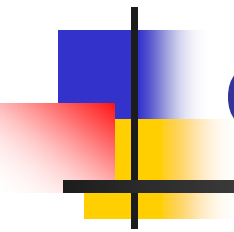


Introduction to
CAM (Computer Aided Manufacturing)

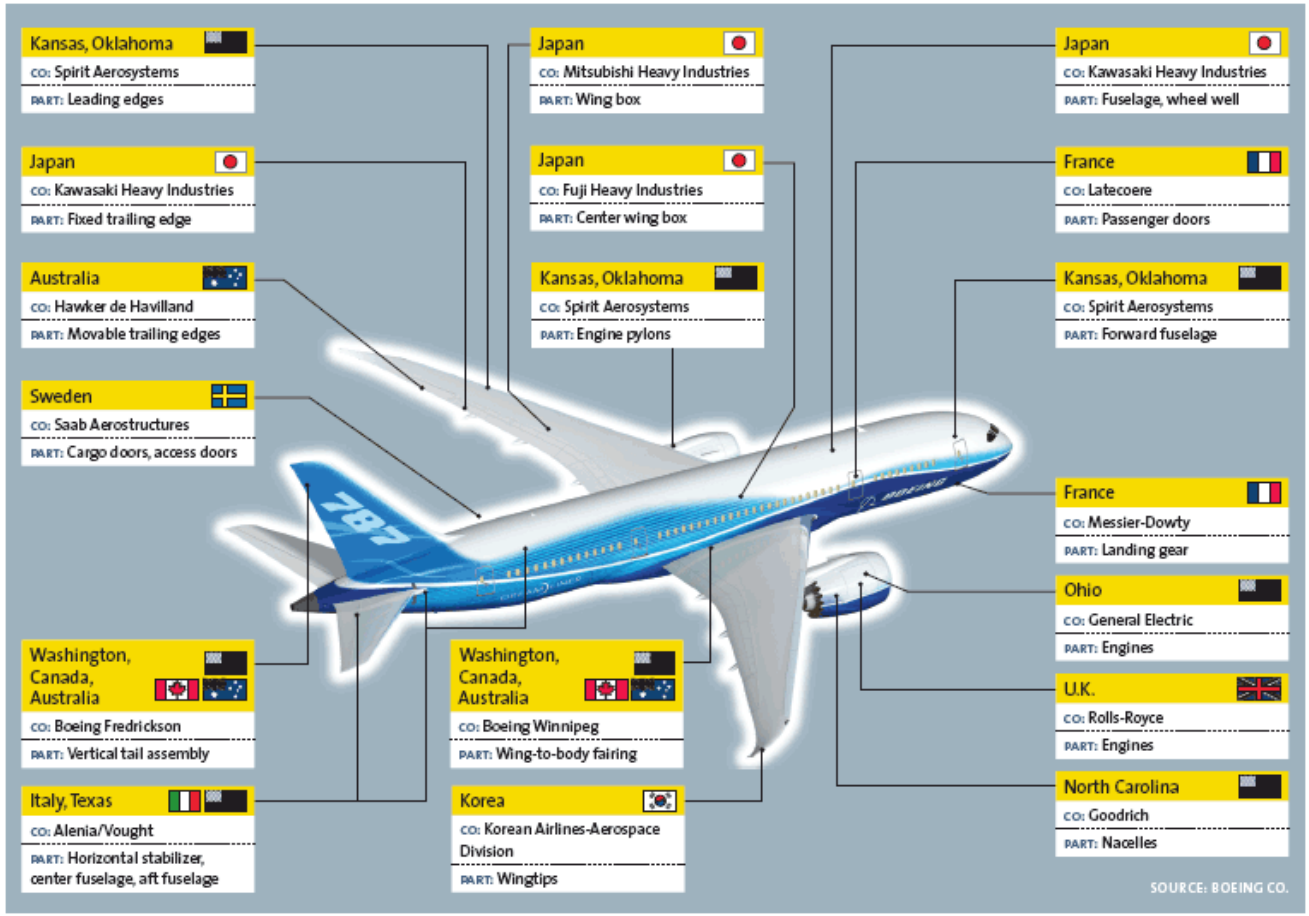
Prof. Sung-Hoon Ahn

September 6, 2006

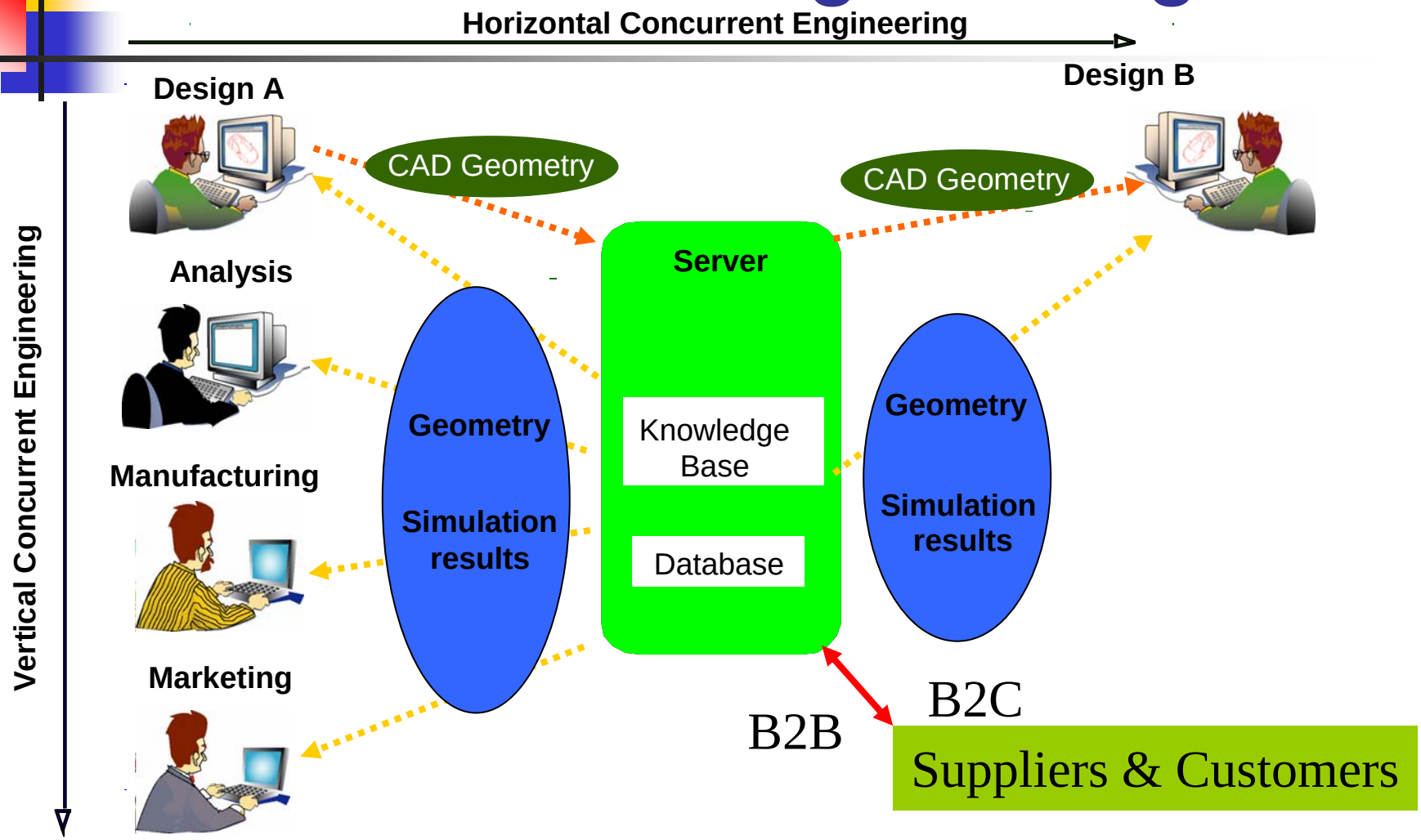
CAD/CAM integration

Boeing 787

- Global collaboration
- US design, manufactured around the world
- Higher efficiency – composite materials (40~55% weight)



Goal: Shared Engineering

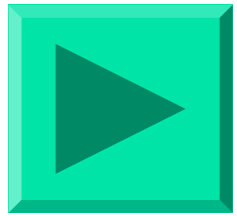


Issues to be covered in CAM

- NC (Numerical Control) Programming
- CAM Software
- Rapid Prototype
- VR/AR
- Reverse Engineering

Example of CAD/CAM integration

- Scanning
- Surface merging
- NC code generation
- Machining
- Color mapping
- Network-based communication
- … …



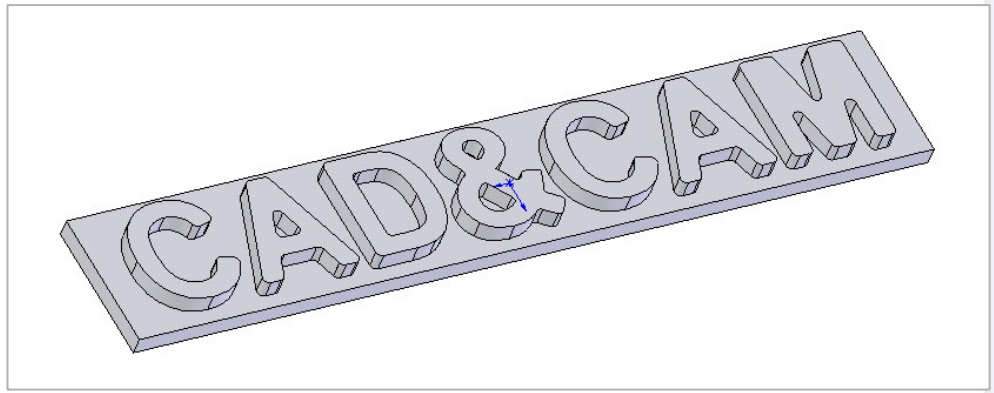
NC code

epm.nc - 메모장

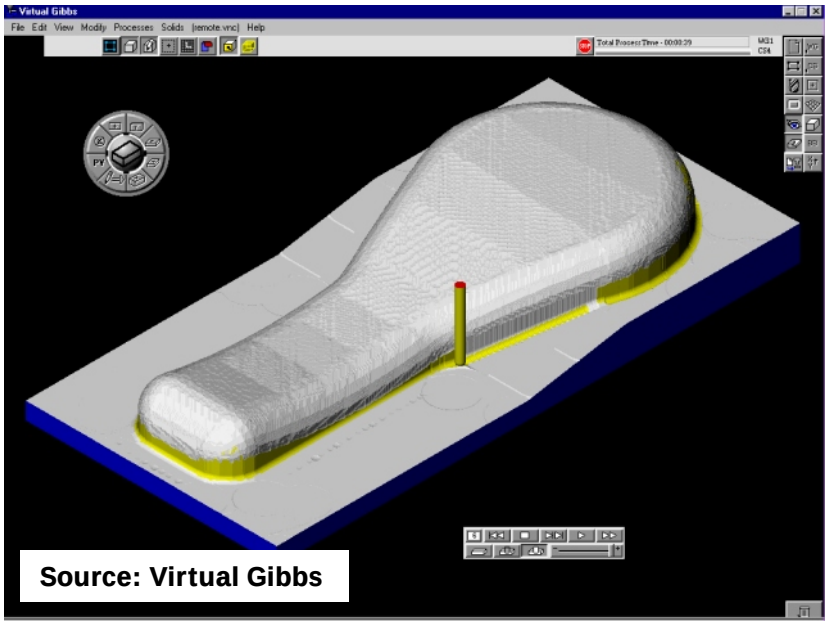
파일(F) 편집(E) 서식(O) 보기(V) 도움말(H)

```
%
O1234
G40 G49 G80
G91 G28 Z0.
G90 G57
S24000 M3
G92 X.0 Y.0 Z50.0
G0 Y-1.0 Z15.0 Z2.0
G1 Z.0 F50.0
Z10.0
X9.902
X82.607
X144.169
X201.121
X261.122
X318.621
X380.562
X450.0
Z.0
G0Z15.0
X451.0Y.0
Z2.0
G1Z.0
Z10.0F100.0
X450.0
X380.562
X318.621
X261.122
X201.121
X144.169
X82.607
X9.902
X.0
X-1.0
Z.0
G0Z15.0
Y1.0
Z2.0
G1Z.0F50.0
Z10.0F100.0
X.0
```

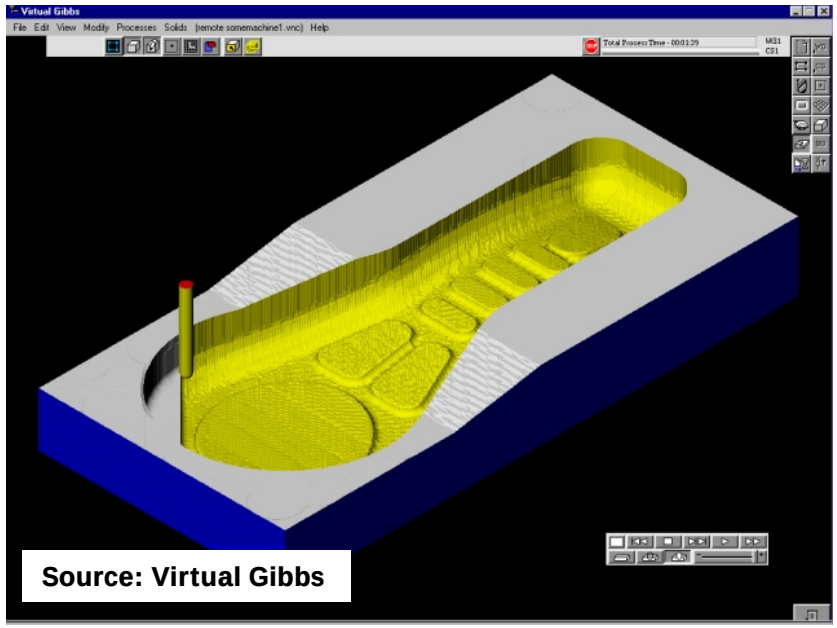
- Low level language for machine control
- Applicable to many types of manufacturing hardware
- Example:



NC (Numerical Control) Programming



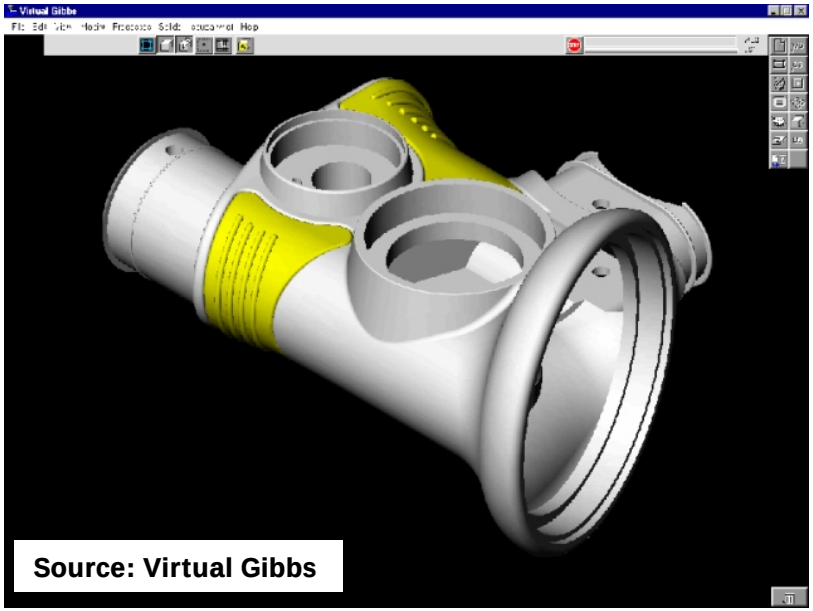
(a) Core



(b) Cavity

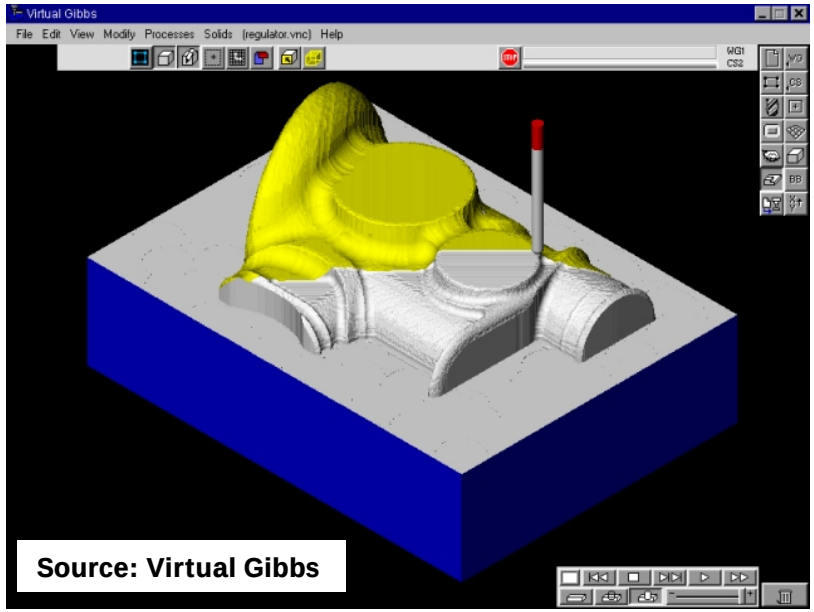
Example of NC programming model

CAD to CAM Interface



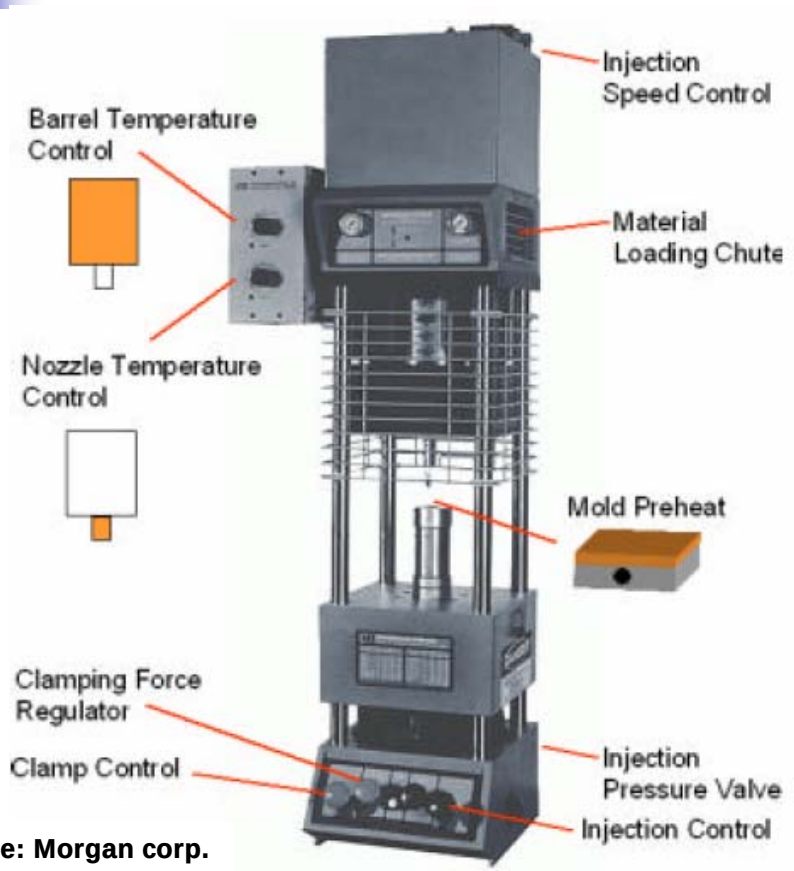
3D CAD

STL,
STEP,
IGES

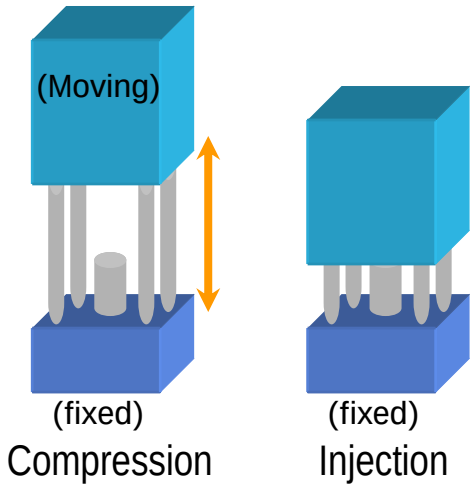


3D CAM

Injection Molding



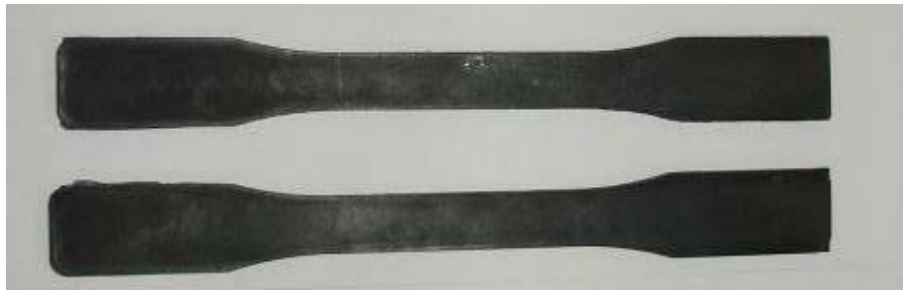
Source: Morgan corp.



Schematic of the Morgan G-100T Press – not for mass production

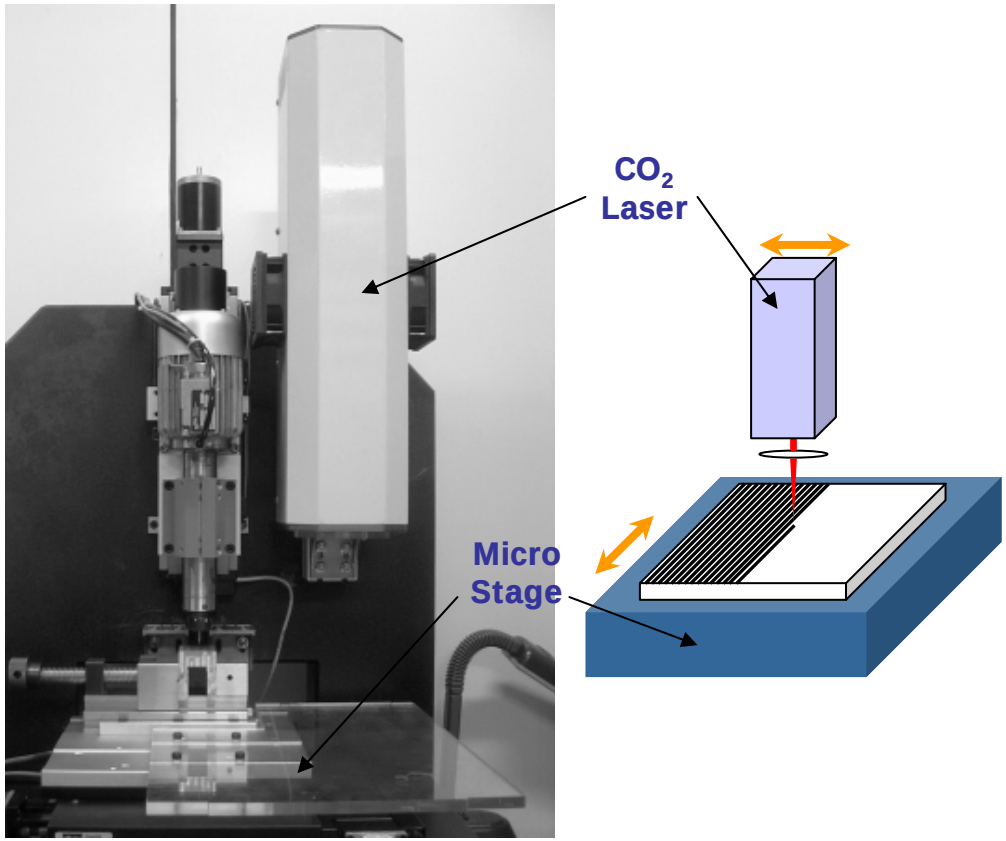
Injection Molding

Two-part mold for injection molding

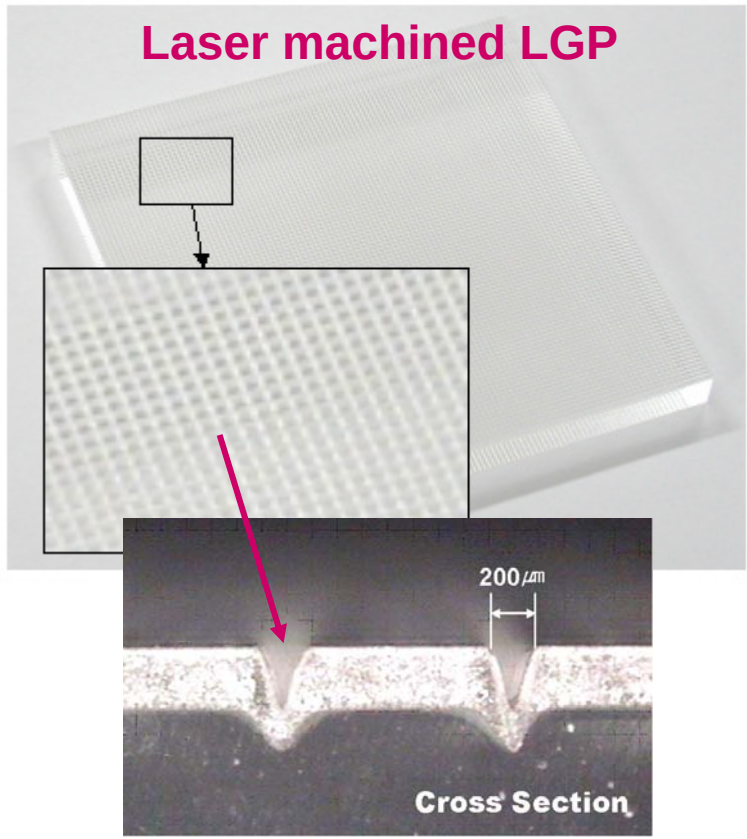


Molded tensile specimens

Laser Machining



3-axis stage for Laser Machining

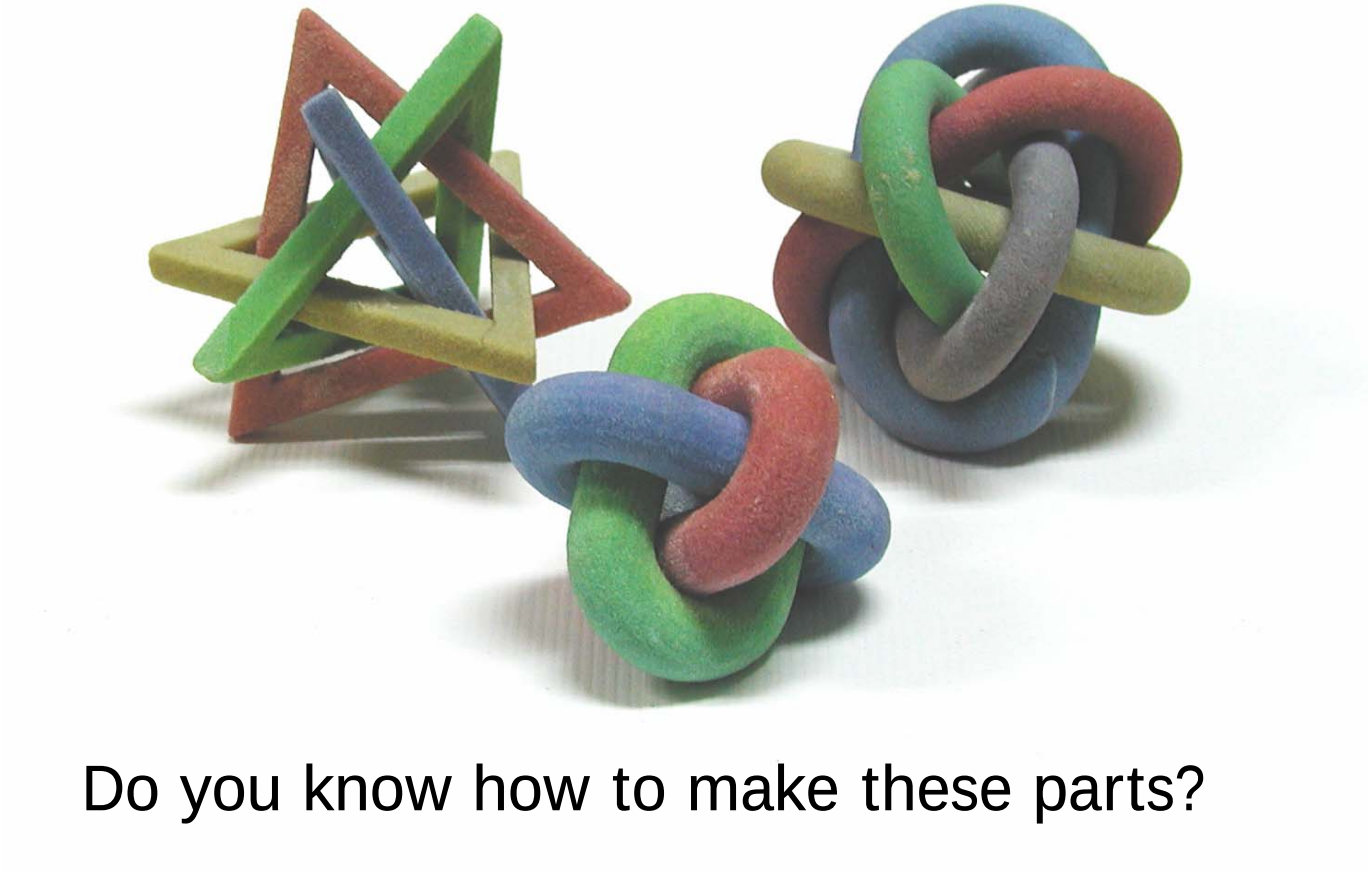


Cross section of grooves (X 100)

Laser cutting

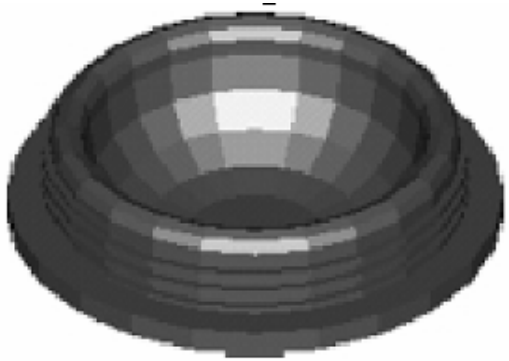
- 2D profile cut
- Useful for your class project

What is Manufacturability?

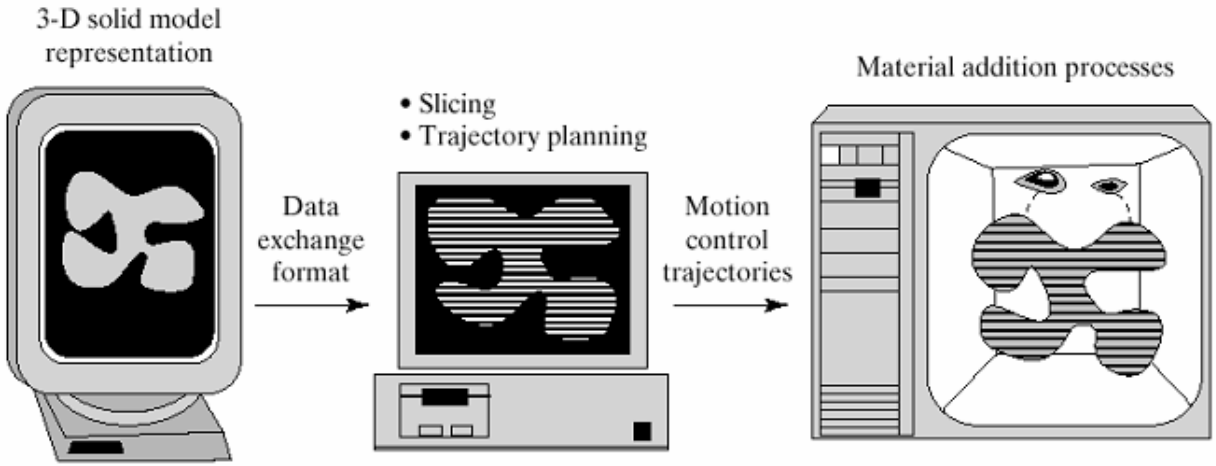


Do you know how to make these parts?

Rapid Prototyping (RP) - concept



(a)



(b)

NASA: Fabrication in Space

FDM1600 test at zero gravity

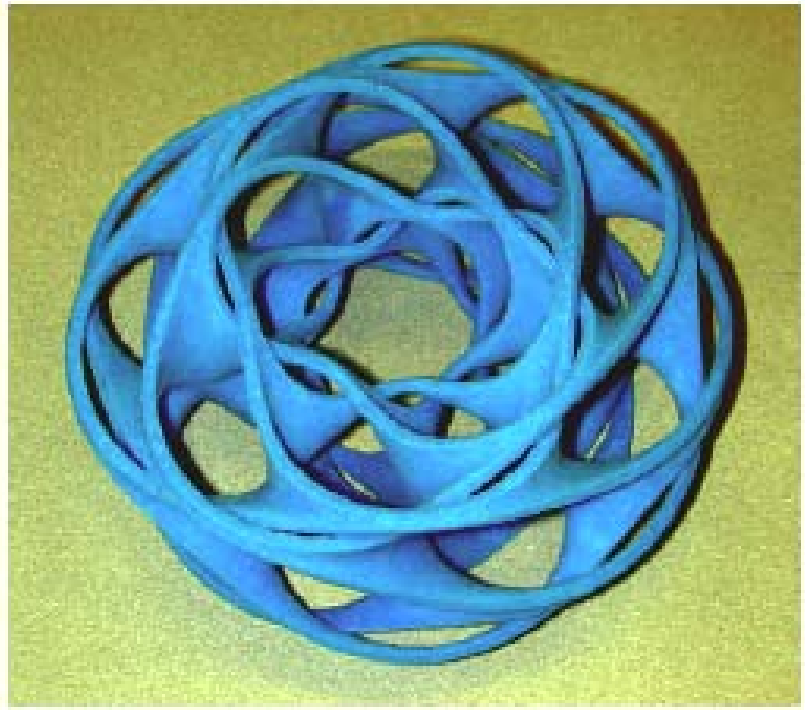
Johnson Space Center & Marshall Space Flight Center, 2000

Design for Manufacturing (DFM)

- More important questions
  - How much cost?
  - How long to take?
- These issues are influenced by:
  - Manufacturing process
  - Availability of machines
  - Material
  - Batch size (how many parts)
  - etc.

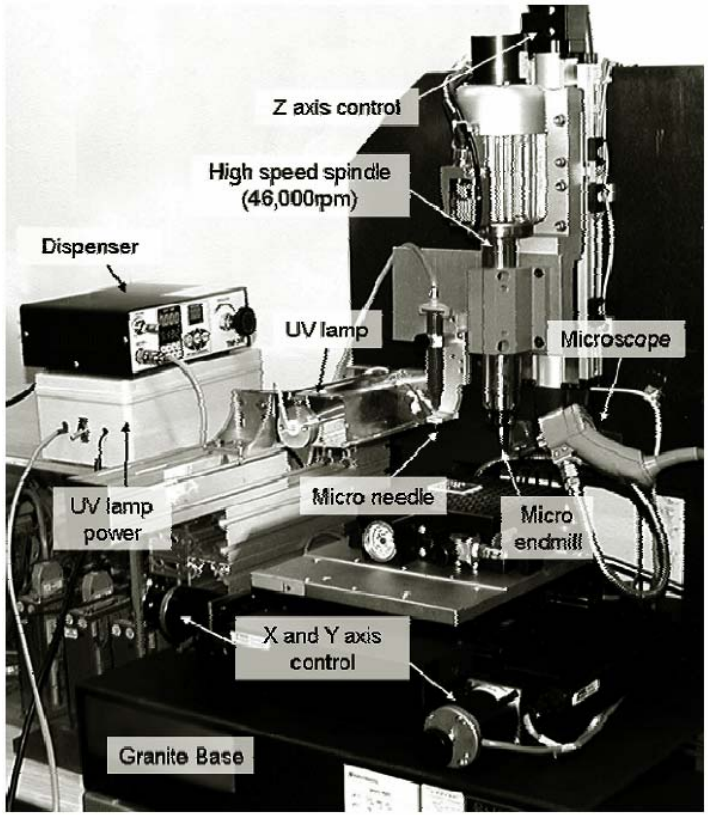
RP Parts

Color parts fabricated by rapid prototyping

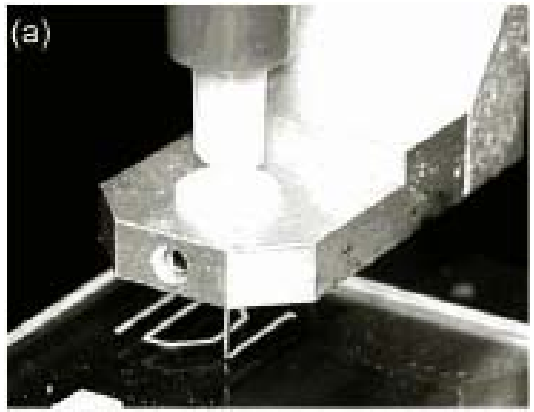


Micro RP for nano composite

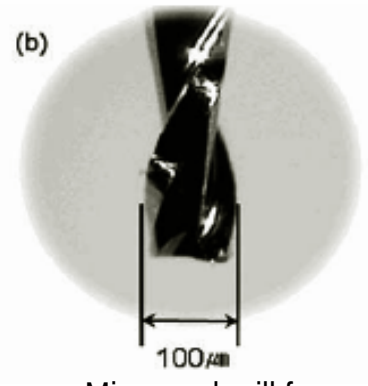
- Hybrid Rapid Prototype



Micro stage for hybrid RP



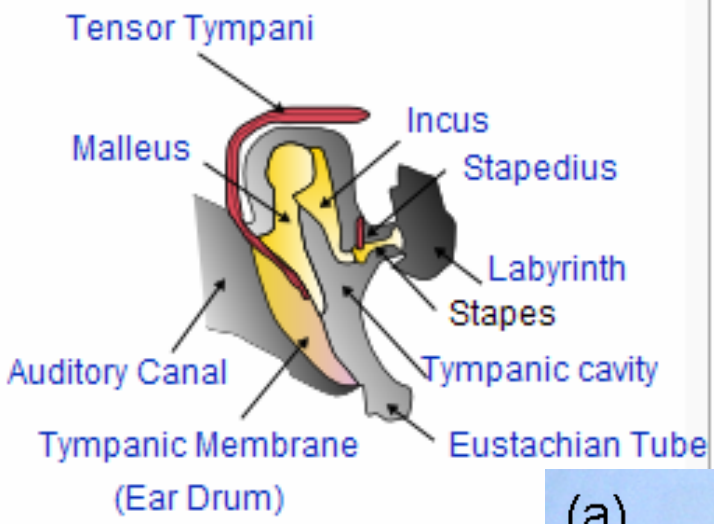
Deposition process



Micro end-mill for machining

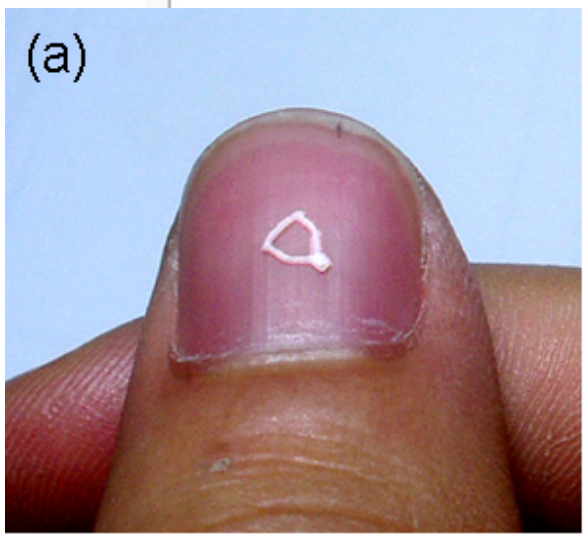
Hybrid machining process

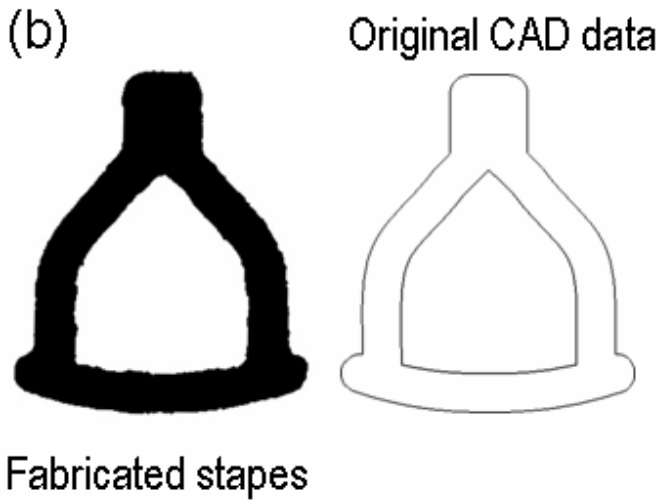
Bio-RP part



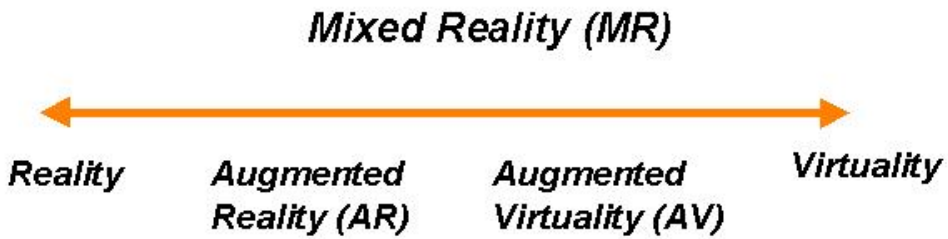
Source: Wikipedia

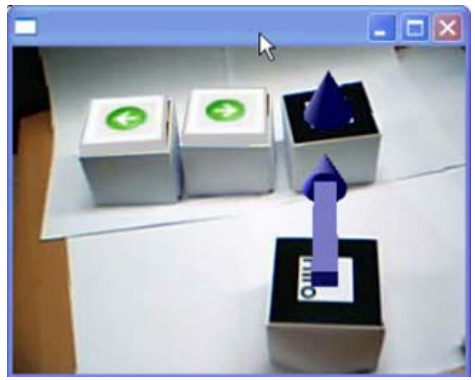
Examples of micro RP – stapes made of hydroxyapatite

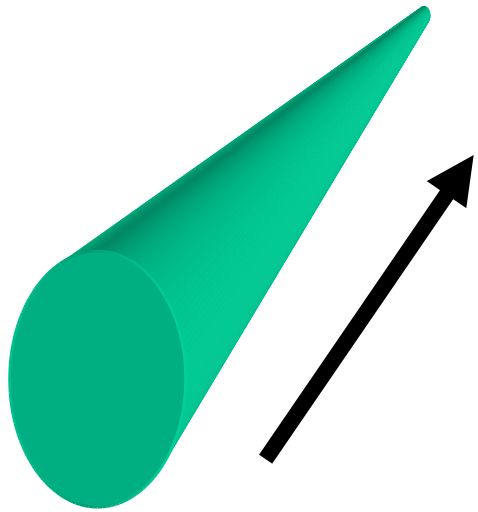




Augmented Reality/Virtual Reality







AR/VR

Movie - Minority report (2002)

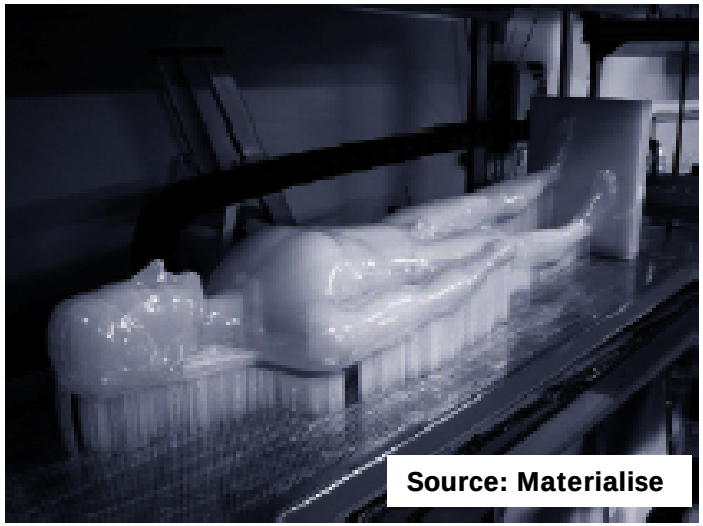
< AR Desktop >

< Magic Book >

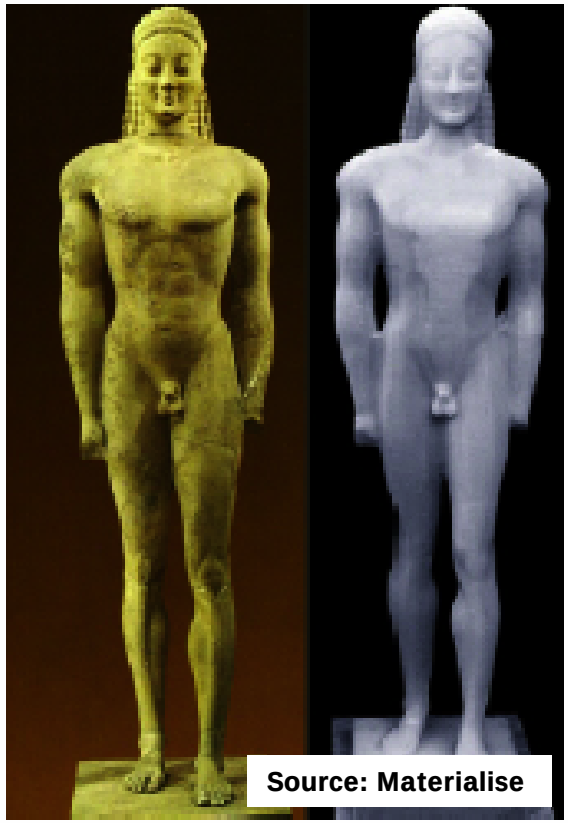
Reverse Engineering

Example of reverse engineering

Copying sculpture



Lifting the kouros out of the Mammoth.

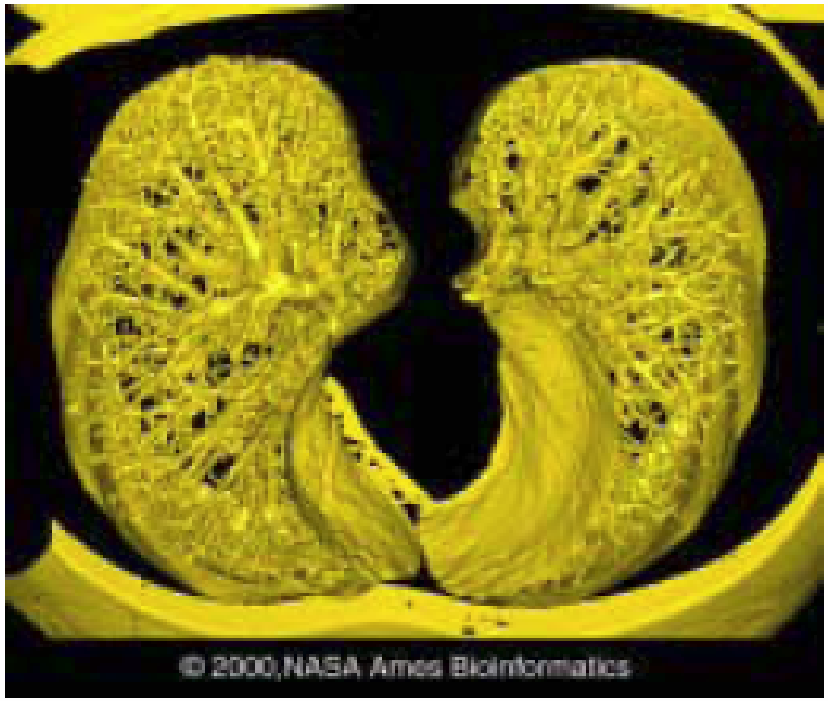


The original Volomandra Kouros and the SLA replica

Replica

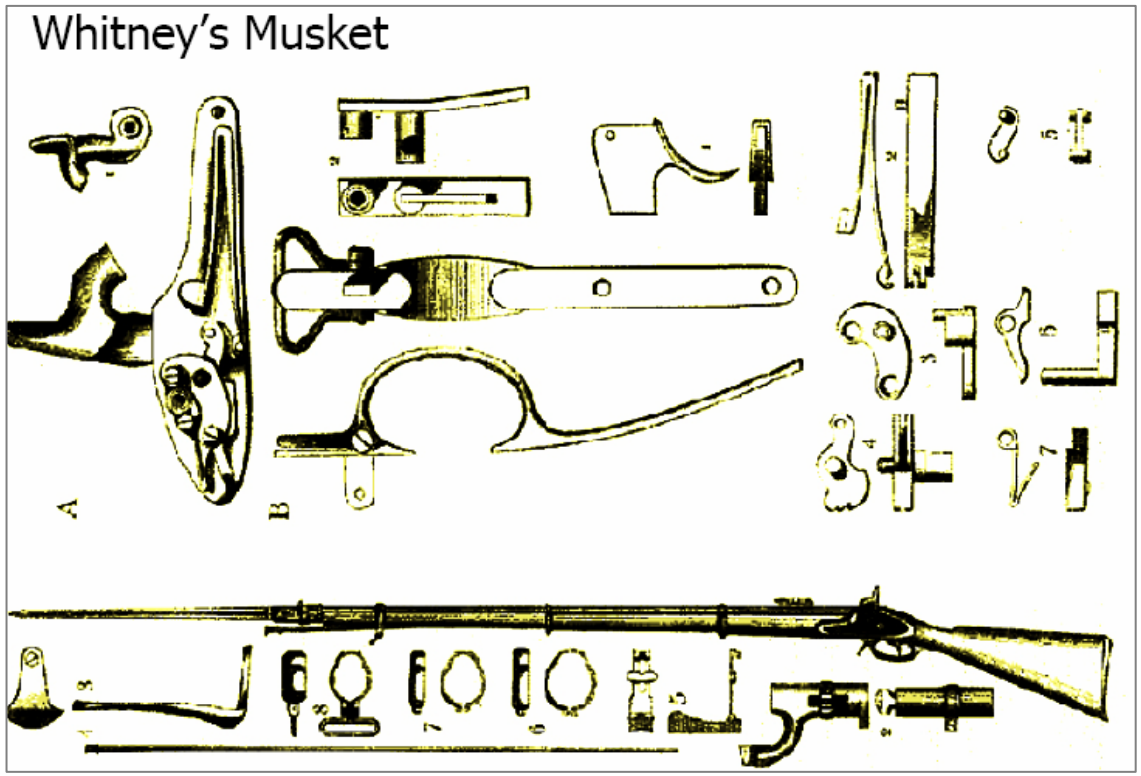
Reverse Engineering

Medical applications

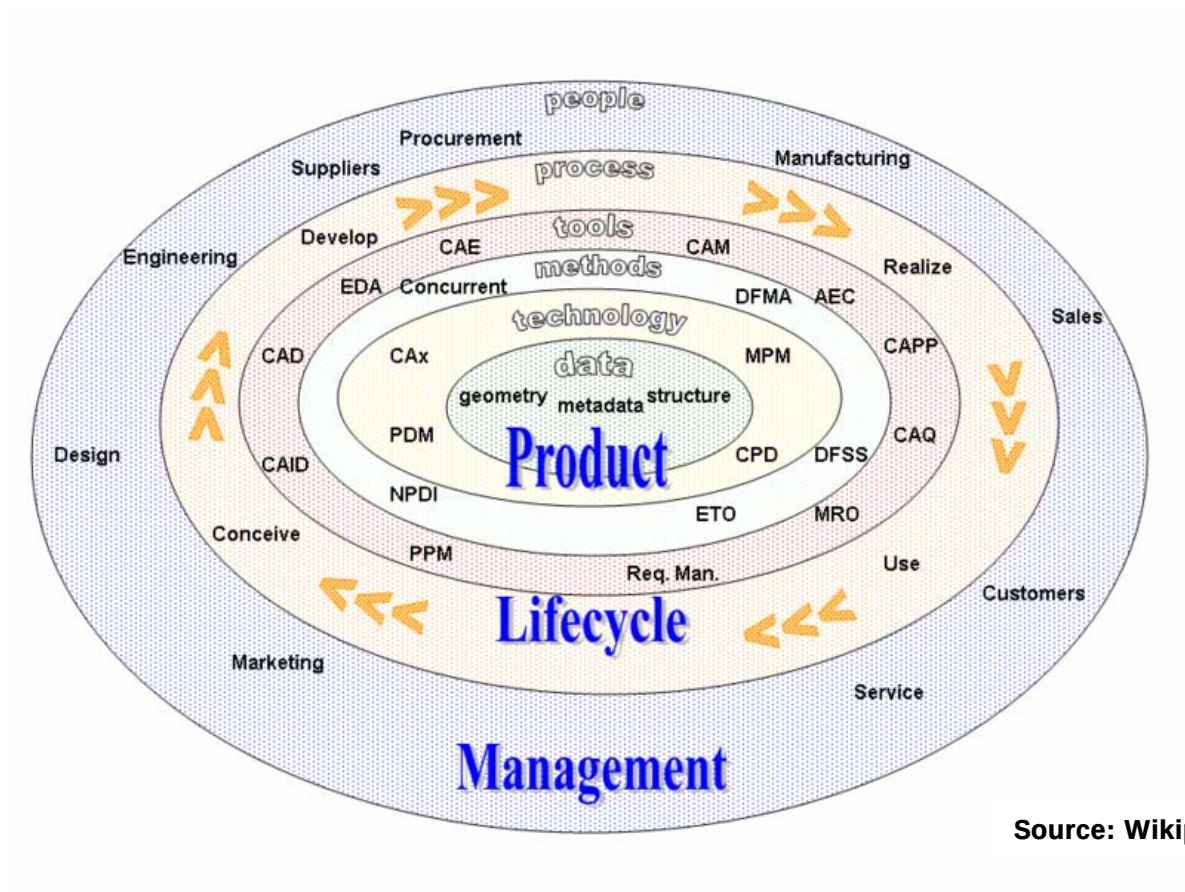


Design For X (DFX)

- ‘X’ can represent:
  - Assembly (DFA)
  - Manufacturing (DFM)
  - Quality (DFQ)
  - Environment (DFE)

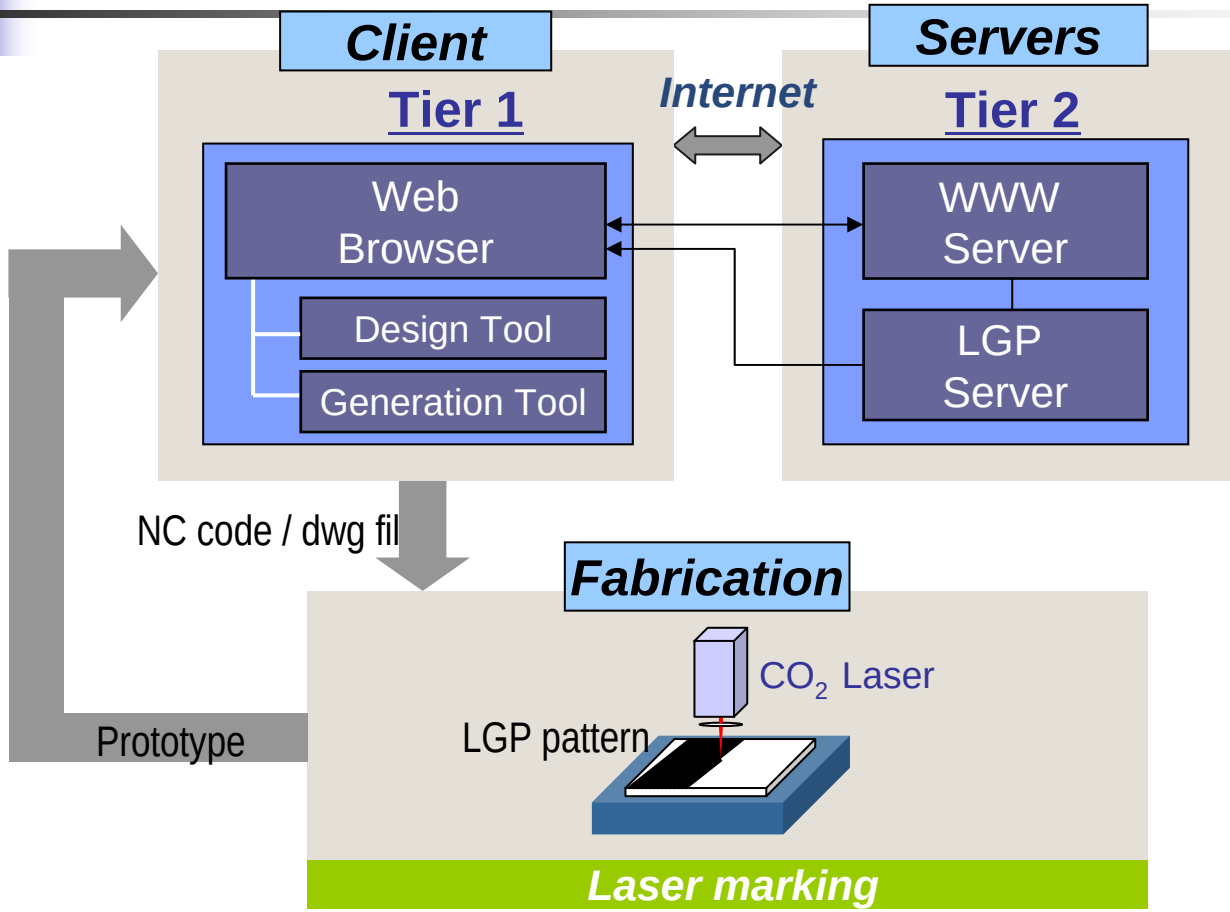


Product Data Management (PDM)



Source: Wikipedia

Web-based Manufacturing Systems



Pattern of LGP (Light Guide Panel) Service

Web-based Manufacturing Systems

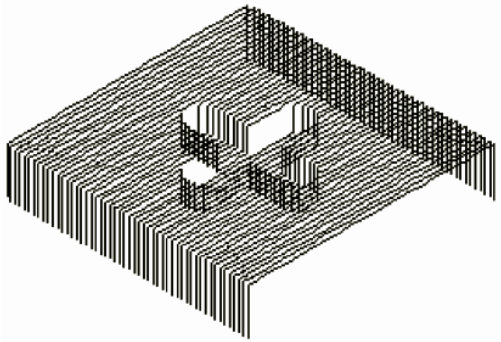
Micro Machining Advisory Service

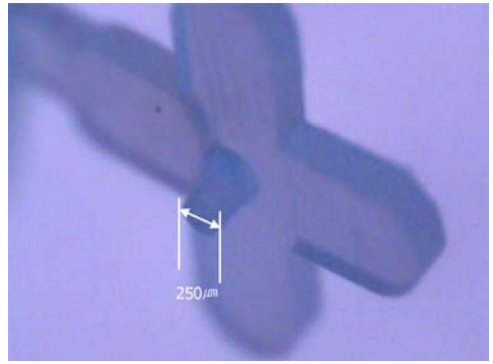
Knowledge based CAD/CAM Lab. All rights reserved.

Home | DFM | Example | Process Information | Manufacturing | Knowledge Base | Links

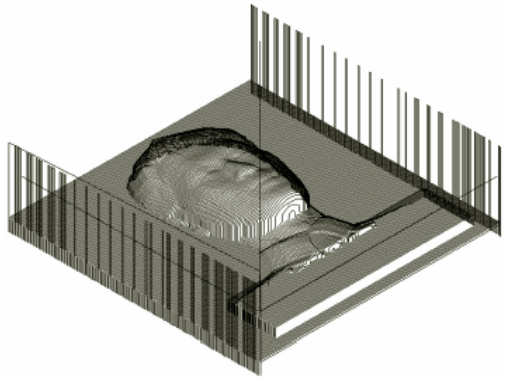
Manufacturing Parameter Input Form

Cut Mode	Scanning (Now only SCANNING available)
Input Model (*.stl)	**test.stl** **Check your uploaded model's name.** (It will changeable 'cause of same model name)
Plane Normal	X 0.0 Y 1.0 Z 0.0
Pattern Type	Zigzag
Tool Diameter	0.127mm
Path Interval	0.5
Cutting Tolerance	0.1
Surface Offset	0.05
Start Point (x,y,z)	X 0.0 Y 0.0 Z 15.0
Clearance Height	Type Abs_Z Value 15.0
Approach Height (Incremental)	2.0
Approach and Exit Type	Xyplane Approach Length 0.0 Exit Length 0.0
Path Connection [D/R/J]	D
Linking Tolerance (between path and path)	0.7
Feed Rate	Surface 800.0 Approach 800.0 First 800.0 Last 800.0 Connection 800.0
Spindle Speed (rev/min)	10000.0
Boundary Machining	Yes ◉ No ○
Roughing	Yes ○ No ◉
Input for Roughing	Stock Height 5.0 Axial Cutting Depth 3.0
	Submit





NC codes and fabricated part I



NC codes and fabricated part II

MIMS (MIcro Machining Service)

The Google Guys

- Started at Stanford (1996)
- Commercialization: search technology for Web pages, facts, quotes, etc. (1998)
- Sales $ 8 billion (2005)

- Google Earth
  http://earth.google.com

Term projects from 2005

- Budget for each team: ₩150,000
- Processes to use
  - Machining
  - Injection molding
  - Rapid Prototyping
  - Laser cutting

Possible subject areas of project

- Product development – new/innovative product from concept to part
- Software using CAD/CAM technology
  - Web-based
  - API of CAD/CAM system
  - Geometric modeling tool
- Proposal from students (group)