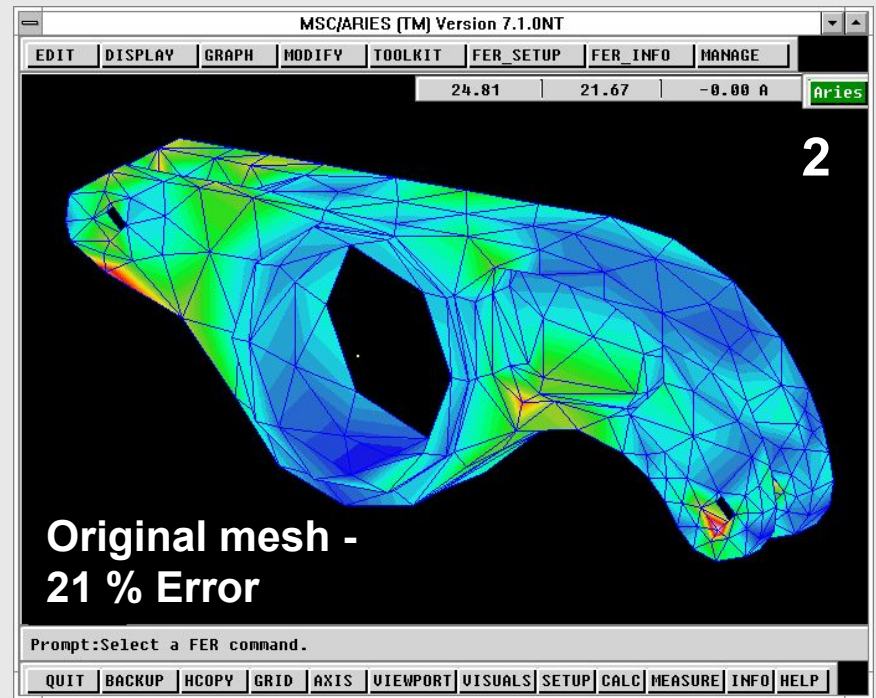
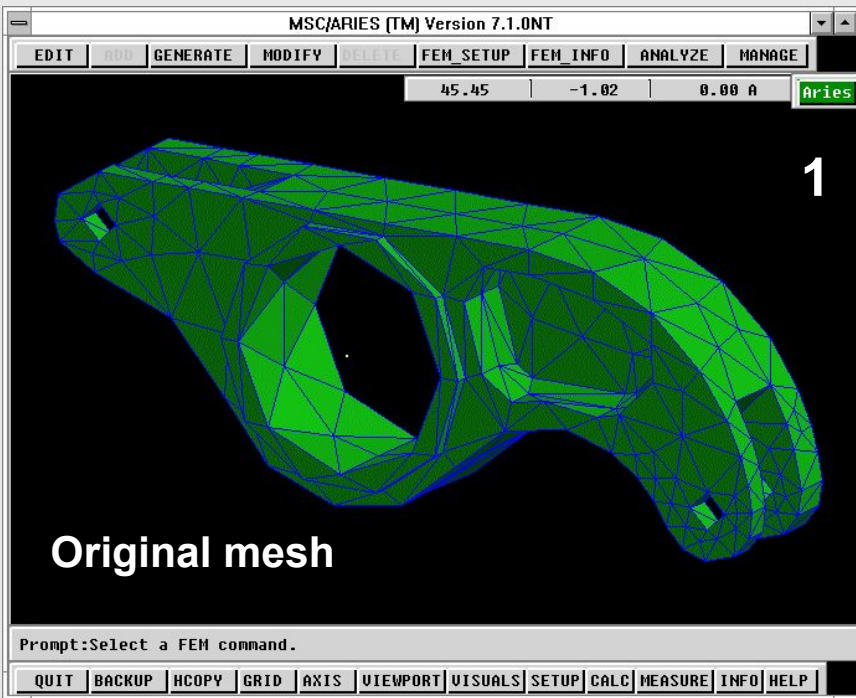
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FE Meshing

- **Adaptive mesh refinement**
 - Automatic mesh refinement to optimize mesh density
 - Use with automatically generated h or p meshes
 - Global or local refinement
 - New mesh density based on current error versus target error
- **Reduces mesh density related errors**



FE Meshing

- ◆ Direct creation of nodes/elements
- ◆ Extrude/revolve 1D to 2D, 2D to 3D

- ◆ Mirror
- ◆ Mesh editing

- ◆ Element quality checks
- ◆ Merge node

- ◆ Auto MPC connection of meshes between linear or quad tets to linear hex



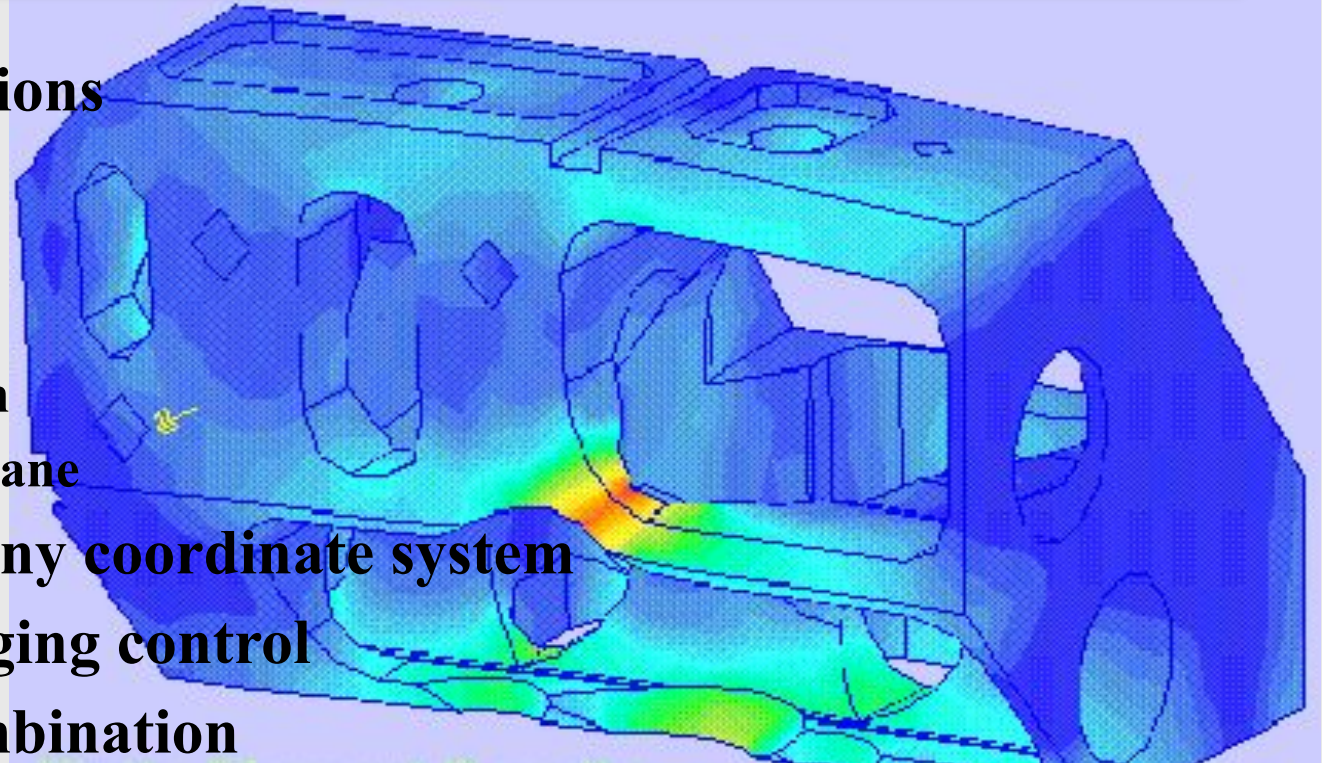
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Results Review

- **Display options**
 - Vector
 - Contour
 - Graph
 - Animation
 - Cutting plane
- **Results in any coordinate system**
- **Data averaging control**
- **Results combination**
- **Error calculation**



Linear Statics

- **Loads constant with time**
- **Material assumed linear and perfectly elastic**
- **Results calculated**
 - **Stress**
 - **Displacement**
 - **Strain**
 - **Strain energy**
 - **Reaction force**

Normal Modes

- ❑ **Calculates undamped natural modes of vibration**
- ❑ **Material assumed linear and perfectly elastic**
- ❑ **Results calculated (normalized)**
 - **Stress**
 - **Displacement**
 - **Strain**
 - **Strain energy**
 - **Reaction force**

Linear Buckling

- **Calculates load factor for critical buckling**
- **Material assumed linear and perfectly elastic**
- **Results calculated**
 - **Stress**
 - **Displacement**
 - **Strain**
 - **Strain energy**
 - **Reaction force**

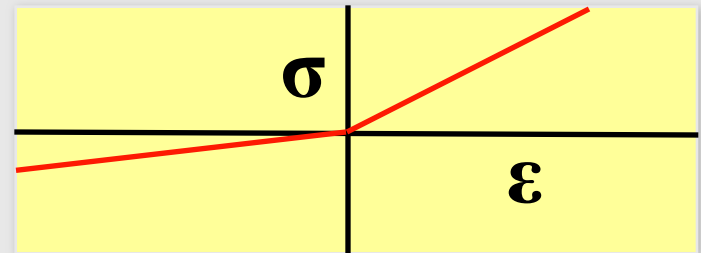
Non-Linear Statics

□ Geometric non-linearity

- Change in stiffness associated with large deformations
- Load follows deformed shape

□ Material non-linearity

- Bi-linear elastic/plastic with plastic strain, or
- Non-linear elastic, no plastic strain
 - Compressive/tensile stress-strain curves can be different



Non-Linear Statics

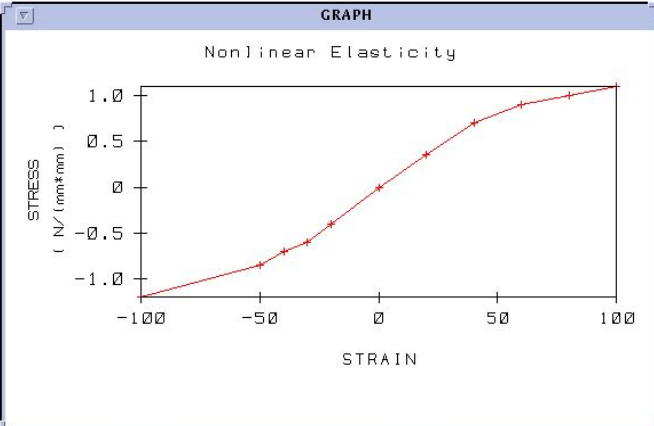
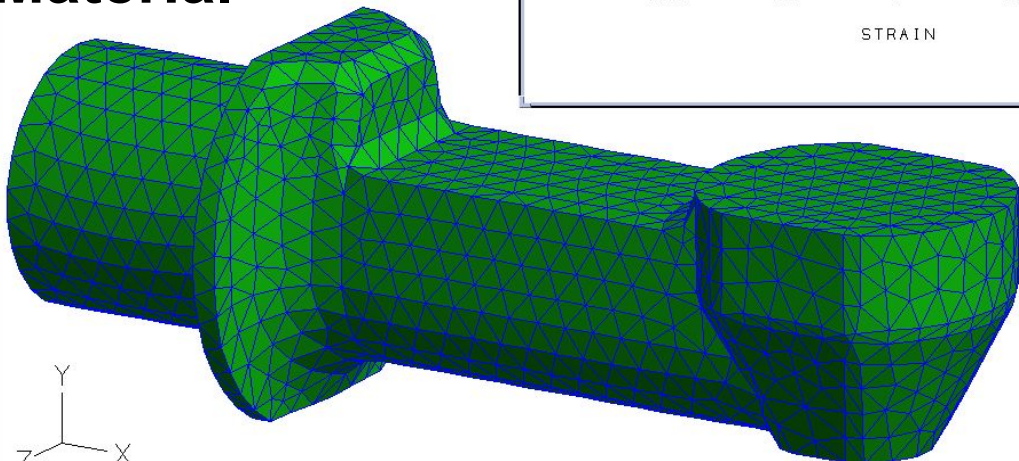
EDIT DELETE MANAGE

GRAPH_MANAGER 7.59 45.88 0.00 A Aries

DELETE_GRAPH

CREATE_GRAPH

Non-linear Elastic Material



Prompt: Select a GRAPH command.

QUIT | BACKUP | HCOPI | GRID | AXIS | VIEWPORT | VISUALS | SETUP | CALC | MEASURE | INFO | HELP

STRAIN	STRESS (N/(mm ² mm))
-100	-1.0
-75	-0.8
-50	-0.6
-25	-0.4
0	0.0
25	0.4
50	0.7
75	0.9
100	1.0



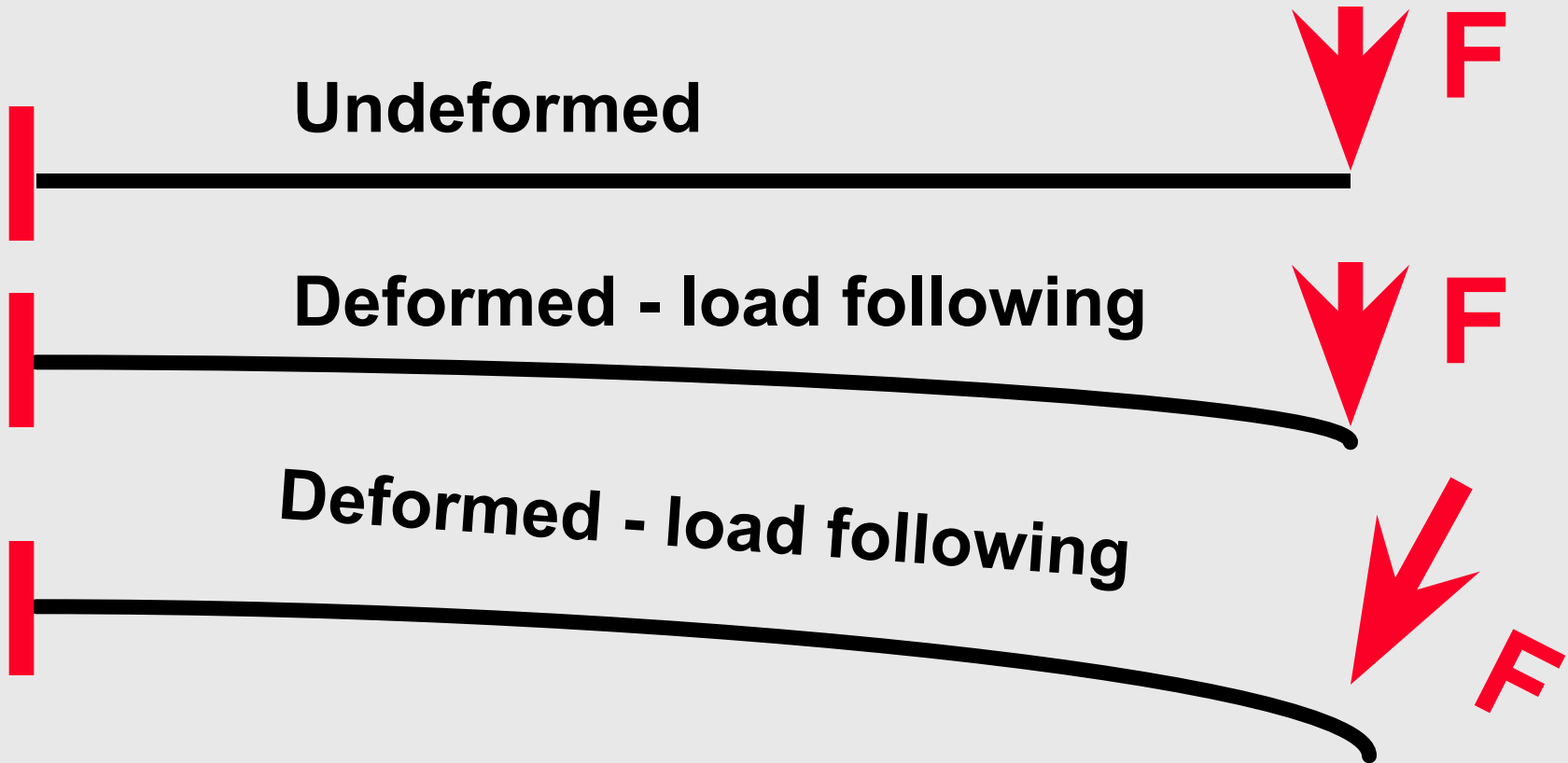
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Structures-2 Non-Linear Statics

Load Following



Linear Transient Dynamics

- Time varying geometry and finite element loads
- Structural and modal damping
- Results calculated for each time step
 - Stress
 - Displacement
 - Strain
 - Velocity
 - Acceleration
 - Reaction force



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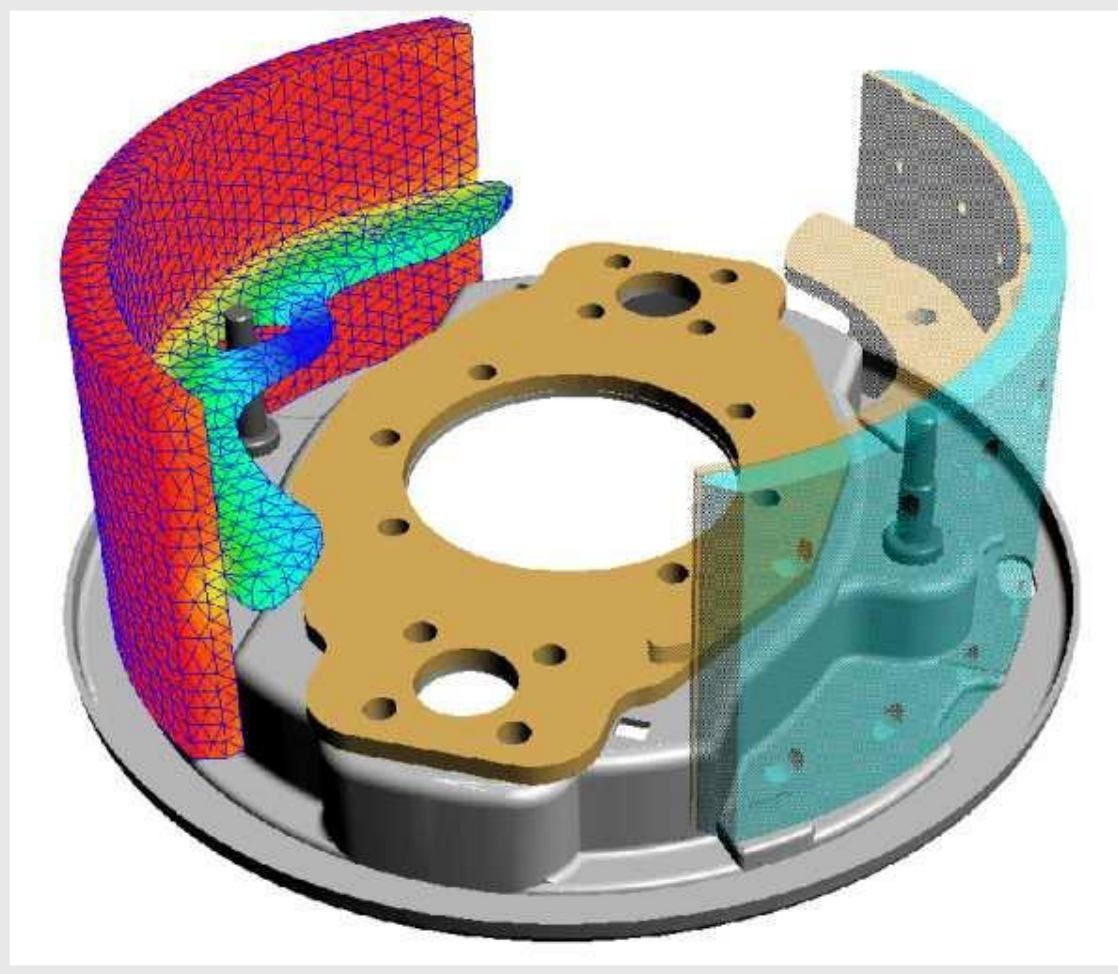
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Heat Transfer

- **Steady state and transient linear and non-linear heat transfer**
- **Heat transfer modes**
 - **Conduction**
 - **Free convection**
 - **Forced convection**
 - **Radiation**
- **Temperature and time dependent**
 - **Heat flux**
 - **Mass flow rate**

Heat Transfer

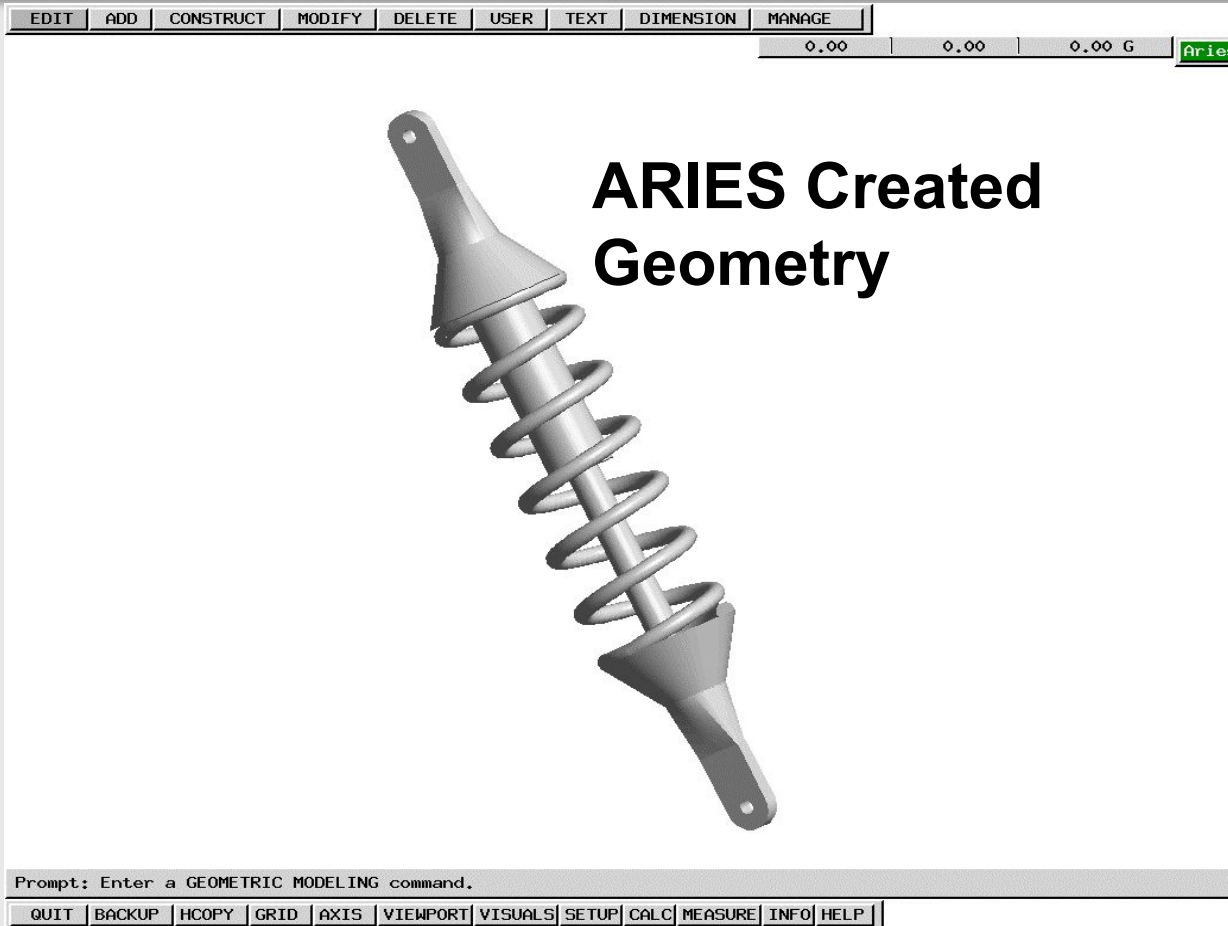


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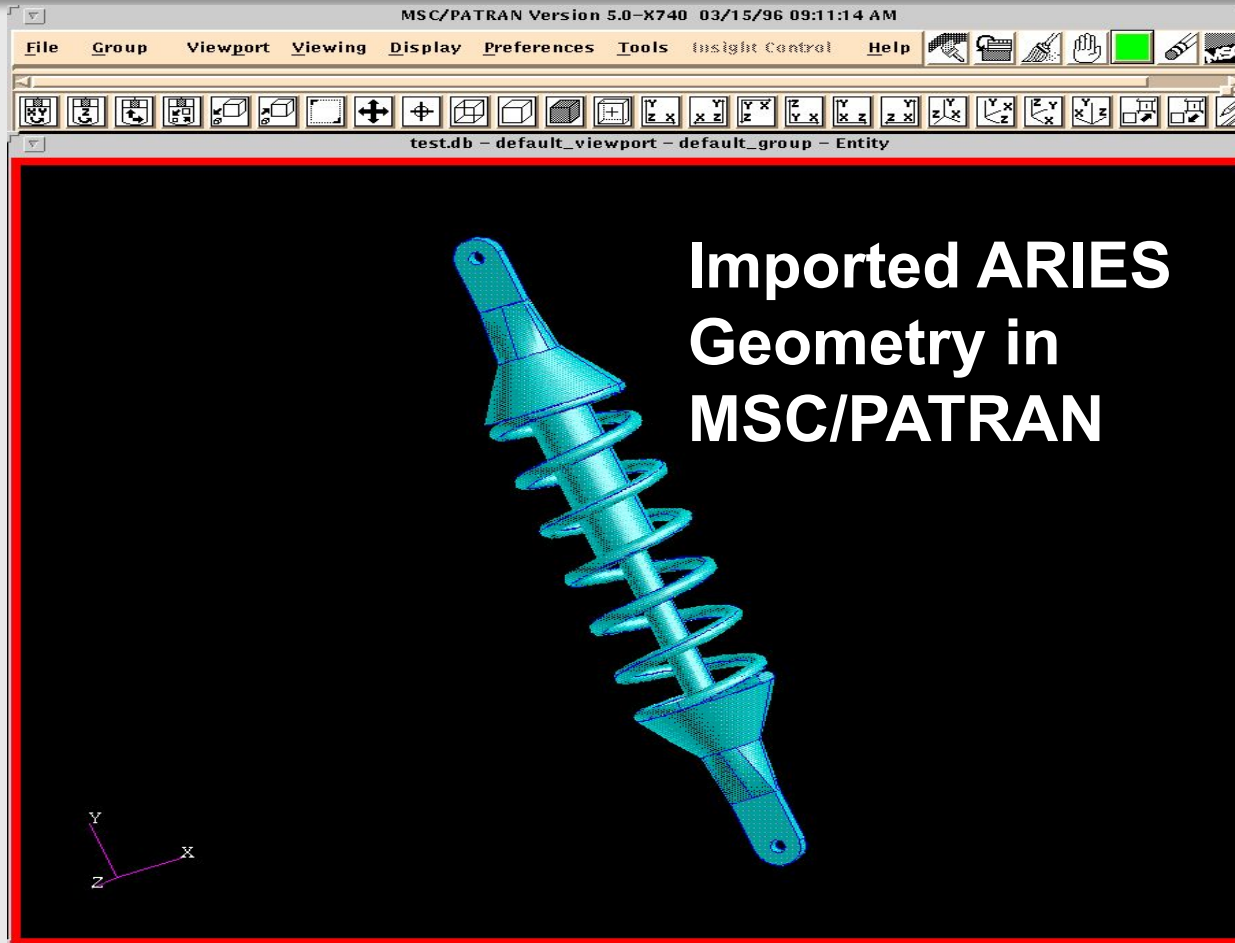


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Optimization

An Automated Process That:

- Satisfies Your Design Objective
- Within Design Constraint(s)
- By Modifying Design Variables



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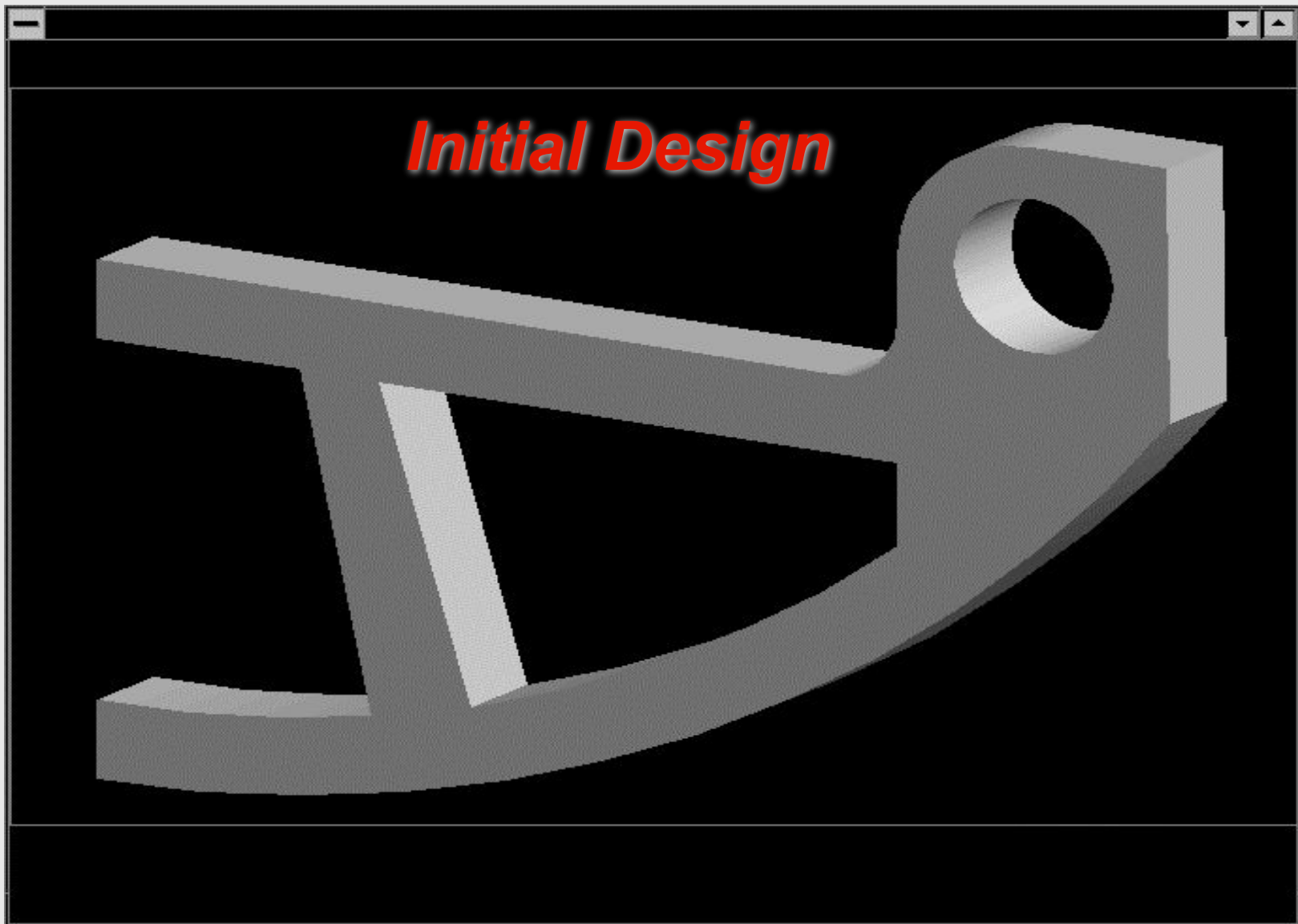


Optimization - Overview

- **1 Design Objective**
 - minimize/maximize weight, frequency, load factor
- **'n' Design Constraints - local and or global**
 - min/max stress, displacement, freq, load factor
- **'n' Design Variables**
 - Dimensional variables
 - Element shell thickness, Non Structural Mass
- **Solve multiple constraints simultaneously**
 - Linear statics (with multiple load cases)
 - Modal (per mode shape max/min control)
 - Buckling analysis

Optimization - Overview

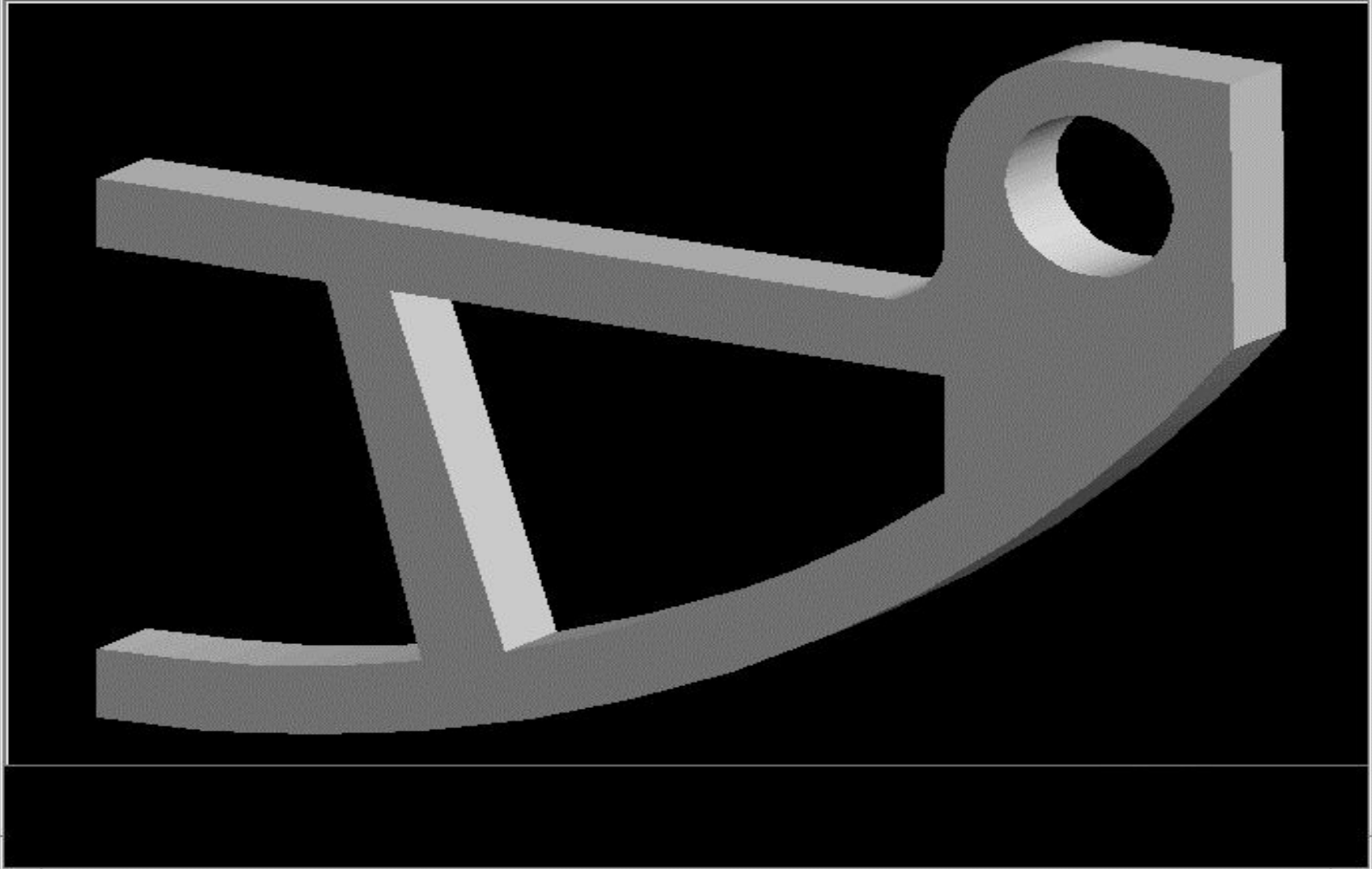
- **Shape**
 - Geometry dimensions as design variables
- **Sizing (element properties)**
 - Shell thickness, non-structural mass
- **Design sensitivity**
 - Effect of a change in a design variable on
 - Design Objective, Design Constraint(s)
- **Shape and sizing can be combined**



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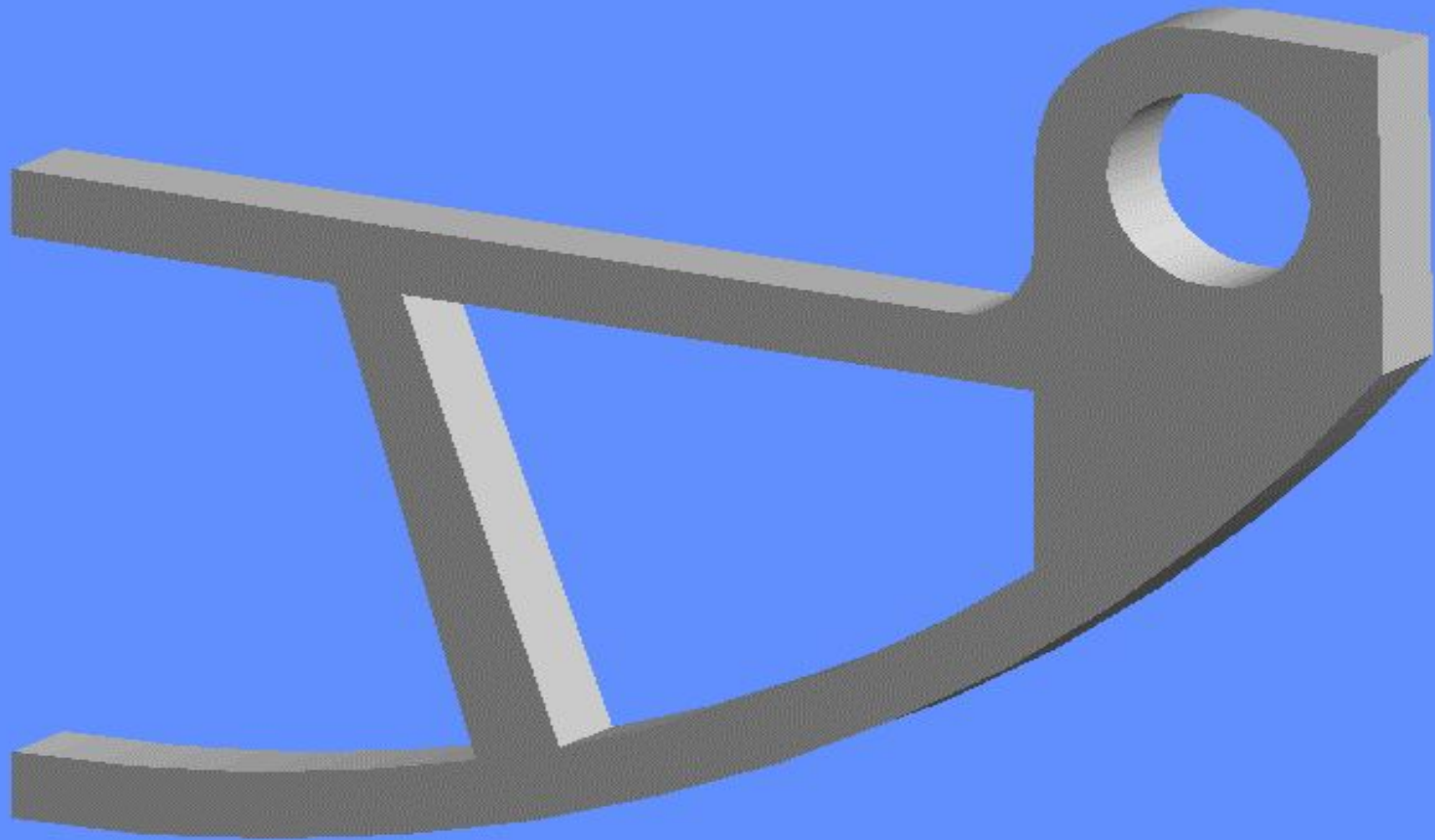




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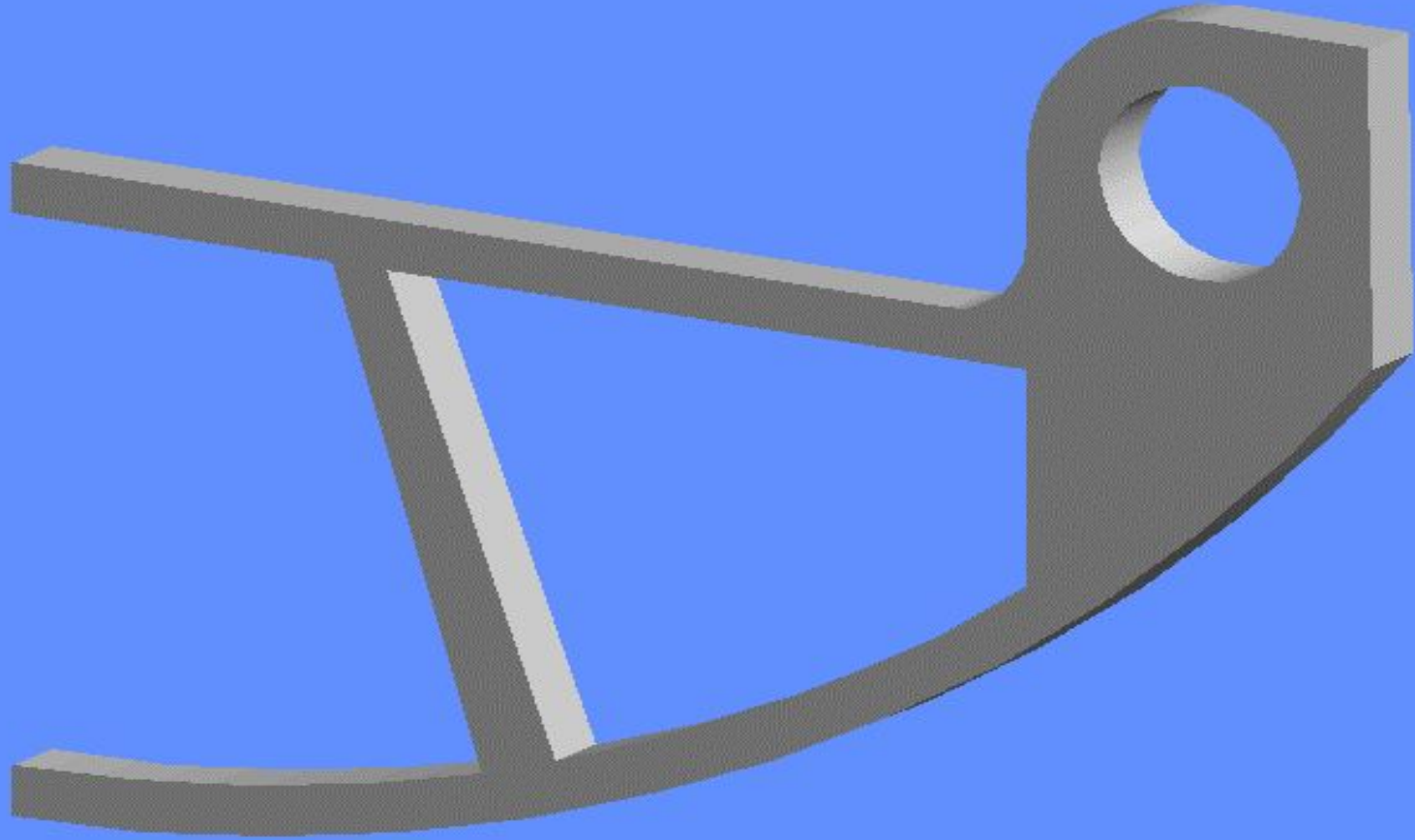




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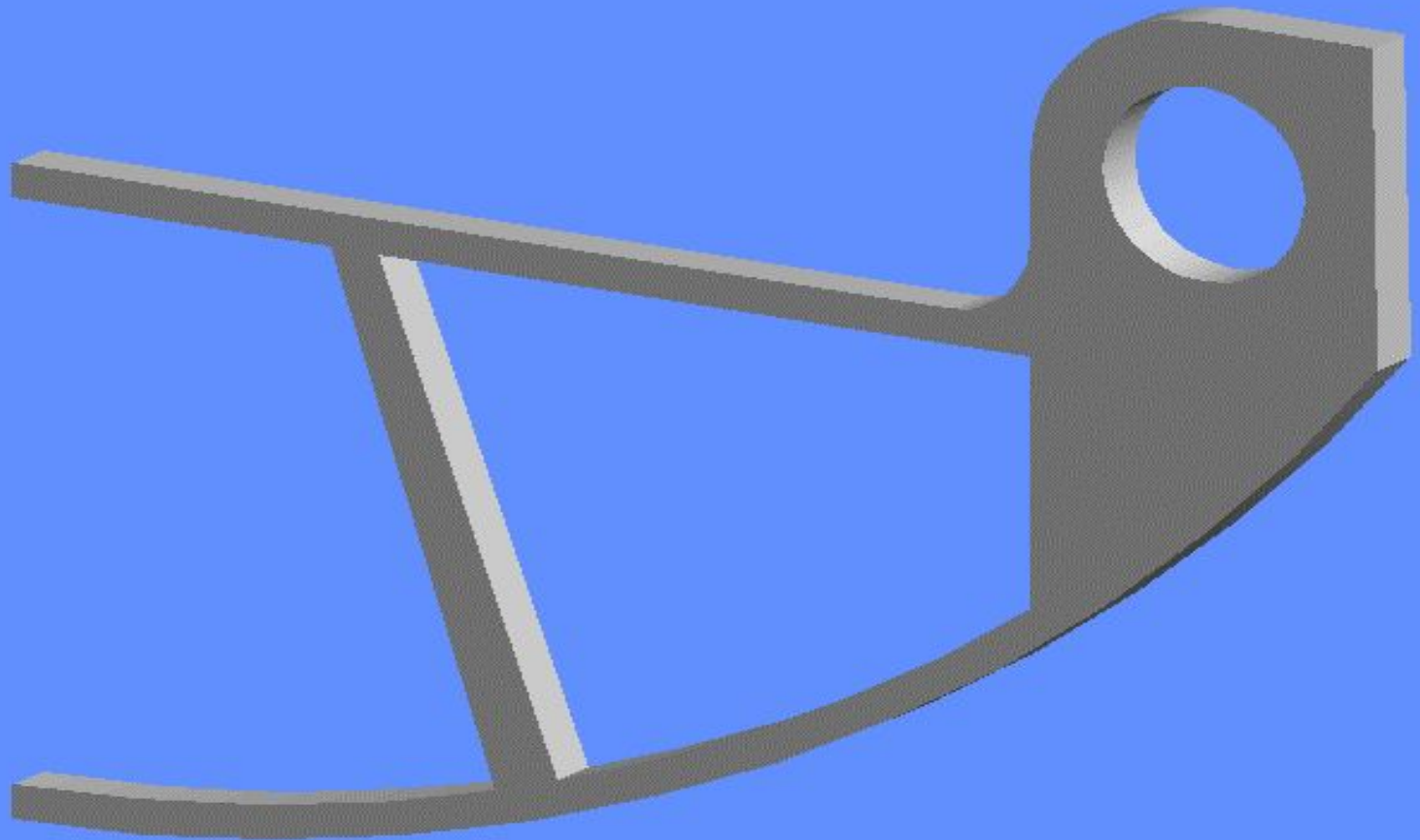




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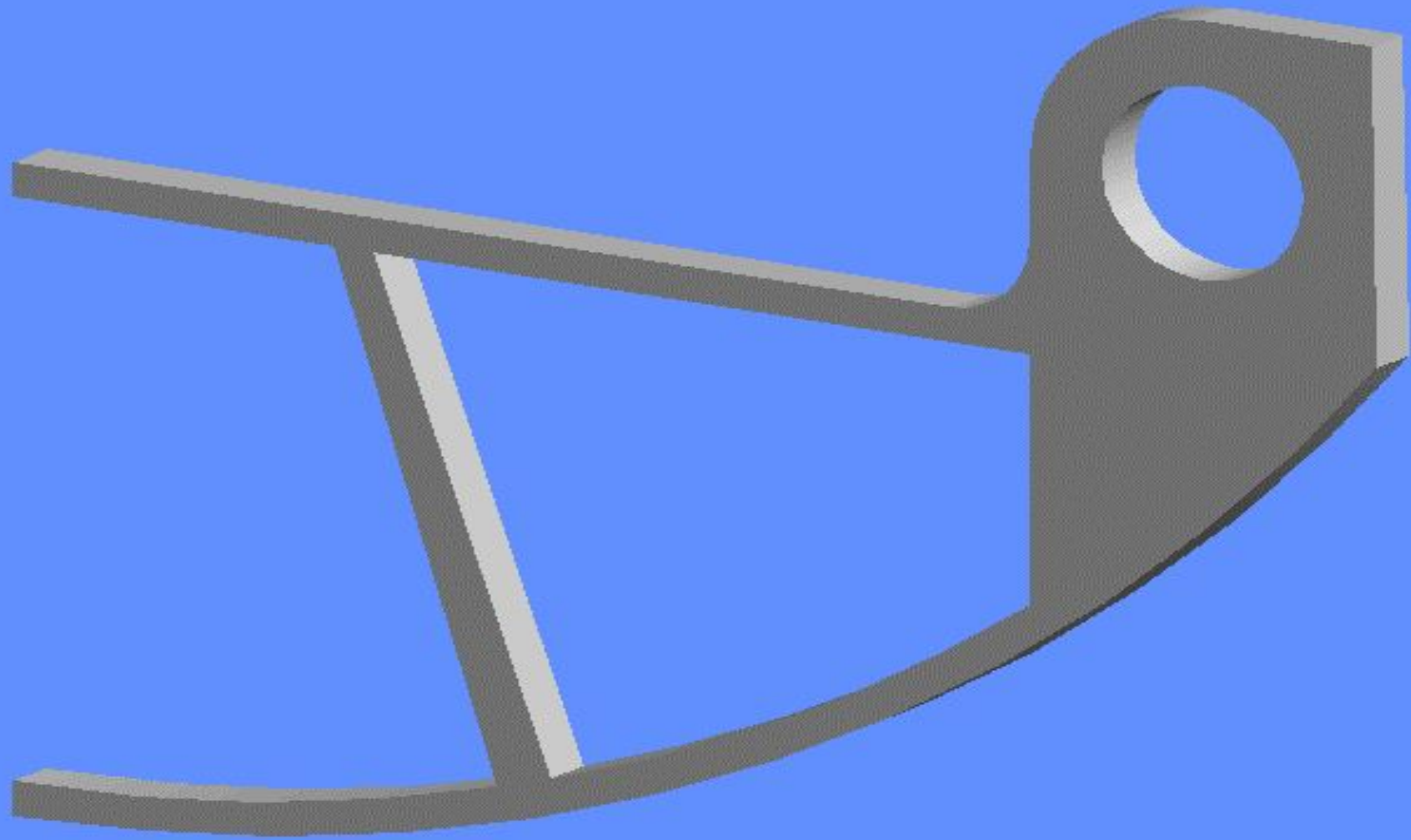




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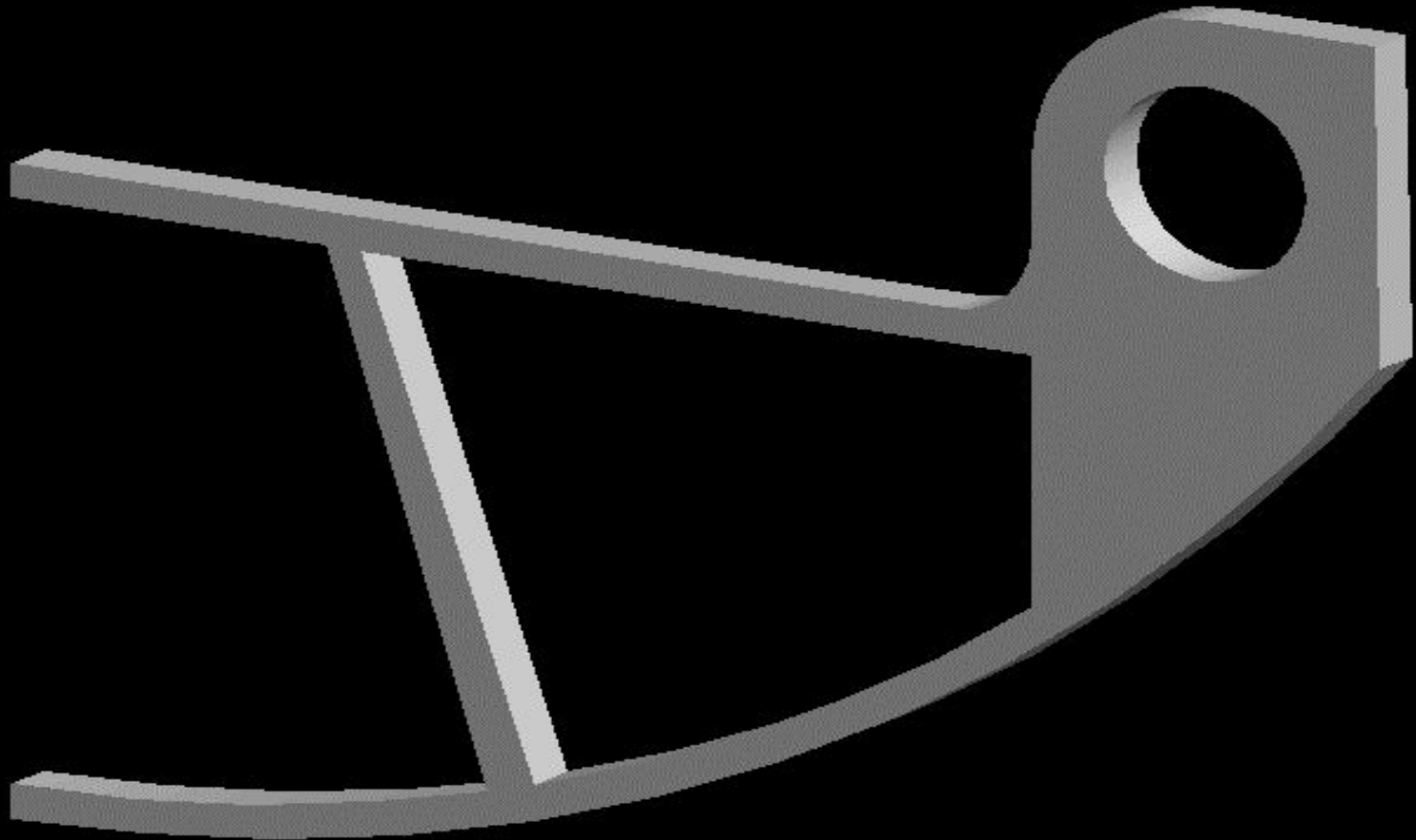




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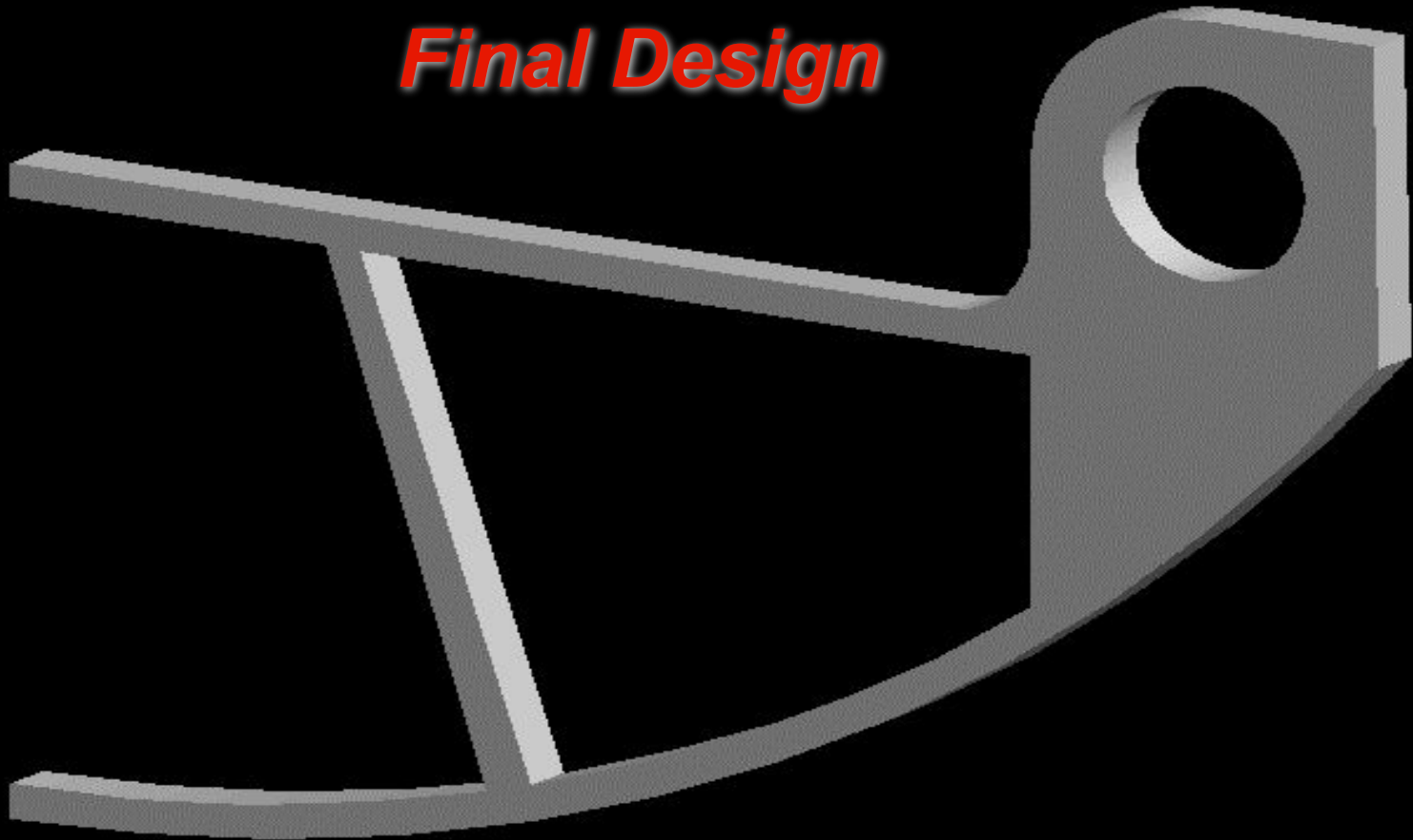


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Final Design



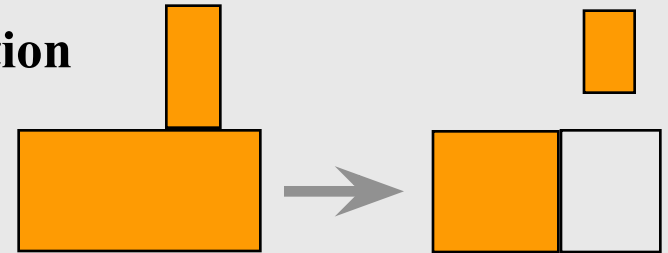
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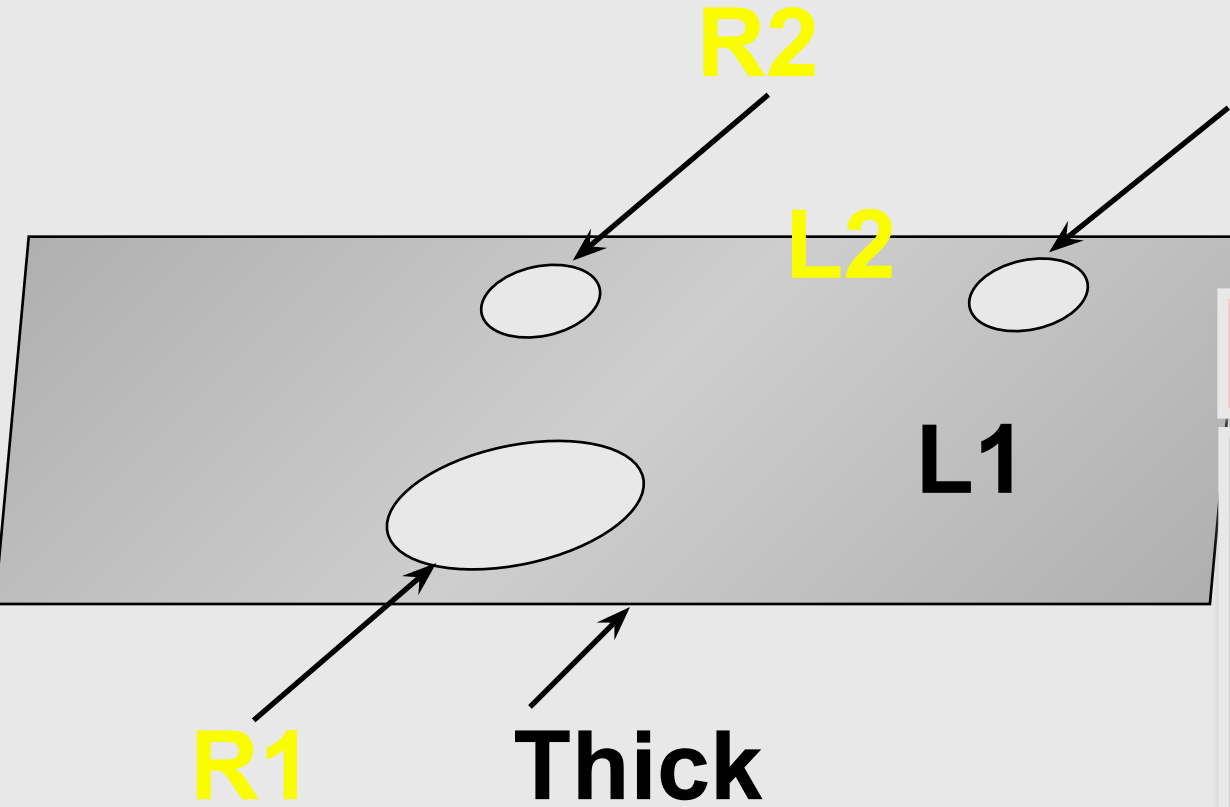
Optimization - Application

- **Build solid or surface geometry**
- **Associate dimension variables in Parametrics:**
 - Use as design variables for Optimization
 - Maintain design intent
- **(Parameterize using DRP)**
 - Maintain design intent
- **(Attach DRP model(s) to solids in Parametrics)**



Optimization - Application

- Create finite element model
- Select Optimization application
 - 1 Design Objective minimize/maximize:
 - weight, frequency, load_factor
 - ‘n’ Design Constraints - local and/or global min/max stress, disp, freq, load factor
 - ‘n’ Design Variables
 - Dimensional,
 - Shell thickness, Non Structural Mass



DRP Model	
<i>DEP</i>	<i>INDEP</i>
R1	= 2 x R2
R2	= R3
L2	= R1 x 3

Selecting Design Variables



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Optimization - Results Review

- **Post process in Optimization application**
 - Graph design objective/ constraint(s)/ variable(s) against design cycle
 - Display geometry at intermediate design cycles
- **Review results of final design in FE_Results**
 - Standard results review process
 - Animate between FE models across design cycles

P-ELEMENTS



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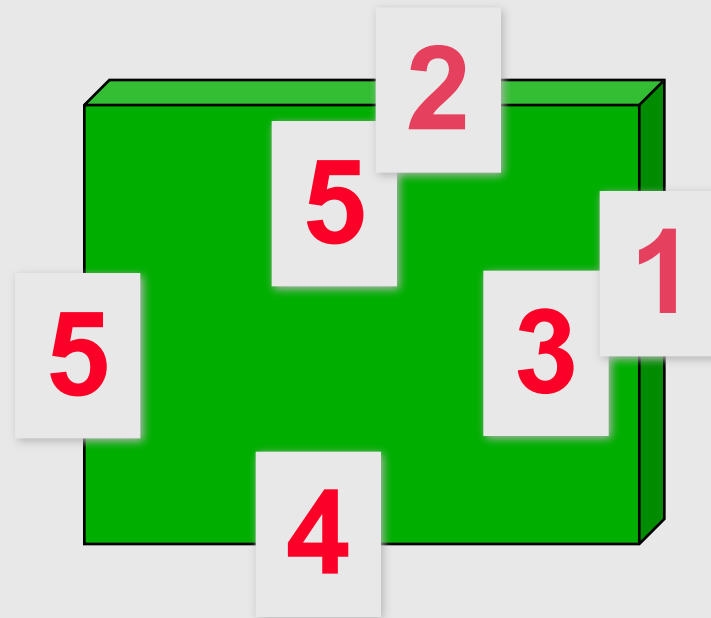


P-Elements - Overview

- **Automatically increases element's shape function polynomial order during solution until convergence**
- **Convergence based on per element strain energy difference between p-order changes**
- **Mesh remains unchanged**

P-Elements - Overview

- Each edge of each element has its p-order independently controlled in MSC/NASTRAN



P-Elements - Application

- **Supported element types**
 - **Tetrahedron**
 - **Brick**
 - **Pentahedron (wedge)**
- **p-order min/max control**
 - **Recommended p-order range 3-10**
- **Adaptivity automatically turns off below specified von Mises stress or strain minimum**
 - **Turns off adaptivity for elements where stress and or strain is negligible**
 - **Reduces CPU time and system resources**

P-Elements - Application

- Can mix h and p elements

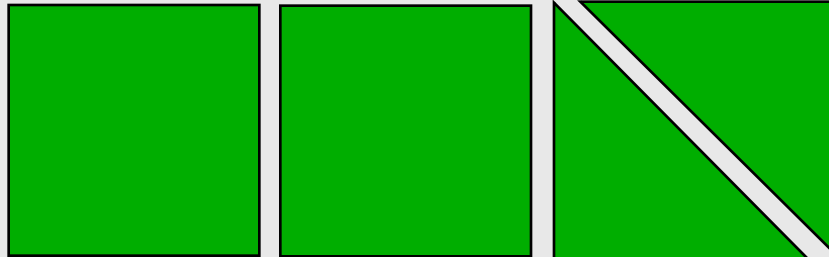


Constrains
shared edges
to p-order = 1

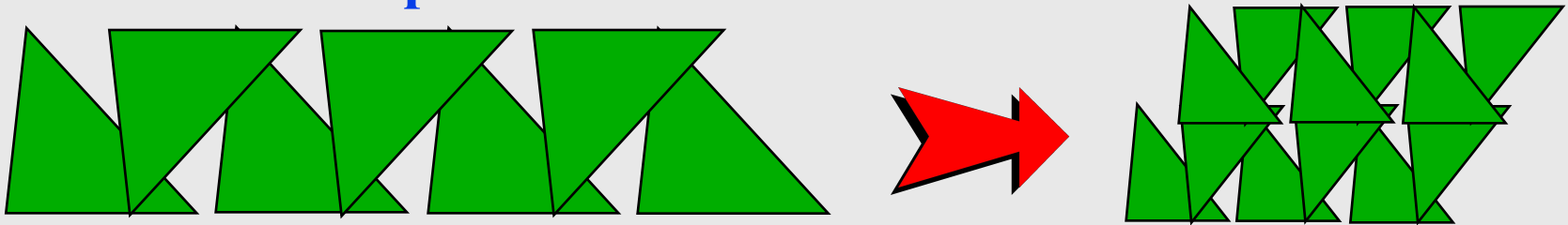
- Use p-elements in areas where high accuracy required, h-elements elsewhere

P-Elements - Application

- Hex to tet mesh connection works identically for p-elements:



- Automatic (h-adaptive) mesh refinement supported for automeshed p-elements



- Uses **ERROR DATASET** calculated from **FER TOOLKIT** error estimation

P-Elements - Results Review

- p-element results review identical to h-elements
- Can display final p element order contours



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AGENDA

- **Geometry**
- **FE Analysis**
- **Optimization**
- **Mechanisms**
- **Plastics**
- **MSC/ARIES**
Positioning



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Mechanisms

- **Two- and three-dimensional mechanism modeling analysis and results review**
- **Uses MDI/ADAMS Kinematics solver**
- **Solves motion of fully constrained (0 DOF) kinematic systems i.e. the motion of the system is completely constrained by applied motion(s) and joint constraints**



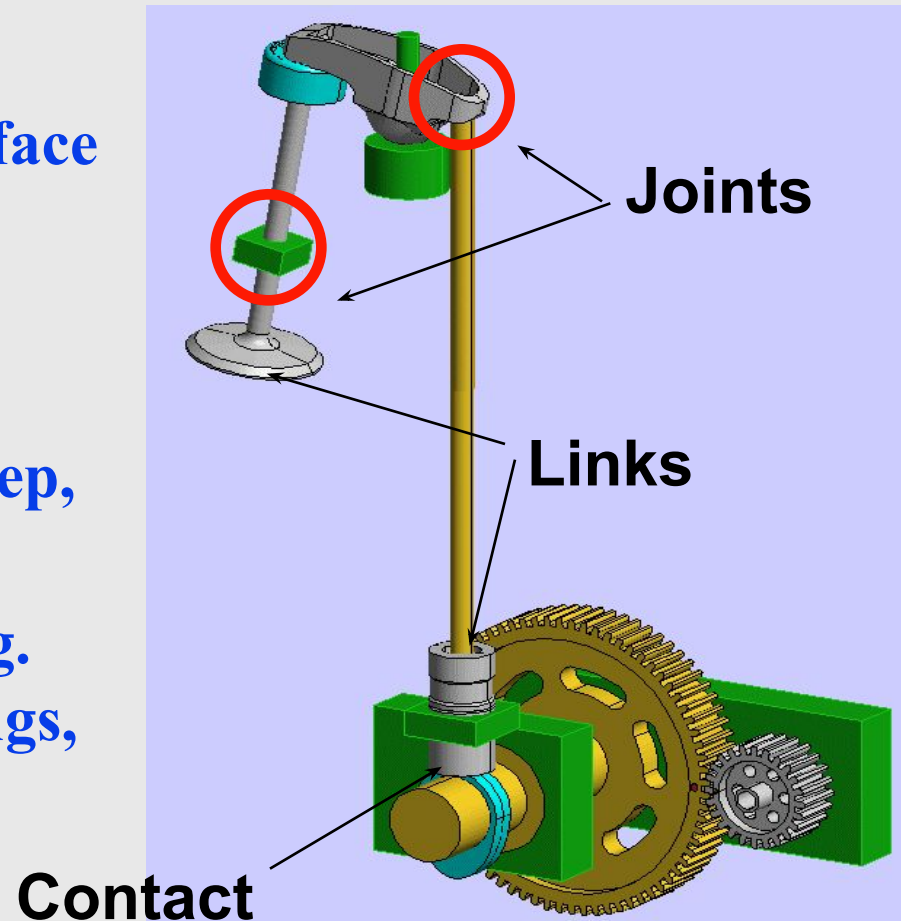
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Mechanisms Pre Processing

- Create link geometry
- Geometry can be solid, surface or wireframe
- Add joints (supports all MDI/ADAMS joints)
- Add constant, harmonic, step, random motion
- Add motion constraints (e.g. cams), applied forces, springs, gravity
- Solve



Mechanisms Results Review

- ❑ **Animated motion of links**
- ❑ **Motion path of any point**
- ❑ **Joint reaction force/moment**
- ❑ **Rotational/translational link displacement, velocity, acceleration**
- ❑ **Clearance/interference between links**
- ❑ **Results interrogation in local static/dynamic coordinate system**

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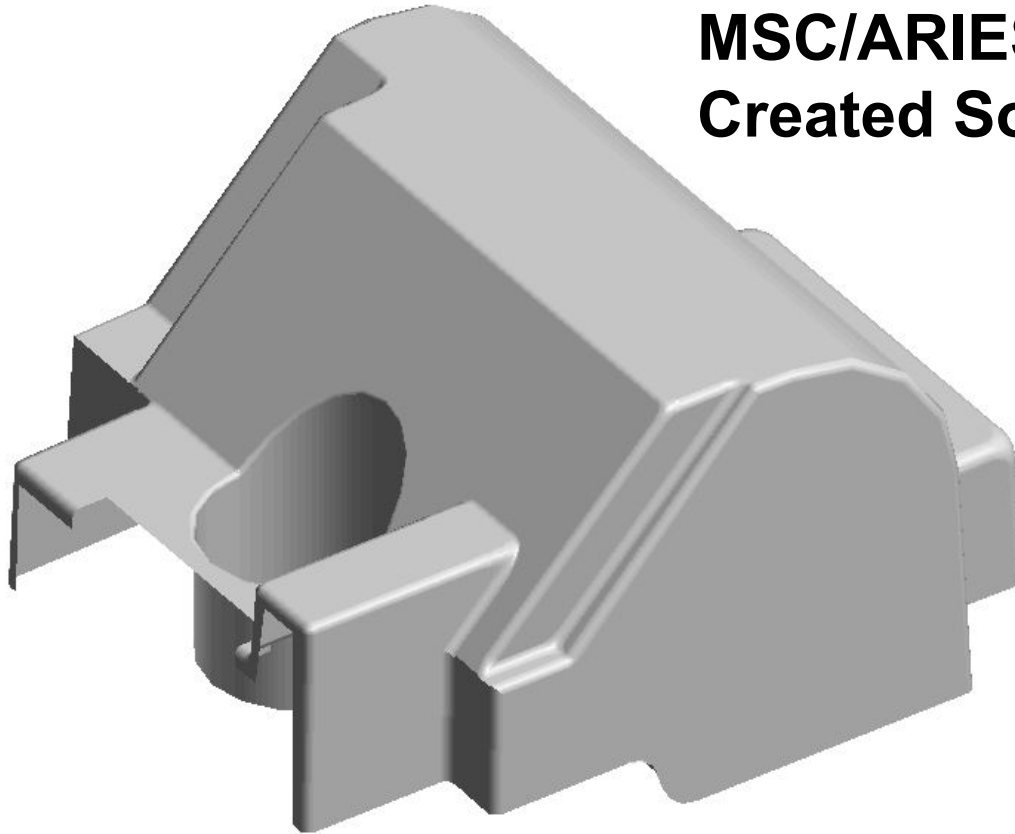
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Plastics

- 3D mold fill analysis
- Uses Moldflow/Flowcheck solver
- Solves “Will It Fill”
 - Fast analysis to calculate areas of fill / no-fill / possible fill
 - Experiment with number of injection points/ location, material and part thickness
- Solves “Fill_Pattern”
 - Fill time
 - Air trap location
 - Weld line locations

Plastics



**MSC/ARIES
Created Solid**

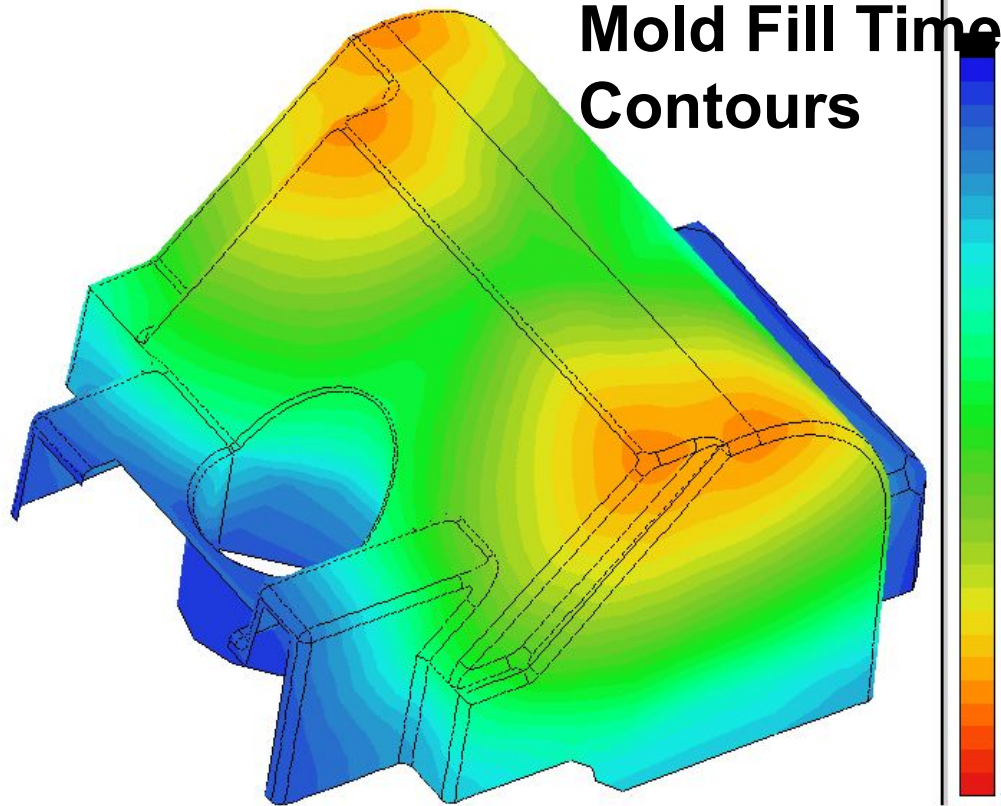


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Plastics



CONTOURS	
TIME	
sec	
1.03414E+00	
1.00280E+00	
9.71462E-01	
9.40125E-01	
9.08787E-01	
8.77450E-01	
8.46112E-01	
8.14775E-01	
7.83438E-01	
7.52100E-01	
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3.44712E-01	
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2.82037E-01	
2.50700E-01	
2.19363E-01	
1.88025E-01	
1.56687E-01	
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CONFIGURATION



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Modular Configuration

OPTIONAL MODULES

STRUCTURES - 1

STRUCTURES - 2

HEAT TRANSFER

MECHANISMS

PLASTICS

GEOMETRY INTERFACE - IGES

GEOMETRY INTERFACE - STEP AP203

GEOMETRY INTERFACE - VDAFS

GEOMETRY INTERFACE - CATIA

GEOMETRY INTERFACE -
STEREOLITHOGRAPHY

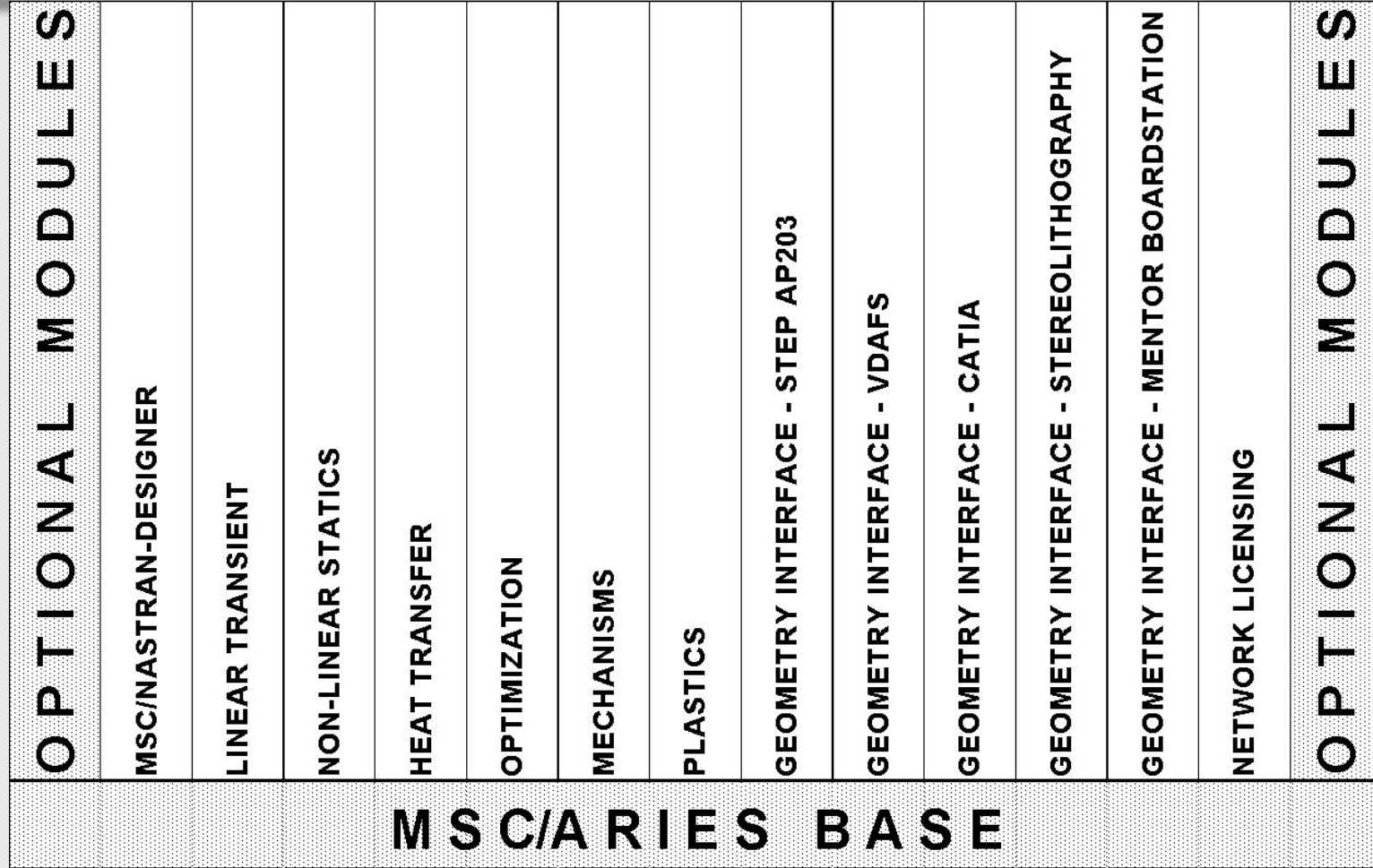
GEOMETRY INTERFACE - MENTOR
BOARDSTATION

NETWORK LICENSING

OPTIONAL MODULES

M S C / A R I E S B A S E

Modular Configuration



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MSC/ARIES Base

MODULE

DESCRIPTION

Geometry	ACIS Based solid, surface, wireframe part and assembly modeling
Parametrics	Parameterization of solids and surfaces
Design Rule Processor	Linear and non-linear equation solver. Solid and surface feature relationships
Mass Properties	Mass properties of parts and assemblies
Materials	Structural and thermal material properties manager
Markup	Part and assembly annotation
Geometry Interface - ACIS	Import and export of solid, surface, wireframe via ACIS sat and sab format
Geometry Interface - MSC/PATRAN	Export of solid, surface, wireframe via PATRAN Express format
Geometry Interface - DXF	Export of solid, surface, wireframe via DXF format
HPGL Plot Driver	HPGL pen plotter driver
Printer Drivers	Printer drivers and tiff, gif, ppm, epsf, raster formats
Graphics Accelerators	Hardware graphics accelerators - Sun Solaris, SGI, HP, IBM
FE Modeler	FE pre and post
FEM Preference - MSC/NASTRAN	MSC/NASTRAN preference for all Structures-1 and Structures-2 analysis types
FEM Preference - MSC/PATRAN	MSC/PATRAN preference for Lin. Statics and Normal Modes. PATRAN neutral format



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Optional Modules

MODULE	DESCRIPTION
Structures-1	Integrated MSC/NASTRAN solver: Lin. Statics, Normal Modes, Lin. Buckling, Optimization Unlimited Model Size, Interlock Check=ON
Structures-2	Integrated MSC/NASTRAN solver: Nonlinear Statics, Lin. Transient Dynamics, Unlimited Model Size, Interlock Check=ON
Heat Transfer	Integrated MSC/NASTRAN solver: Heat Transfer, Unlimited Model Size, Interlock Check=ON
Mechanisms	Mechanism Modeler (i.e. Pre and Post), Integrated MDI ADAMS Kinematics solver
Plastics	Integrated Moldflow FLOWCHECK solver: Will It Fill, Fill Pattern
Geometry Interface - IGES	Import and export solid, surface, wireframe via IGES standard
Geometry Interface - STEP AP203 (pre-release)	Import and export solid, surface and wireframe via STEP AP203, Part 42 standard
Geometry Interface - VDAFS (pre-release)	Import and export surface, wireframe via VDAFS standard
Geometry Interface - CATIA	Import surface, wireframe via CATIA Export format
Geometry Interface - Stereolithography	Export solid, surface via stl format
Geometry Interface - Mentor BoardStation	Import and export Mentor BoardStation PCB's via IDF format
Network Licensing	Floating network license for MSC/ARIES Base and all optional modules

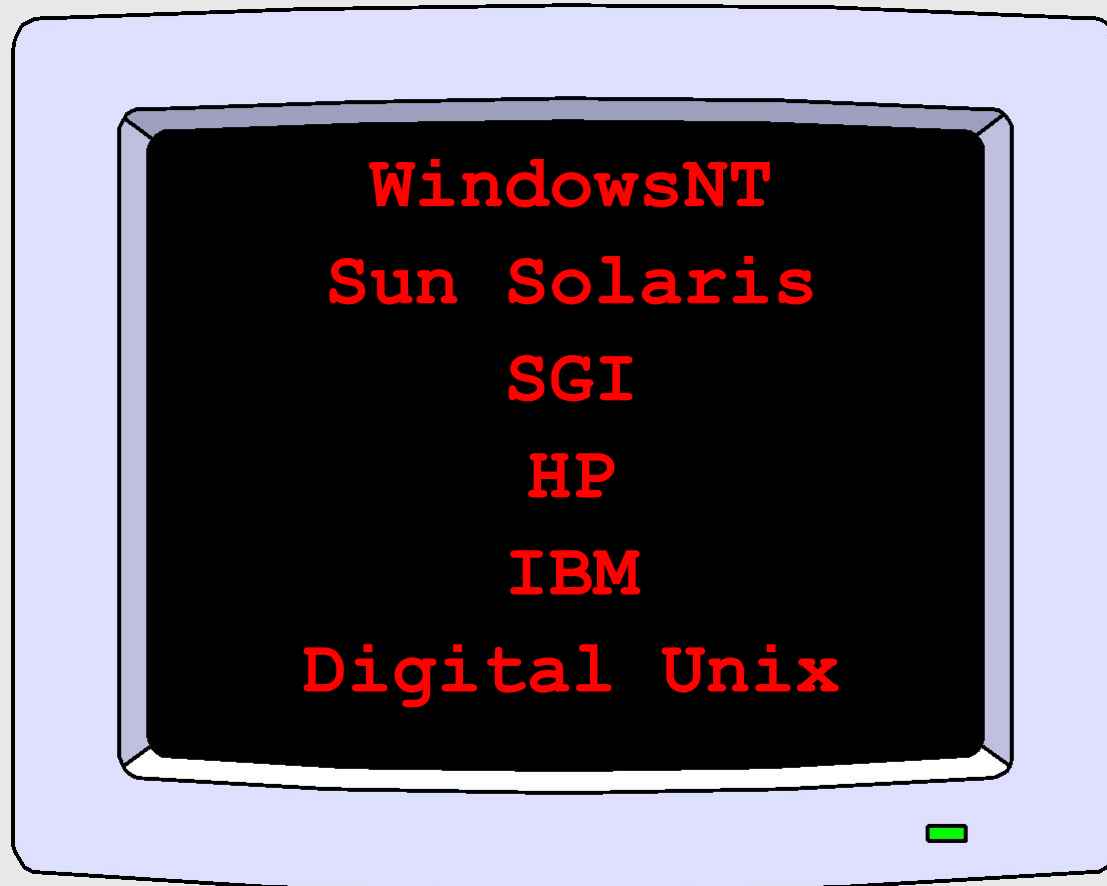


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Platform Support



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Platform Requirements - WinNT

- **Intel based (not Digital NT)**
 - Recommend \geq Pentium 75MHz, 32Mb RAM
 - 125 Mb swap space
 - Any Microsoft supported graphics adapter in 256 color mode
 - WindowsNT
 - Windows 3.1 and Windows95 *not available*
- **Licensing**
 - Node-lock, standalone only
 - *No network license support*
- **Requires Ethernet adapter for licensing**



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Platform Requirements - Unix

- **Supported Unix workstation**
 - 32Mb RAM
 - 125 Mb swap space
- **Licensing**
 - Node-lock, and
 - Floating network license



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- **Geometry**
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Positioning



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MSC/ARIES Positioning

- **Standalone Design and Analysis System**
 - Designed and analyzed in MSC/ARIES
- **Analysis of ACIS Based Geometry**
 - Design built in CAD system
 - Design geometry import into MSC/ARIES
 - Analyzed in MSC/ARIES
- **Focus on Ease-of-Use and Automation For...**



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MSC/ARIES Positioning

- **Structural**
- **Thermal**
- **Mechanisms**
- **Plastic Molding Analysis**



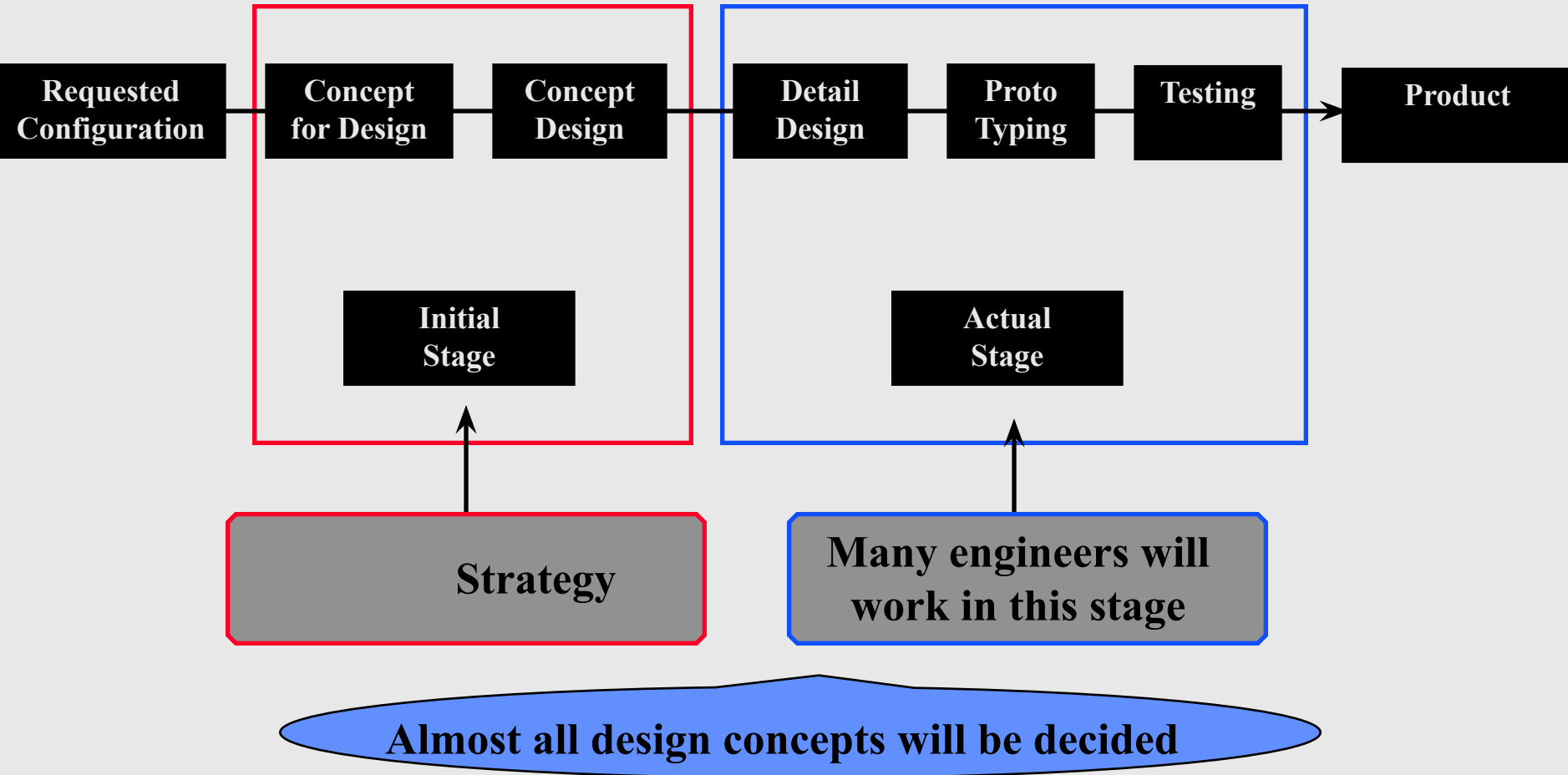
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MSC/ARIES

The Flow of Development



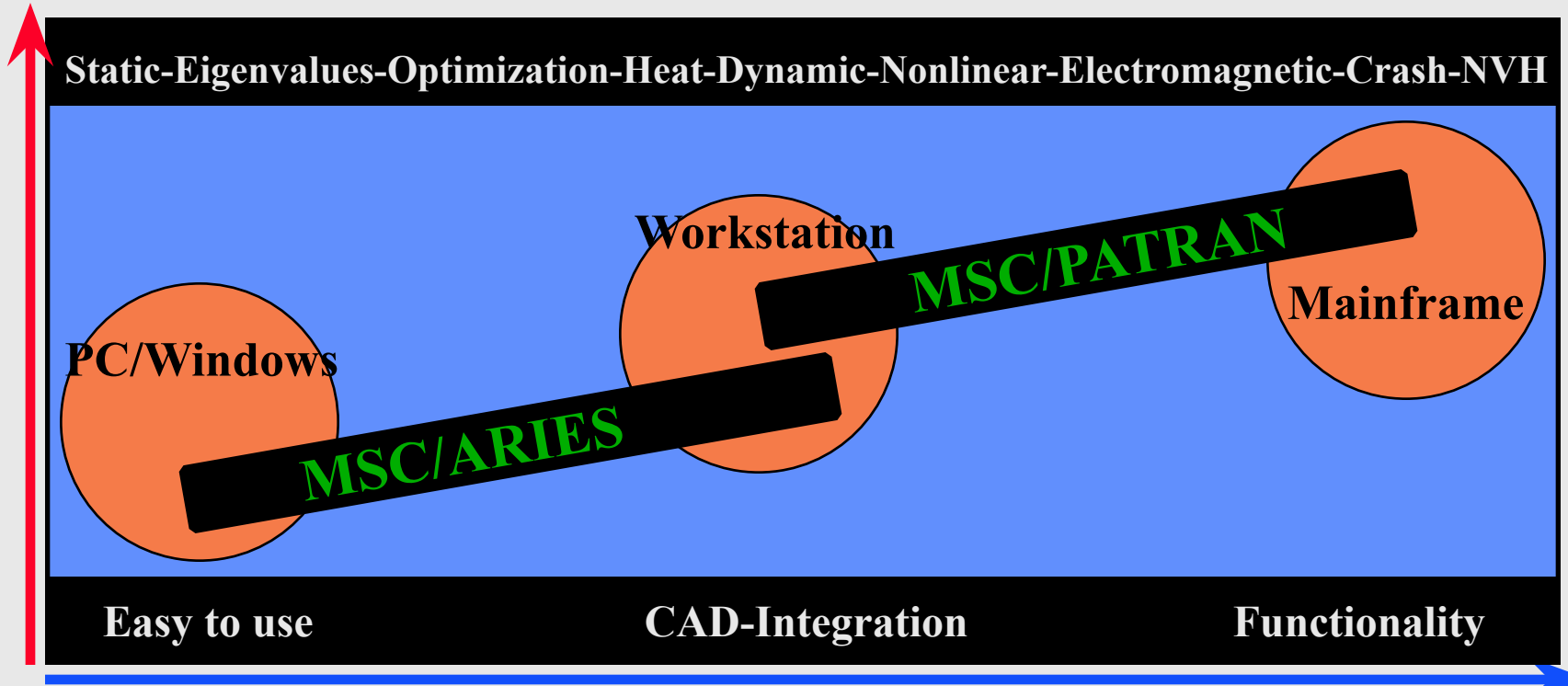
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Positioning of MSC/ARIES

FEA Analyst



Design Engineer

Low price

High price



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Positioning of MSC/ARIES

Modification Costs

End

Manufacturing Process

CAD System

Manufacturing
Bill of Materials
Material Database

Drafting

Analysis
Optimization
Modeling

Design

MSC/ARIES
Predictive Engineering
CAD linked

Start



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Positioning of MSC/ARIES

MSC/ARIES

Targeted User

Non-FE Specialist

Geometry Based Analysis

Conceptual CAE Tool &
Modeller

ACIS imported analysis

Designer

MSC/N4W

Targeted User

FE Knowledgeable

GUI Nastran pre &

Limited Geometry C

Relies on Geometry

Windows Look & F

Low-High End FE U



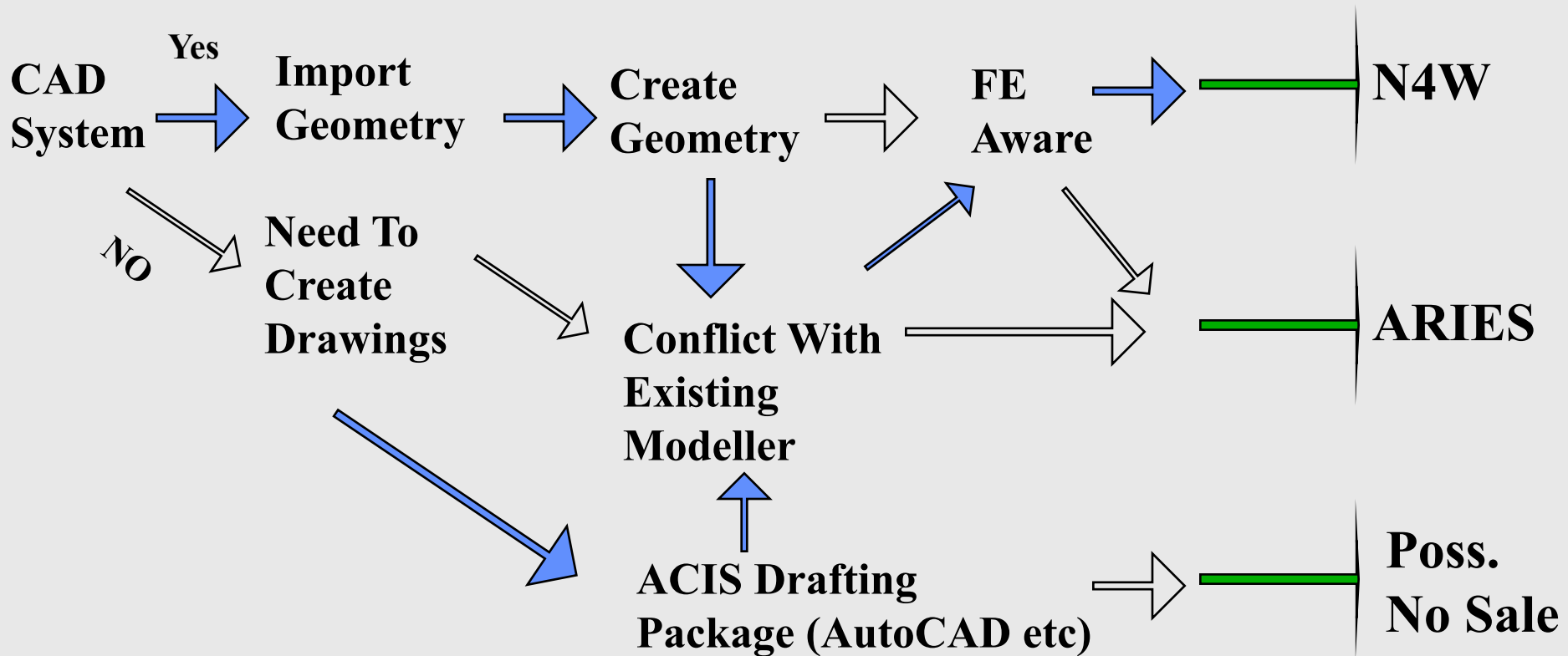
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Positioning of MSC/ARIES

Guide line thought / Question Process



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**THE
END**



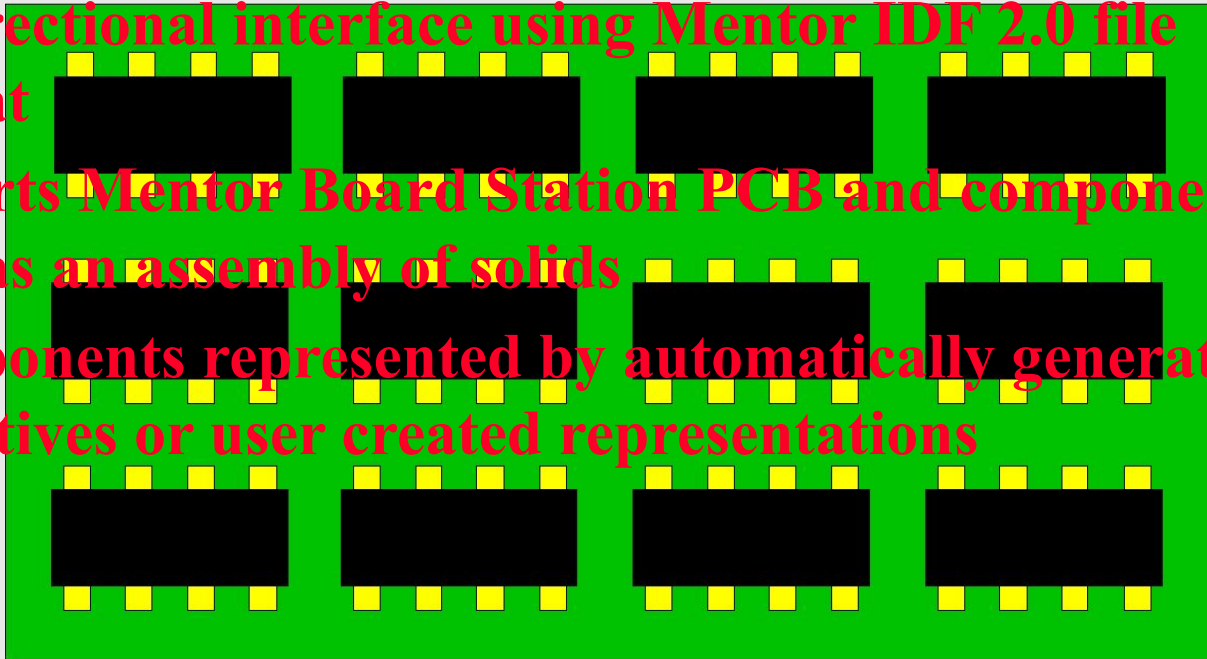
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Mentor BoardStation Interface

- Bi-directional interface using Mentor IDF 2.0 file format
- Imports Mentor Board Station PCB and component data as an assembly of solids
- Components represented by automatically generated primitives or user created representations



Mentor BoardStation Interface

- Supports board holes, vias, keep out and keep within areas
- 2D curves can be added to represent additional keep outs, keep within etc.
- Applications
 - Analysis (e.g. modal, thermal)
 - Checking clearance/interference
 - Housing/rack design

