CAE and Rapid Prototype

1. Integrated Design Approach
2. Future CAE : Image Based
3. Rapid Prototype
4. Layered Manufacturing

Toward Integration

for

manufacturing

Production Engineering

Integrated Design Approach

- Geometric Modeling
  - CAD (non-existing) and CT Scanning (existing)
- Image Based CAE
  - Image Based Analysis Model Development
  - FE Analysis / VOXELCON
  - Redesign and Design Optimization / OPTISHAPE
- Rapid Prototype with Common Database
- Layered Manufacturing

Common Database

- We have common database : compressed image data with jpeg/gif format that can be rapidly converted to STL and SLC files which are common in rapid prototype and layered manufacturing
- 500 slices data can be about 7 MB
- CAD IGES or STEP format is not sufficient to construct an integrated system

Image Based CAE
- a new concept -

for

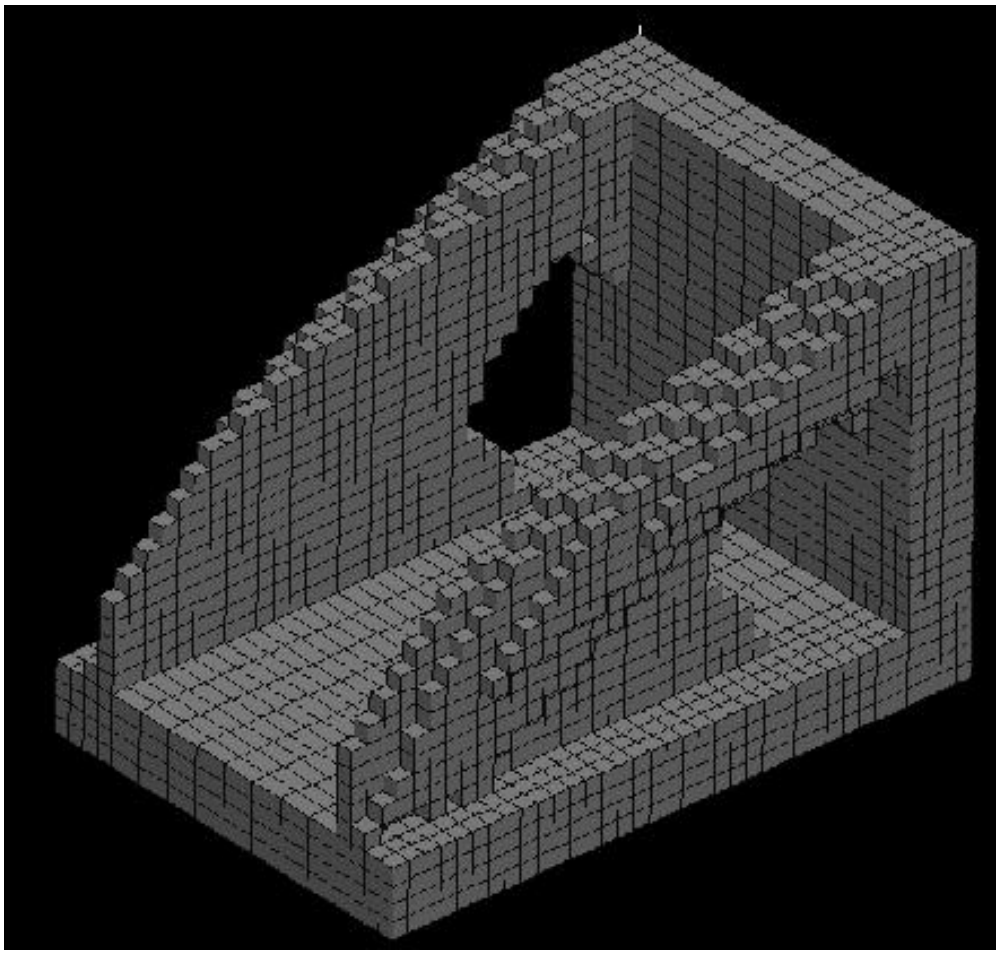
an integrated system

of

Production Engineering

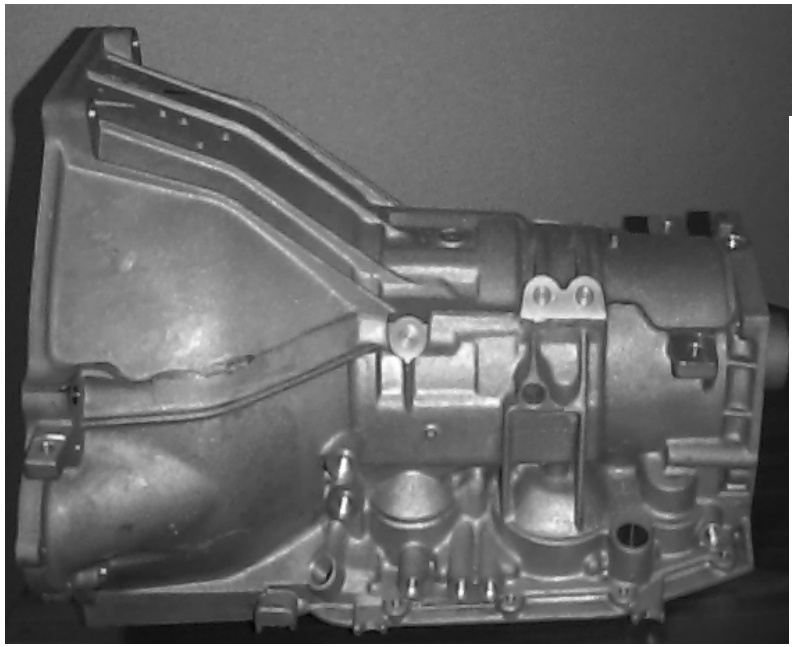
Started From OPTISHAPE

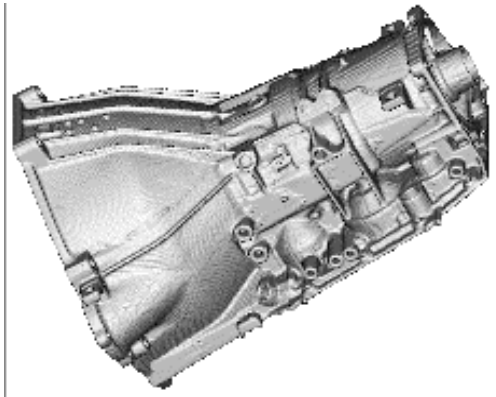
Optimal topology/shape is
represented by pixel/voxel on/off
condition (image)



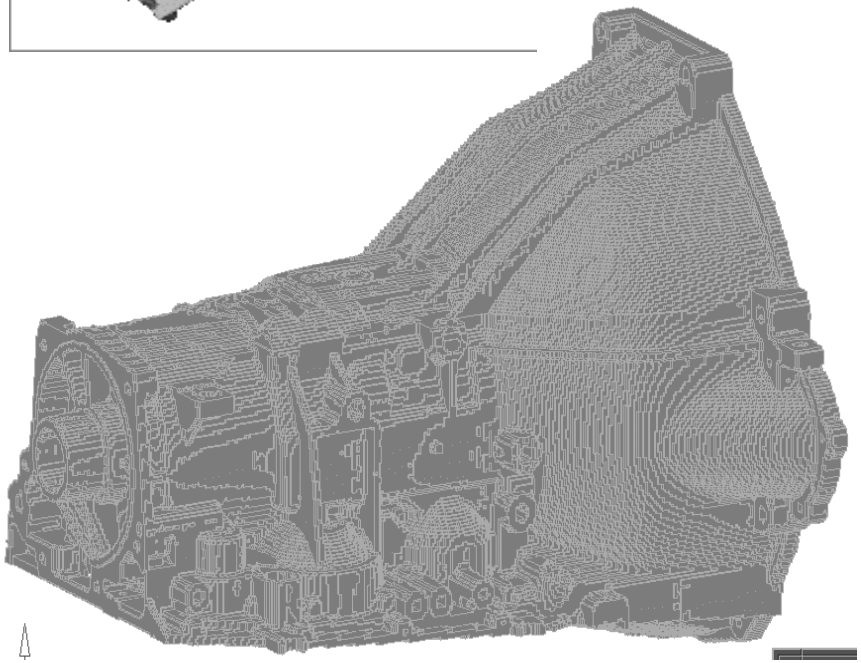
Why Not To Use This !

Apply CT Scanning





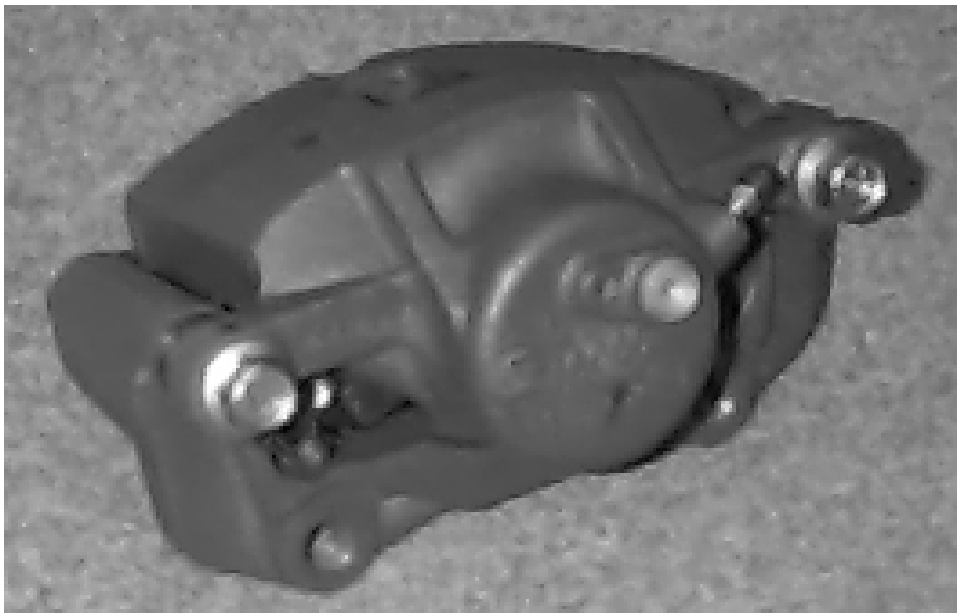
Scanned
3D Image



Voxel Mesh for FEA

Scanning / Example

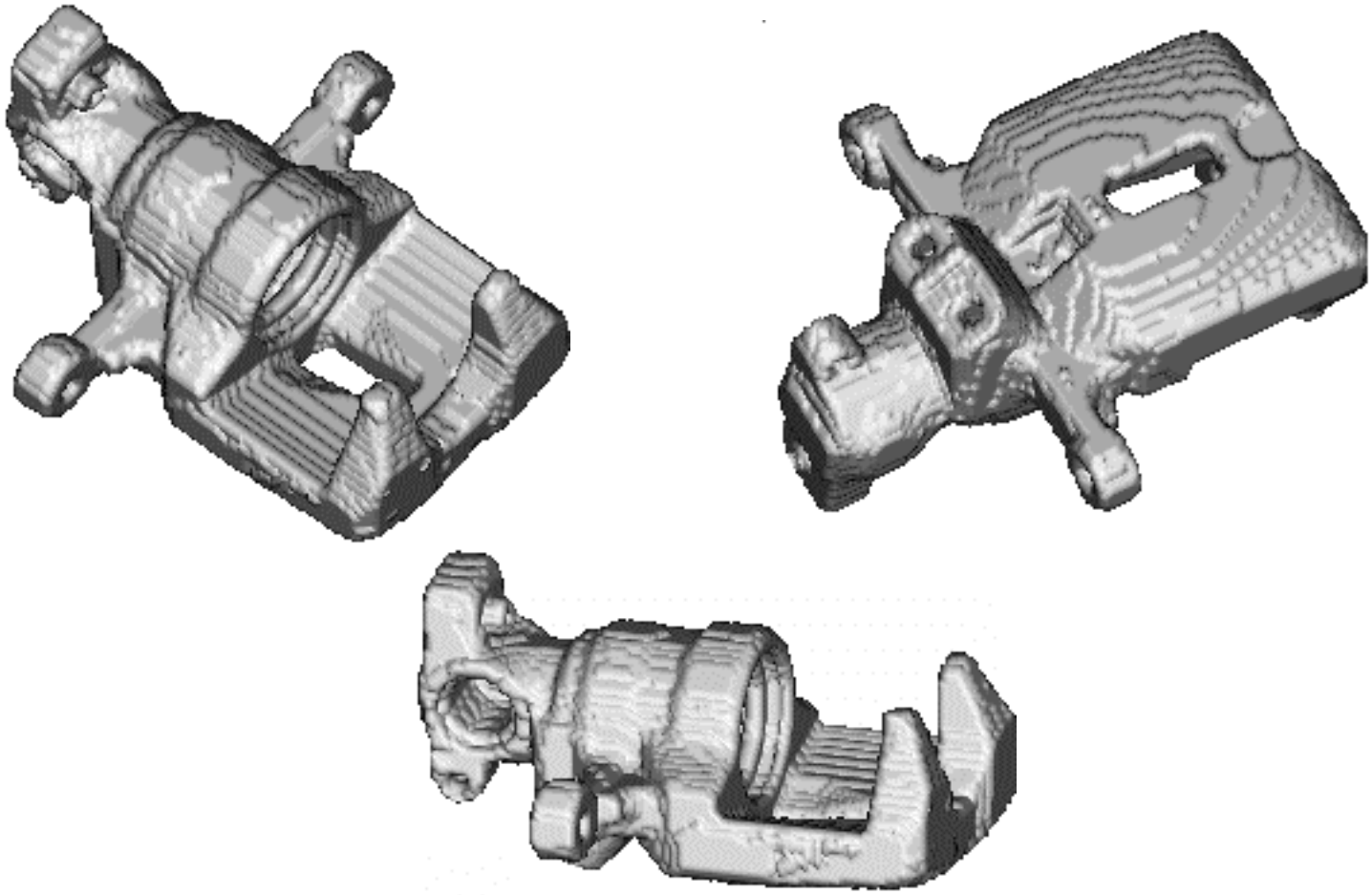
- 1 Week with $ 2,800



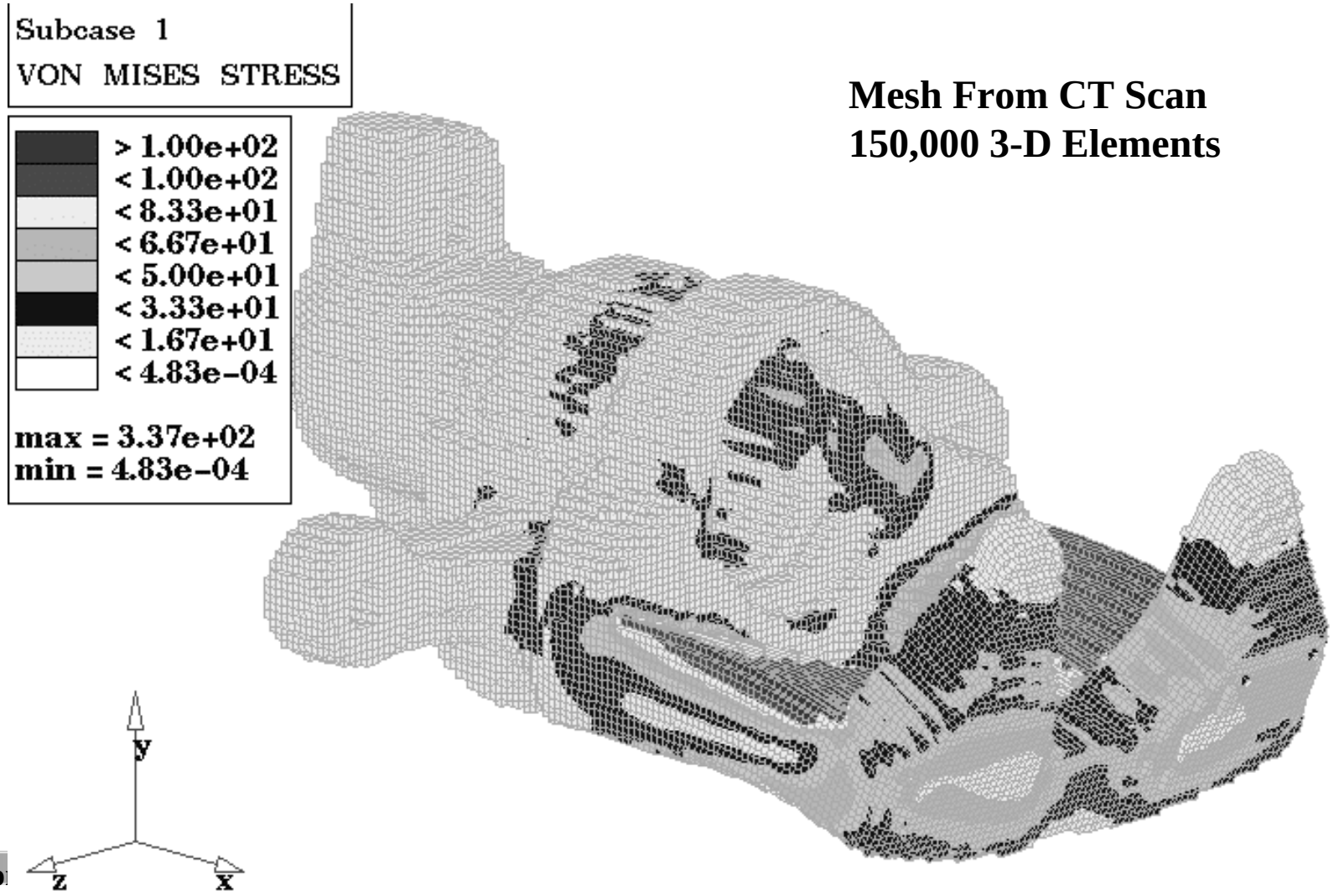
resolution : 0.2 ~ 0.5 mm

CT Slices of the Caliper

3D Surface Rendering

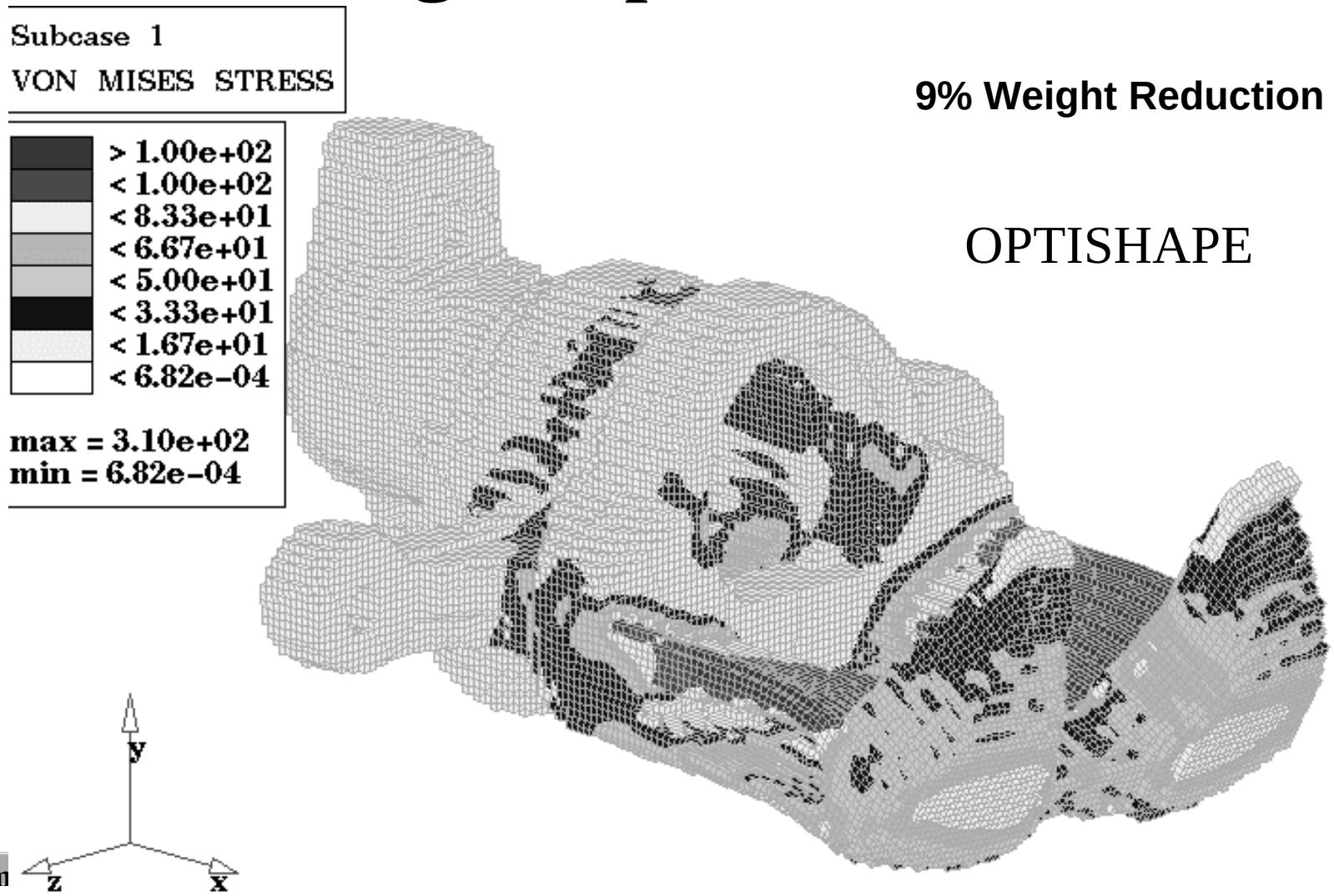


Stress Analysis



Mesh From CT Scan
150,000 3-D Elements

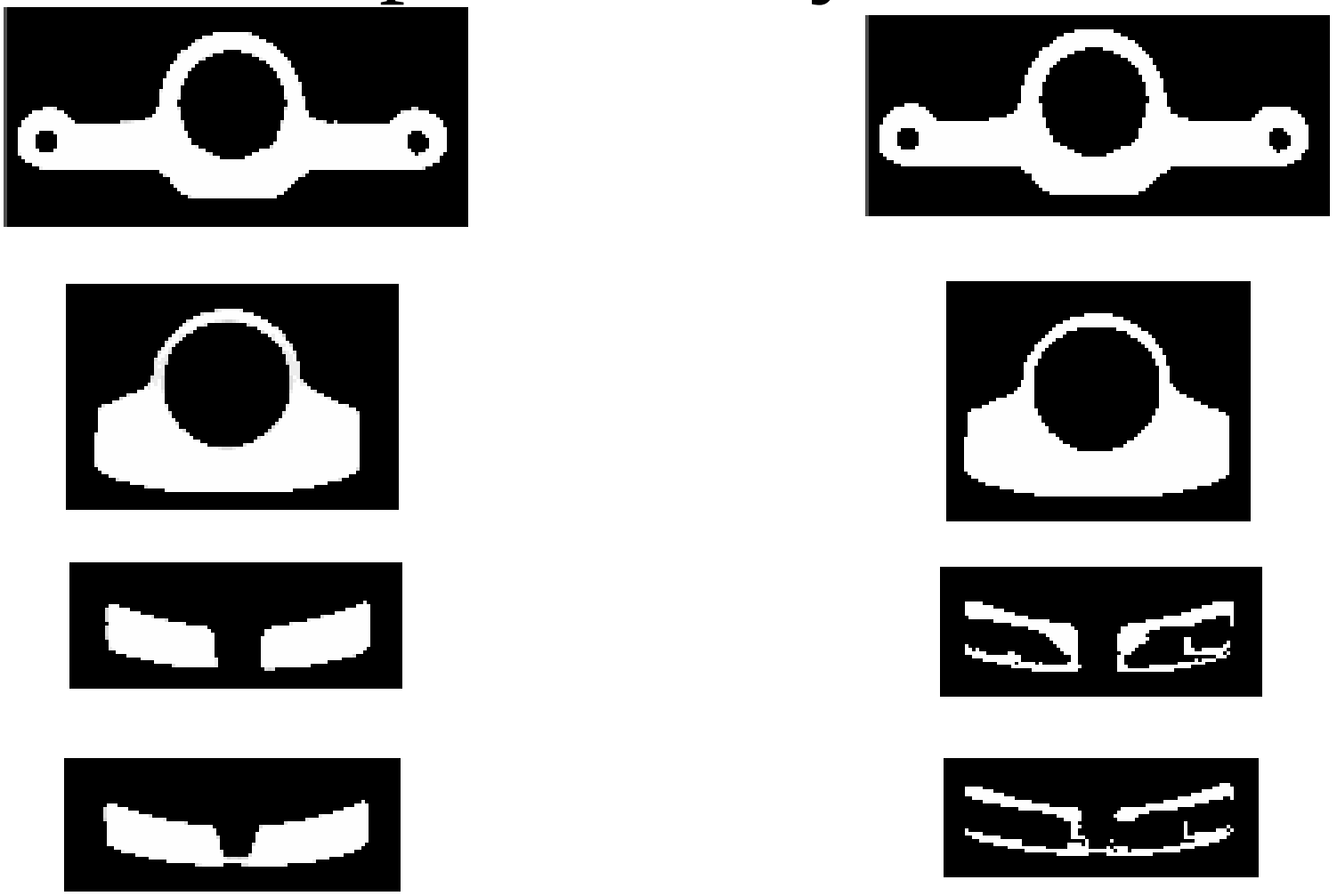
Design Optimization



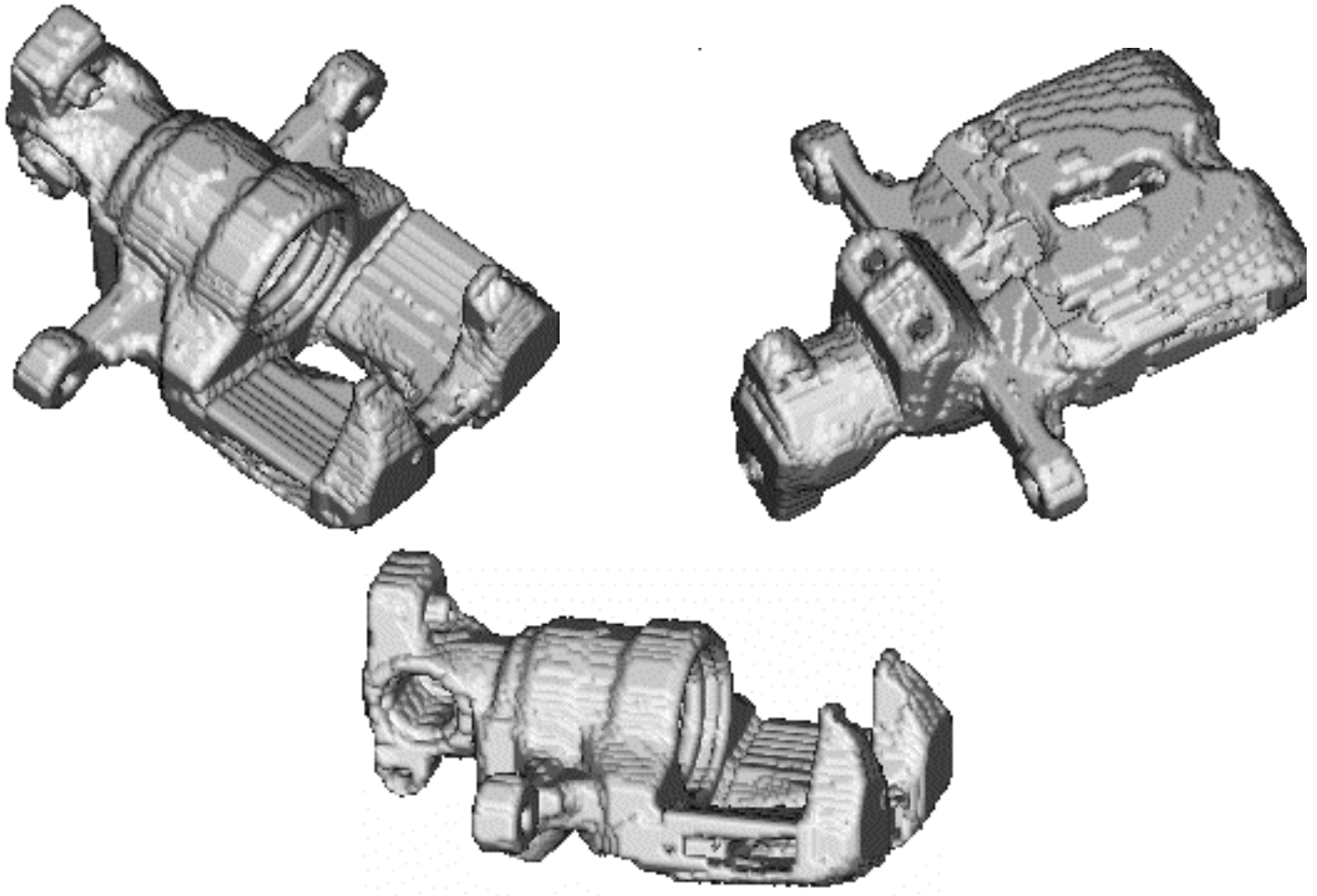
9% Weight Reduction

OPTISHAPE

Comparison by Sections



Rendering of Designed One



Advantage of IBCAE

- Scanning ~ At Most 1 Week
- FE Meshing ~ A Few Minutes
- FE Analysis ~ 1 to 2 Days

- Total — 10 Days

- Standard FEA — 3 Months or more

Why Image Baed ?

OPTISHAPE

+

Rapid Prototype Technology

Solid Free Form Fabrication

Short Turn Around Time

Common Database for CAD

- VOXELCON & OPTISHAPE generate STL files of solid models and optimized layout of structures
- STL files are used in Rapid Prototype equipment such as SL machines
- From STL files SLC files as well as Wire Frame models are generated

CAD Linked Common Database

SFF is a Key Technology

FREE FORM FABRICATION

DIRECT ENGINEERING

RAPID TOOLING

Design Concept
Product & Process Design
Mfg. & Product CAE
Prototype
Fixture Design

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for Advanced Engineering and Fabrication Process

Free Form Fabrication(SFF)

SFF is an array of different technologies for the purpose of creating physical objects directly from three dimensional surfaced or solid geometric data by utilizing very thin slices of the geometric data to create the model

--- Mr. Peter R. Sferro, Ford Motor

SFF Benefits & Growth

- According to Mr. Sferro, Ford Motor,only 300 parts are FFFed in 1988, but more than 15,000 parts in 1994
- Savings
  - Cost 50 ~ 75%
  - Timing 70 ~ 95%
- Quality : Optimized Design

Typical SFF Technologies 1

- Sintering
- Lamination
  - KIRA, HELISYS, FORD, CAD/LAM
- Jet Droplets
  - MIT, SANDERS, BPM, SOLIDGEN
- Photo Polymer
  - Stereo-Lithography, Cubital, EOS, Sony

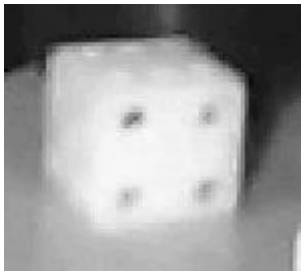
Typical SFF Technologies 2

- Extrusion
  - IBM, STRATASYS
- Welding
  - Rocketdyne, Sarasota, Nottingham
- Plasma Spray
  - MD, Stanford

Stratasys

About $65,000
for this equipment

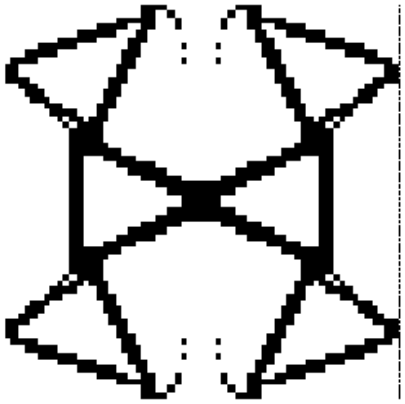
Examples by Stratasys

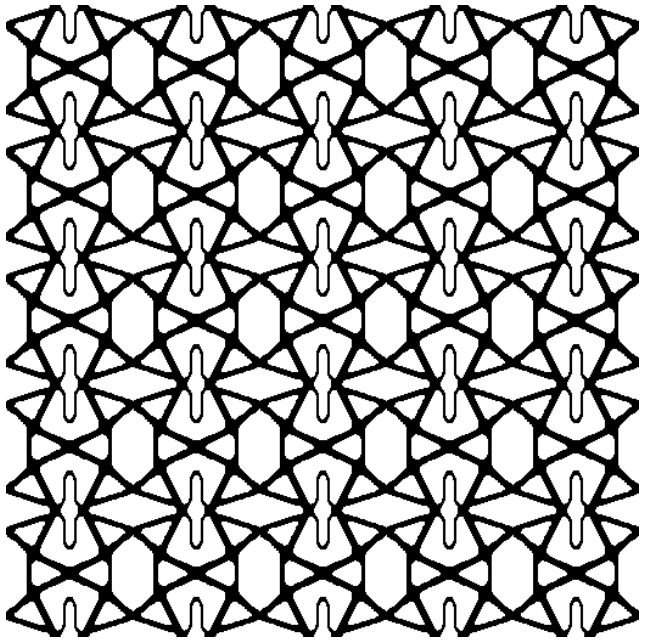


Design To Rapid Prototype

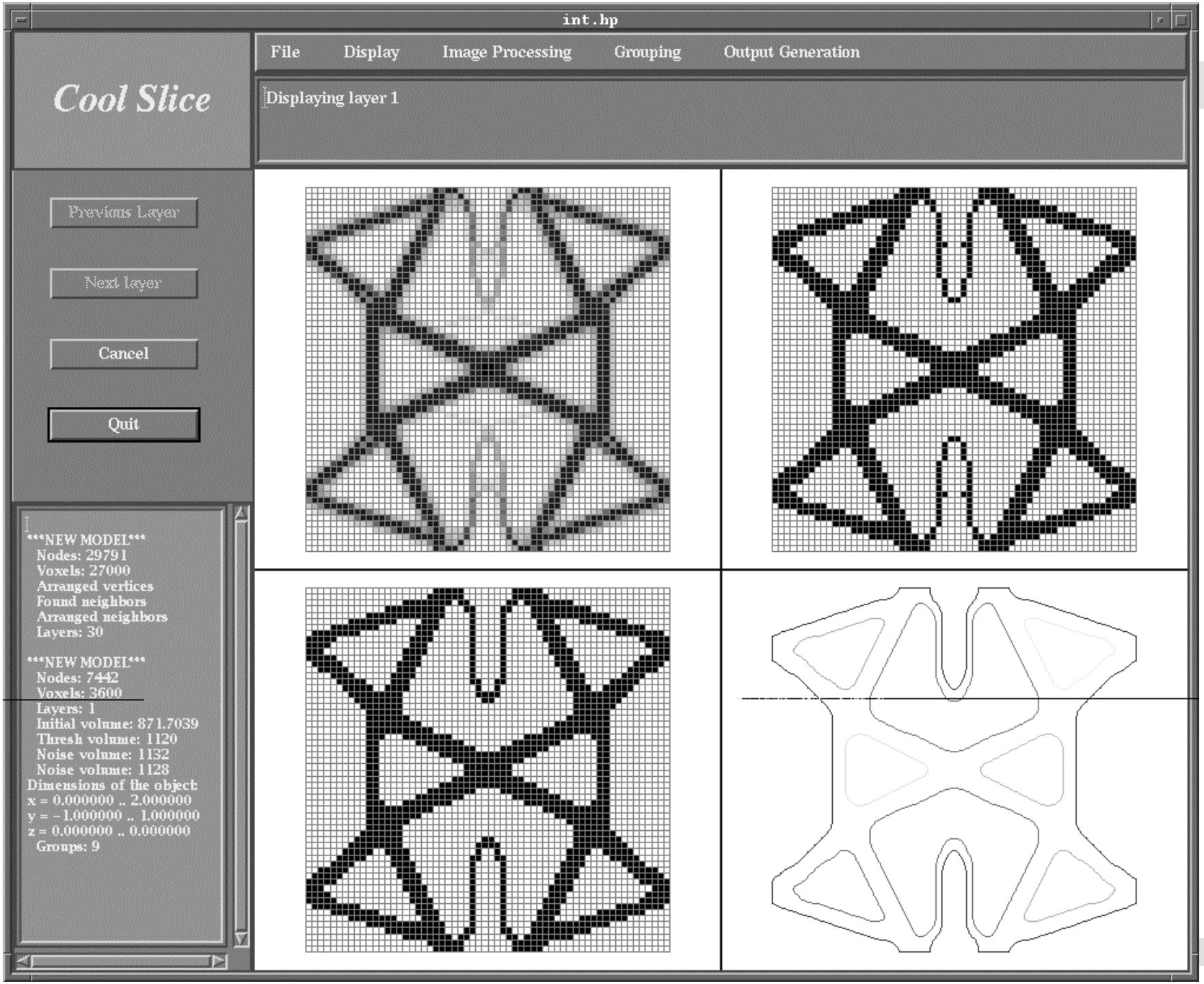
- Image Processing from Voxel Data in the Homogenization Design
  - remove of point contact
  - manufacturability constraints (curvature)
  - creation of a SLC/STL file for SFF
- CAD data generation for SFF
- Rapid Prototype by SFF(Solid Free Form Fabrication) Machines

Isotropic Material Design

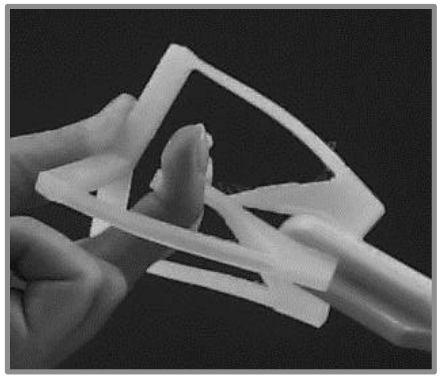


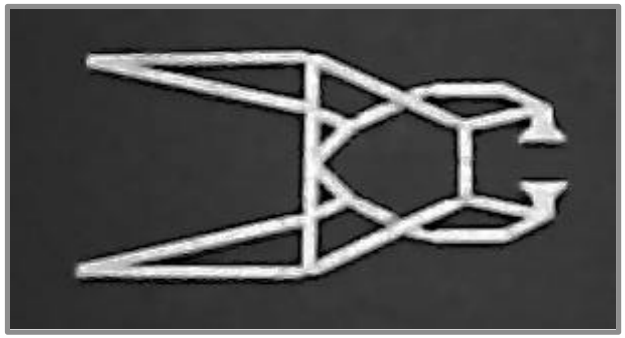


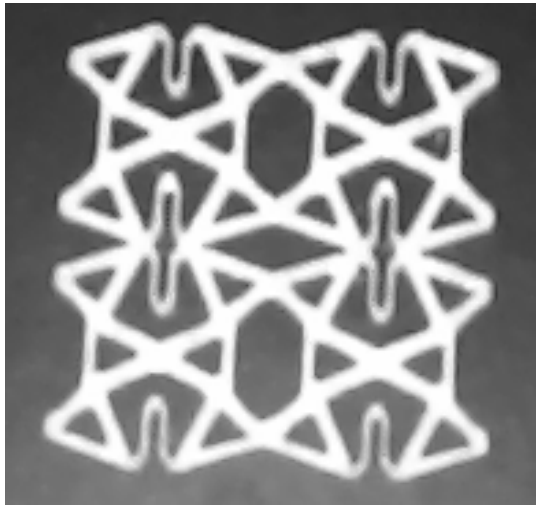
- *Poisson's ratio -0.5*


int.hp
Cool Slice
File
Display
Image Processing
Grouping
Output Generation
Displaying layer 1
Previous Layer
Next layer
Cancel
Quit
NEW MODEL
Nodes: 29791
Voxels: 27000
Arranged vertices
Found neighbors
Arranged neighbors
Layers: 30
NEW MODEL
Nodes: 7442
Voxels: 3600
Layers: 1
Initial volume: 871.7039
Thresh volume: 1120
Noise volume: 1132
Noise volume: 1128
Dimensions of the object:
x = 0.000000 .. 2.000000
y = -1.000000 .. 1.000000
z = 0.000000 .. 0.000000
Groups: 9

Rapid Prototype







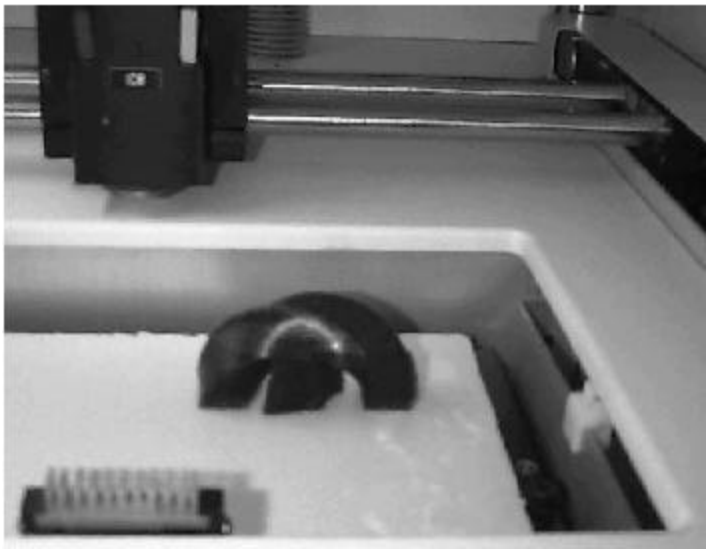
Prashant Kulkarni

Layer-by-Layer

- Emerging manufacturing technology is based on layer-by-layer, point-by-point formation of a shape (geometry)
  - Reverse way of formation of geometry
  - Sculpture is taking out unnecessary portion, but
  - These methods is building up a shape point-by-point, and layer-by-layer
  - Truely digital formation of a shape
- Why not paying more attention to this !

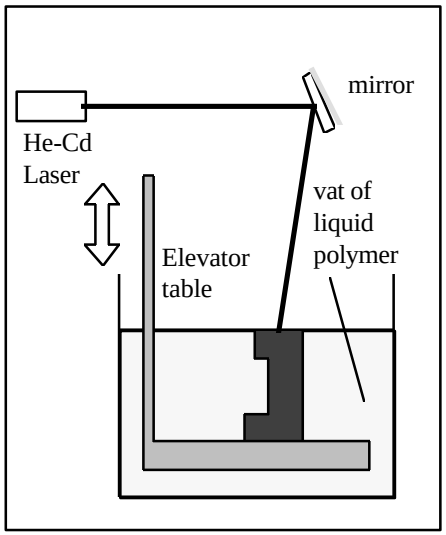
Layered Manufacturing

- Rapid Prototype
  - Stereo-Lithgraphy
  - Fusion Deposition
  - 3D Printing

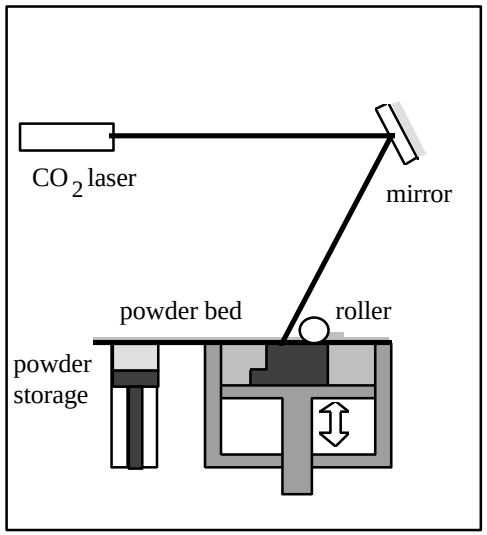


- Layered Manufacturing

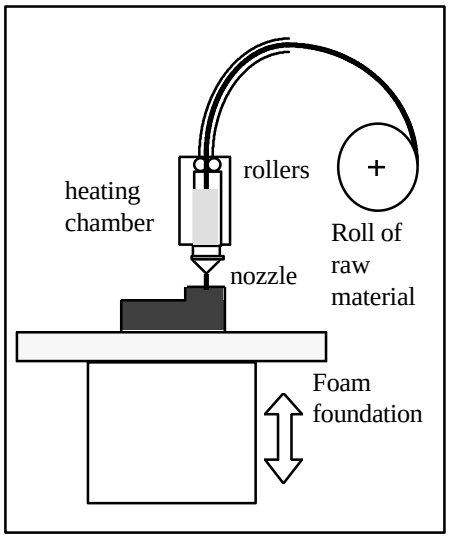
Typical Layerd Manufacturing Processes



Stereolithography



Selective Laser Sintering

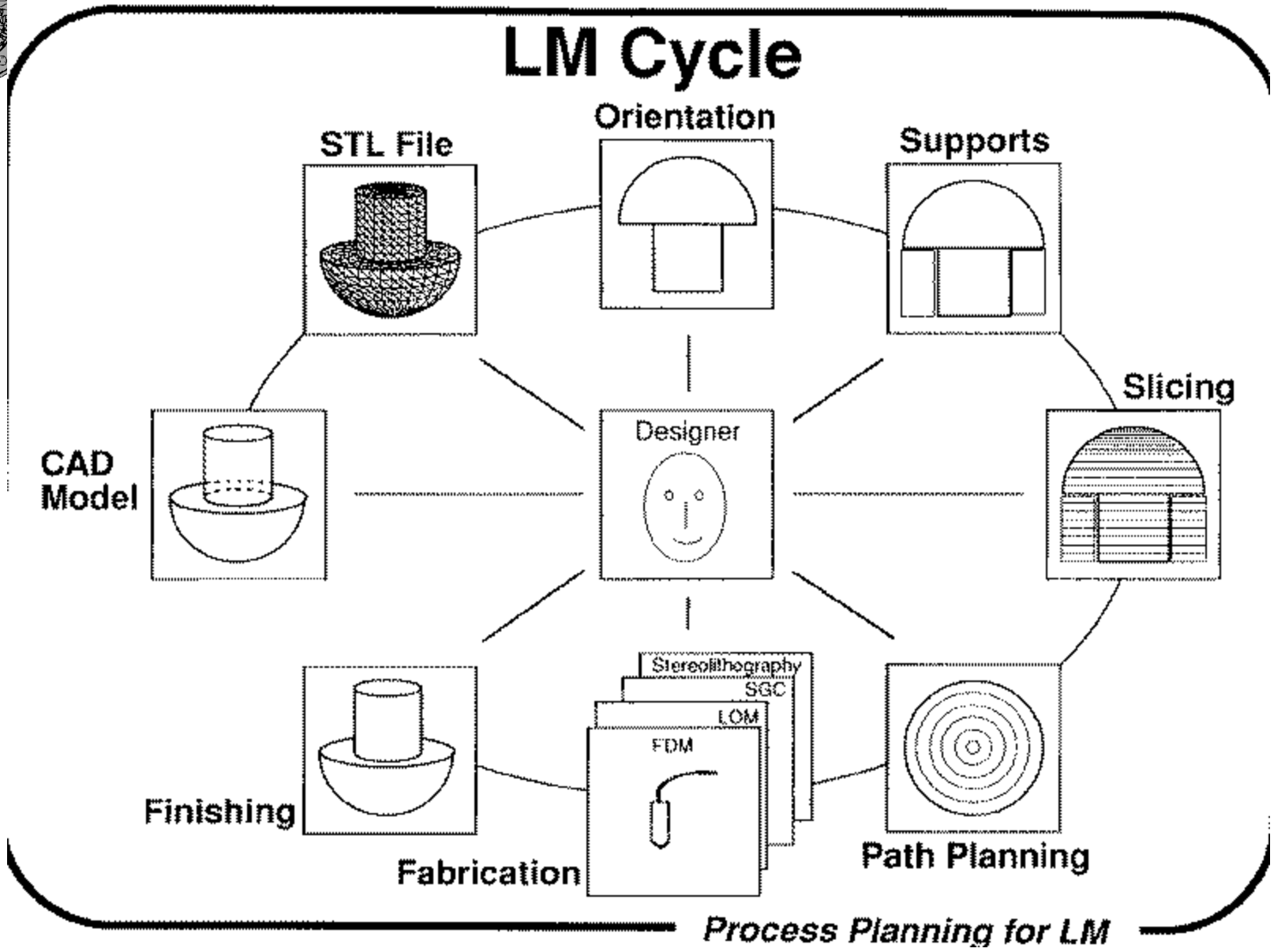


Fused Deposition Modeling

A Comparison

State of build matl.	liquid	powder	solid
wax	–	SLS	FDM,SMM
plastic	SLA , SGC	3DP , SLS	FDM,SMM
ceramic	SLA	3DP , SLS	–
paper	–	–	LOM
metal	–	3DP , SLS	SDM

SLA – Stereolithography
SGC – Solid Ground Curing
SLS – Selective Laser Sintering
3DP – Three Dimensional Printing
LOM – Laminated Object Manufacturing
FDM – Fused Deposition Modeling
SMM – Sanders Model Maker
SDM – Shape Deposition Modeling


LM Cycle
Orientation
STL File
Supports
Slicing
CAD Model
Designer
Stereolithography
SGC
LOM
FDM
Finishing
Fabrication
Path Planning
Process Planning for LM

Now there is possibility to make in real sense integration

For

Production Engineering

Based on

the Concept of OPTISHAPE

We are heading to

Development of an integrated system for Computer Aided Production Engineering ?

CAPE

OPTISHAPE

Present & Near Future

TOPOLOGY
Michigan
Kikuchi/Diaz

SIZING
NASA Ames
Dr. Miura

OPTISHAPE
QUINT

FLEXIBLE
MULTI-BODIES
Michigan
Kikuchi/Nishiwaki

SHAPE
Toyohashi
Azekami

SDRAC I-DEAS

MSC/PATRAN

Other Activity

- ALTAIR Computing
  - OPTISTRUCT X GENESYS
- Vanderplat Associate
  - GENESYS X HYPERMESH/OPTISTRUCT
- MSC Europe
  - MSC/TOPOLOGY (Just Static)
- ANSYS TOPOLOGY (Just Static)