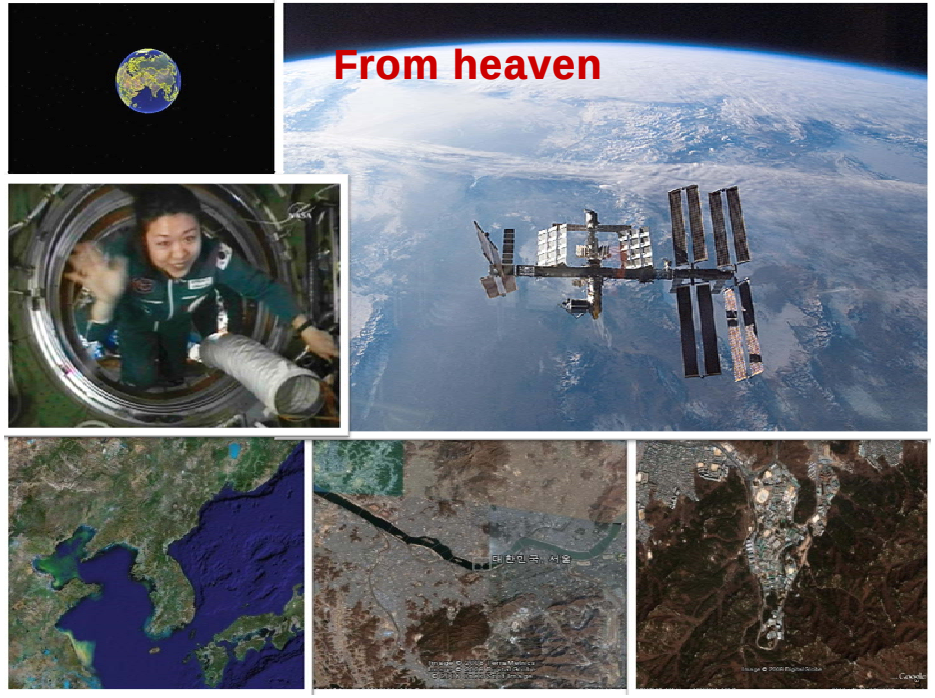
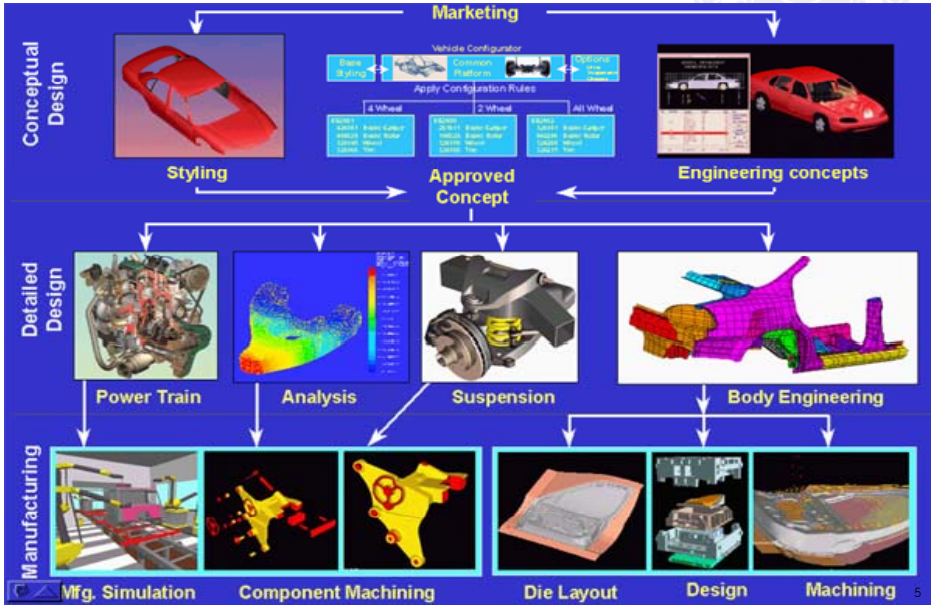
Outline

- Introduction to Design and Manufacturing Process
- Issues to be Covered in CAM
- Examples of CAD to CAM Integration
- Manufacturing Processes
- Manufacturing Equipments and Examples

Photo copyright: Sung-Hoon Ahn



Via the current technologies



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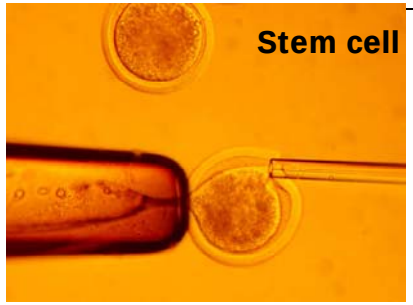
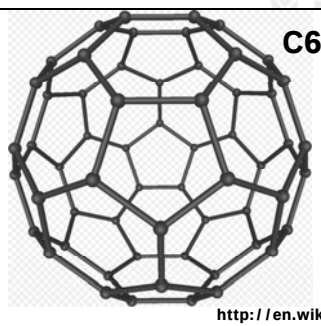
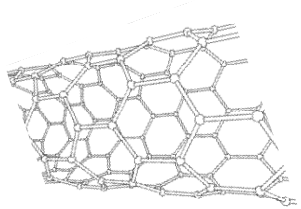




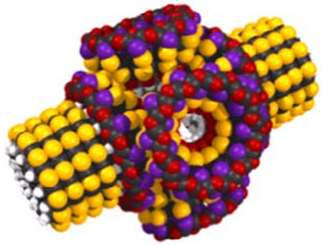
C60 Buckyballs (Fullerene)

http://en.wikipedia.org/wiki/Fullerer

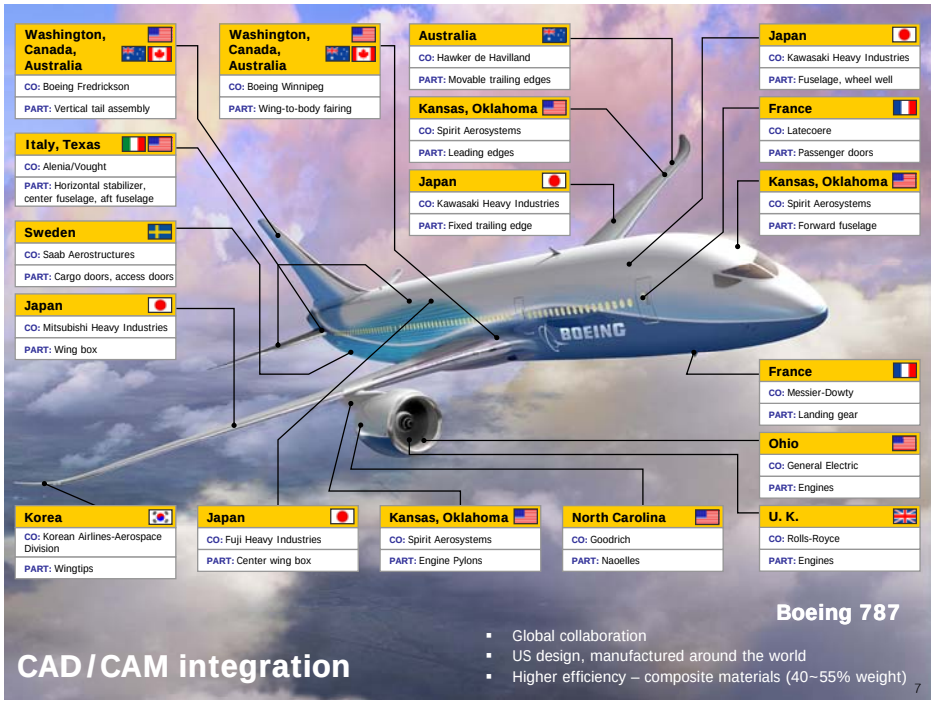


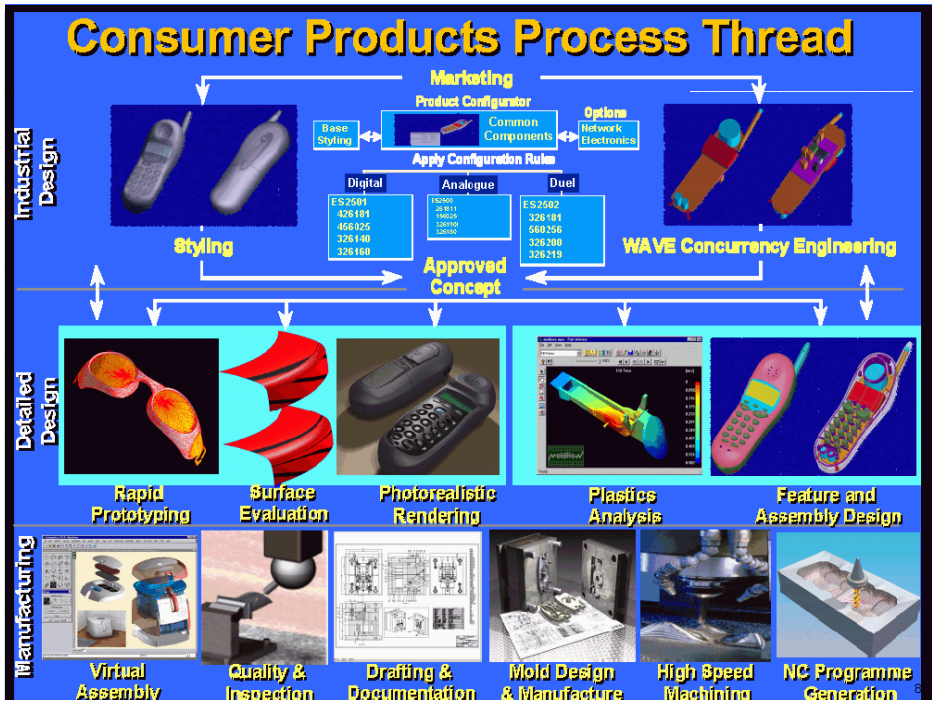
Carbon nanotubes

http://en.wikipedia.org/wiki/Fullerene

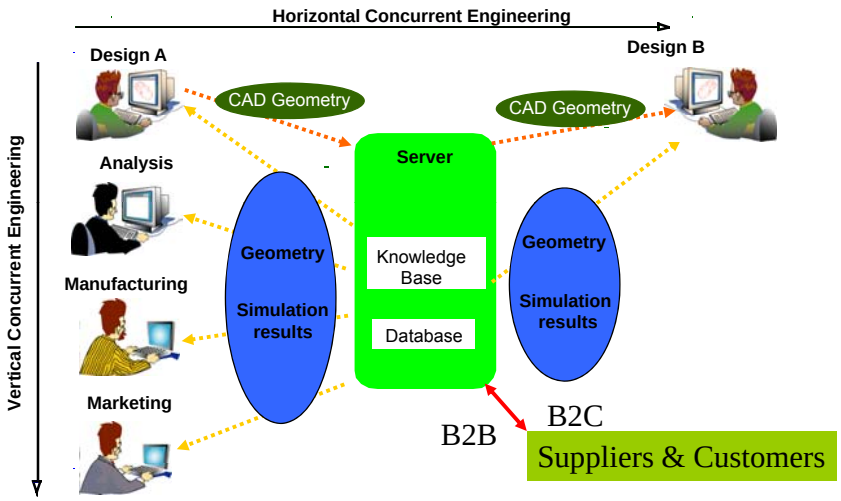


Eric Drexler
Molecular machines





Goal: Shared Engineering



Issues to be covered in CAM

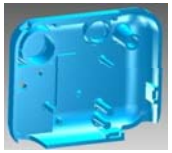
- NC (Numerical Control) Programming
- CAM Software
- Rapid Prototype
- VR/AR
- Reverse Engineering

Example of CAD/CAM integration

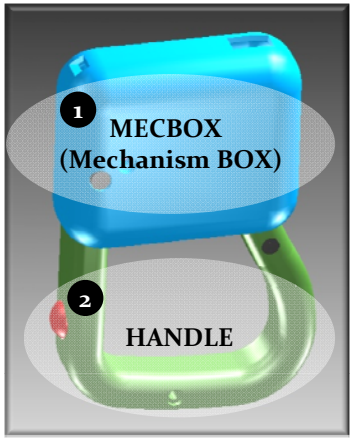
- Scanning
- Surface merging
- NC code generation
- Machining
- Color mapping
- Network-based communication
- … …

Example of CAD/CAM Term Project

- Improved Bus Hanger



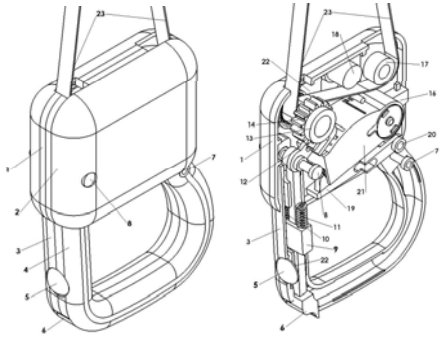




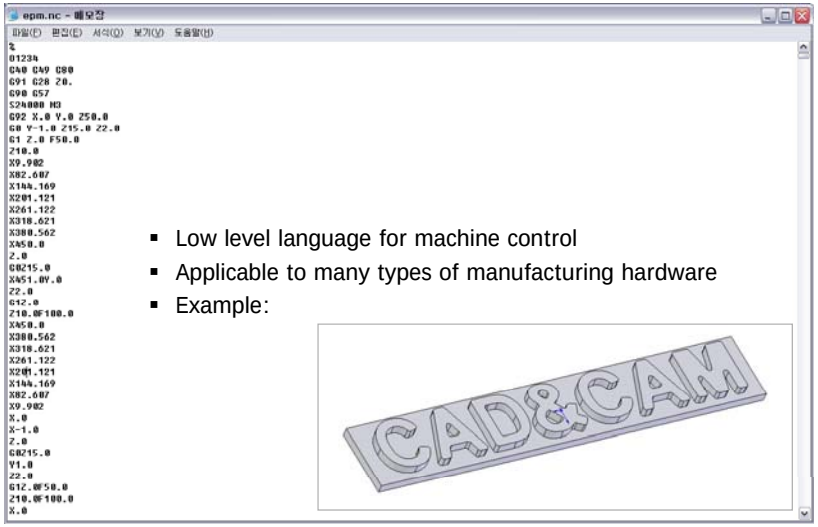
Example of CAD/CAM Term Project

- 실용 신안 출원
  - 자가발전 정차요구 스위치 내장 길이조절 버스손잡이
    (Length adjustable bus handle with stop switch associated private power station)

  - 요약
  - 정차요구 스위치가 부착된 버스용 손잡이의 길이 조절 장치에 관한 발명. 버스를 이용하는 승객들의 다양한 키에 맞춰 버스손잡이의 길이를 조절할 수 있도록 함으로서 버스 탑승시의 편의를 도모하고 더불어 정차요구 스위치를 손잡이 내부에 설치하여 승객이 많아 움직이기 힘든 버스 안에서도 쉽게 정차요구 스위치를 누를 수 있도록 한 장치.

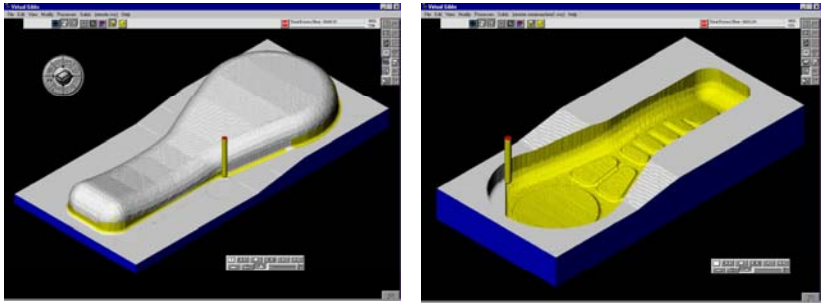


NC code



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

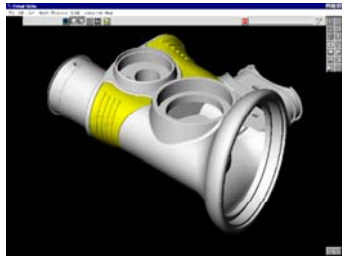
NC (Numerical Control) Programming



(a) Core (b) Cavity

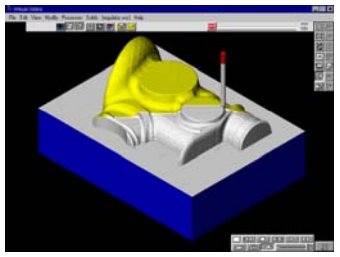
Example of NC programming model (virtual gibbs)

CAD to CAM Interface



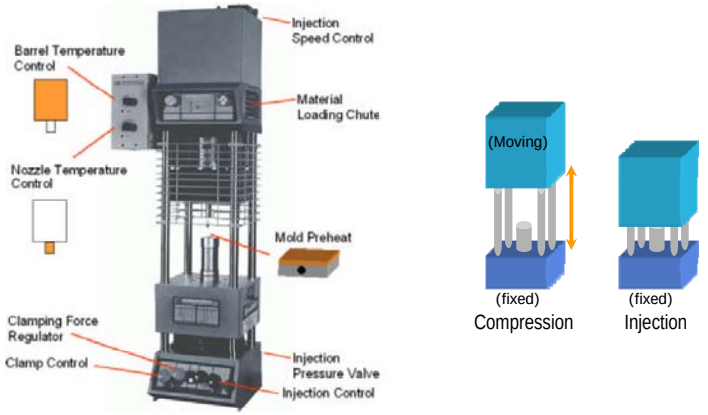
3D CAD (solidworks)

STL, STEP, IGES



3D CAM (virtual gibbs)

Injection Molding



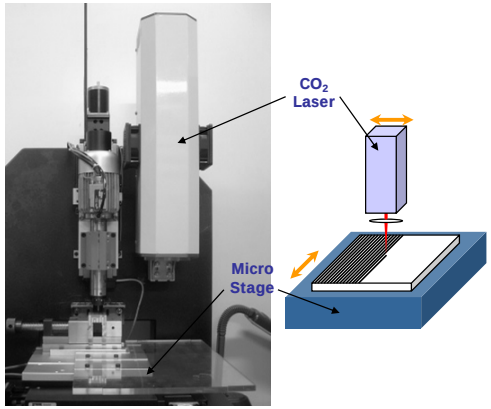
Schematic of the Morgan G-100T Press – not for mass production

Injection Molding

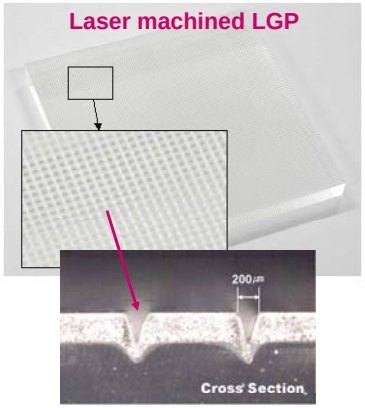
Two-part mold for injection molding

Molded tensile specimens

Laser Machining



3-axis stage for Laser Machining

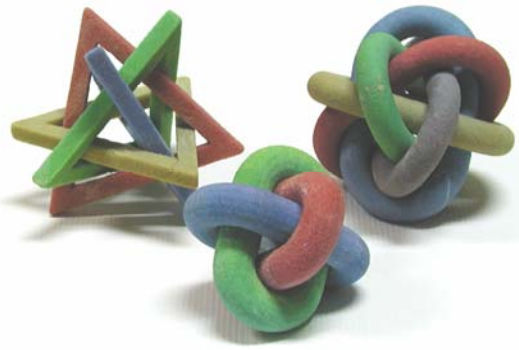


Cross section of grooves (X 100)

Laser cutting

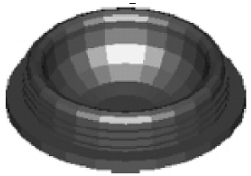
- **2D profile cut**
- **Useful for your class project**

What is Manufacturability?

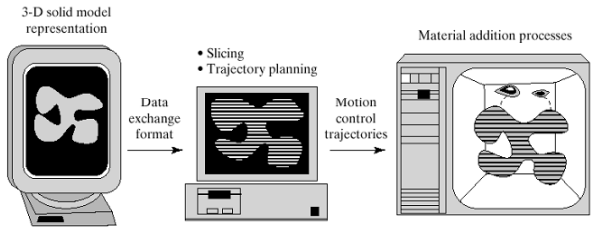


Do you know how to make these parts?

Rapid Prototyping (RP) - concept

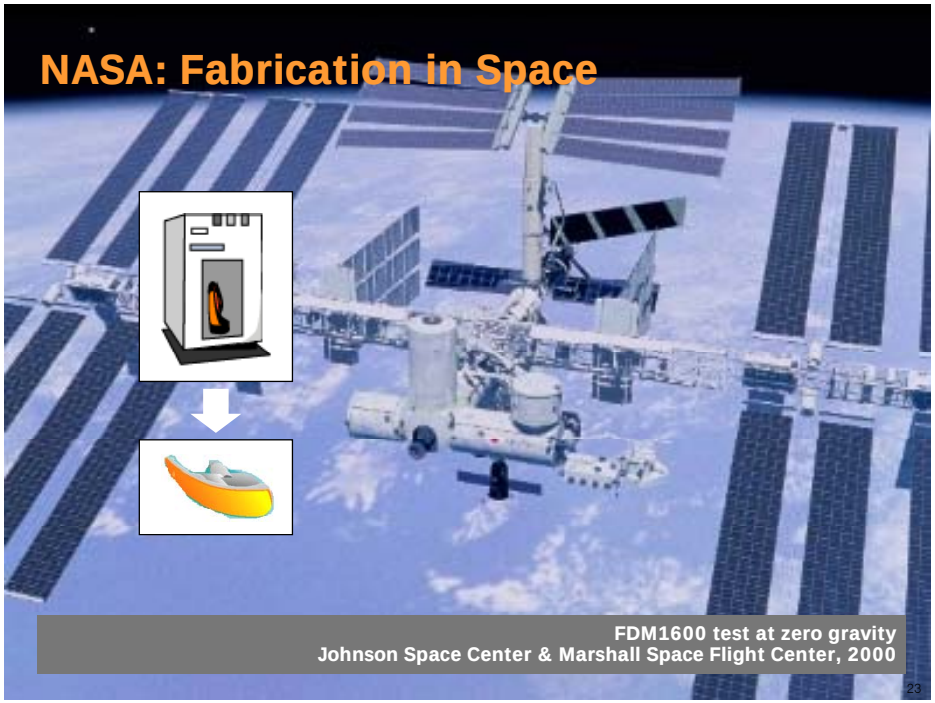


(a)



(b)

NASA: Fabrication in Space



FDM1600 test at zero gravity
Johnson Space Center & Marshall Space Flight Center, 2000

May 31, 2008

- 우주정거장 화장실 수리 펌프 디스커버리호에 탑재

미 항공우주국(NASA)이 31일 발사 예정인 우주왕복선 디스커버리호에 갑자기 고장난 국제우주정거장(ISS)의 화장실을 수리하는 데에 필요한 특수 펌프 등을 급히 싣기로 결정했다.

러시아가 설치해 그간 모든 우주인들이 사용해온 문제의 화장실은 지난 한주간 제대로 작동하지 않고 있다. 현재 ISS에 머물고 있는 남자 우주인 3명은 임시 처리 방법으로 화장실 문제를 해결하고 있으나 이 대안이 대변에만 가능할 뿐 소변에는 적용되지 않아 곤란을 겪고 있다.

이에 러시아에 있는 나사 소속 직원 1명이 0.5m 길이의 특수펌프와 관련 장비를 들고 디스커버리호가 발사 대기 중인 플로리다주 케네디센터로 향했다. 장비는 모두 16kg으로 외교행낭에 넣어 특별기 편으로 운송됐다. 나사는 화장실 펌프를 운송할 공간을 확보하기 위해 예비용으로 준비한 여분의 산소조절기와 세균 박멸 장비 등을 탑재하지 않기로 했다.

디스커버리호의 탑재량 관리책임자인 스콧 히긴보덤은 "화장실을 작동하게 하는 것이 최우선 과제이므로 앞으로 6개월간 긴급히 필요하지 않을 것으로 예상되는 물건을 빼내 화장실 펌프를 실을 공간을 확보하기로 했다"! 고 말했다.

June 4

- 국제우주정거장 고장난 화장실 변기 수리

국제우주정거장(ISS)에 머물고 있는 우주인들이 이제 마음껏 '볼 일'을 볼 수 있게 됐다.

ISS의 우주인들이 4일 고장난 화장실 변기를 수리한 것.

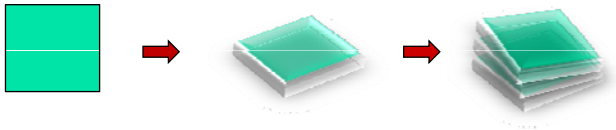
러시아의 비행 엔지니어 올레그 코노넨코가 지난주 우주왕복선 디스커버리호로 긴급 공수된 펌프를 설치하자 변기가 정상적으로 작동했다.

ISS에 체류 중인 3명의 우주인은 그동안 단 하나뿐인 변기가 고장나 곤란을 겪었다. 변기가 고장난 뒤 우주인들은 지난 2주간 물을 더 사용해 변기 물을 내려야 했다.
ISS의 화장실 고장은 전 세계인들에게도 큰 관심사였다.

최근 미국 항공우주국(NASA) 기자회견에서도 ISS 화장실 문제가 주요 화제로 올랐다.

NASA의 커크 샤이어먼 ISS 담당 부책임자는 지난 3일 "화장실 이야기를 하는 것이 유감스럽지만 이는 생활이자 인류 우주탐험의 미래"라고 말했다.

From 2D to 3D printing



2D face

2.5D Prismatic plate

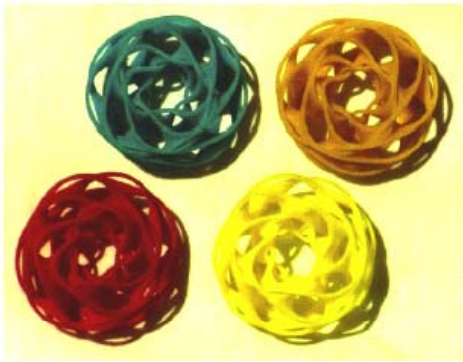
3D structure

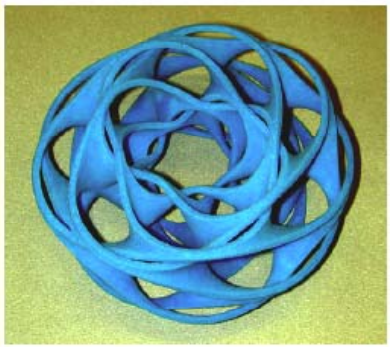
Design for Manufacturing (DFM)

- **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

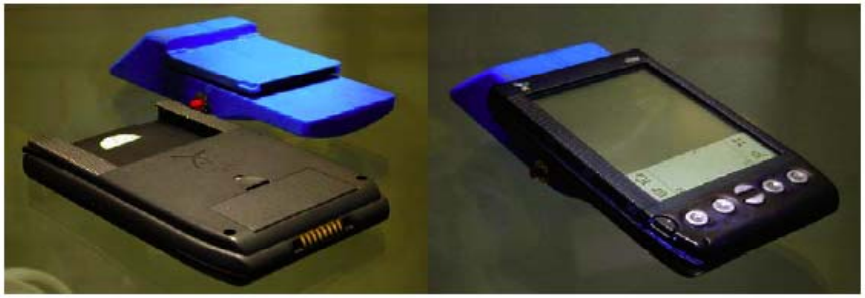
Color parts fabricated by rapid prototyping





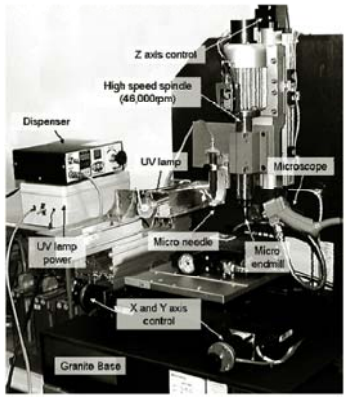
RP Parts

GPS module for PDA

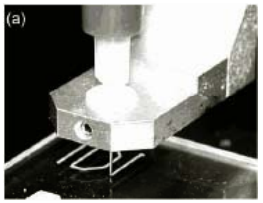


Micro RP for Nano Composite

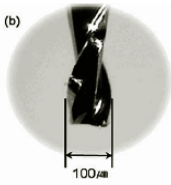
- **Hybrid Rapid Prototype**



Micro stage for hybrid RP



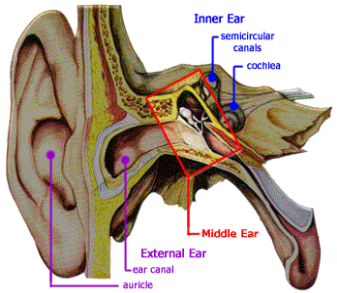
Deposition process



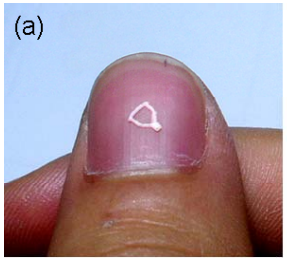
Micro end-mill for machining

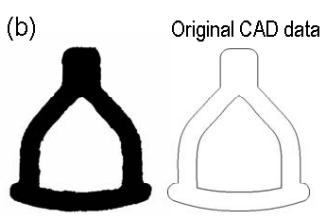
Hybrid machining process

Bio-RP part



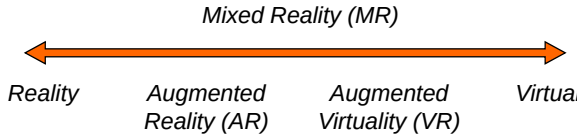
Examples of micro RP – stapes made of hydroxyapatite





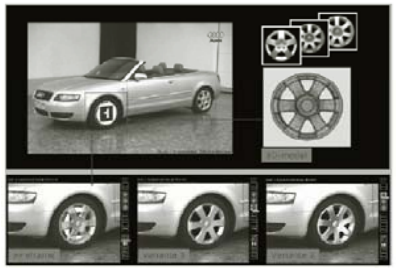
Fabricated stapes

Augmented Reality / Virtual Reality

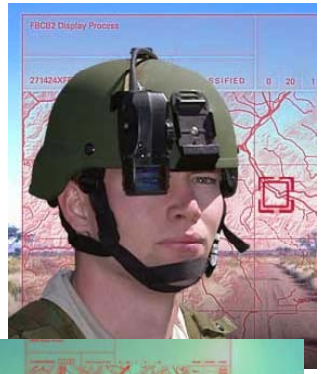


AR/VR

- **Examples of AR/VR solution**



(a) Design option



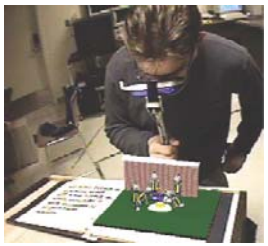
(b) Repair/Service

(c) Military operation

AR/VR

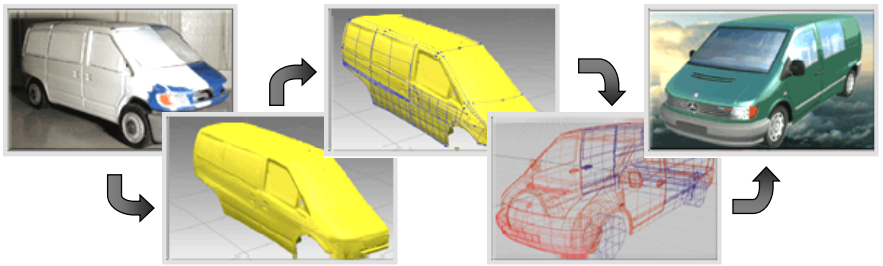
Movie – Pirates of Caribbean

AR Desktop



Magic Book

Reverse Engineering



Example of reverse engineering

Copying sculpture

- **Materialize of arts**

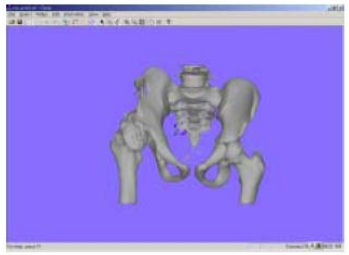
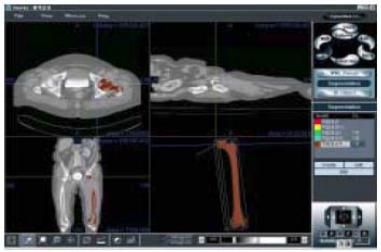
Lifting the kouros out of the Mammoth

The original Volomandra Kouros and the SLA replica

Replica

Reverse Engineering

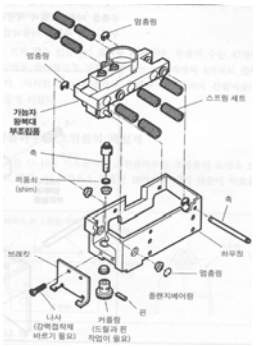
- **Medical applications**

Design For X (DFX)

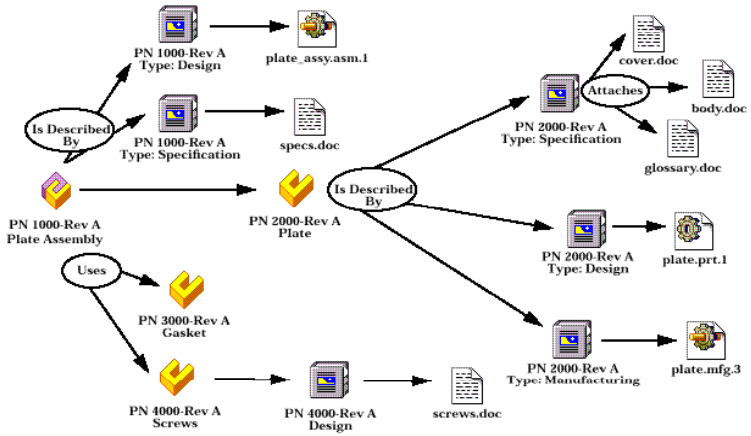
- **'X' can represent:**
  - Assembly (DFA)
  - Manufacturing (DFM)
  - Quality (DFQ)
  - Environment (DFE)

	Original	Redesign	Improvement (%)
Ass. Time (hr)	2.015	0.33	84.7
Kind of parts	24	8	66.7
No. of parts	47	12	74.5
No. of process	58	13	77.6
Metal work (hr)	12.63	3.63	71.1
Weight (lb)	0.48	0.26	45.8


DFA


Product Data Management (PDM)

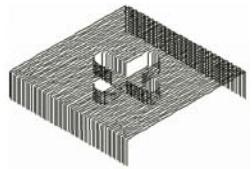
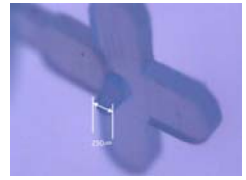
- **A productivity tool for an entire business enterprise that manages all product-related information**

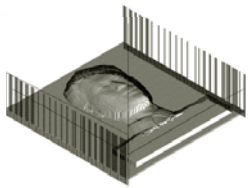


Web-based Manufacturing Systems

- **MIMS (MIcro Machining Service)**

UI – Web browser

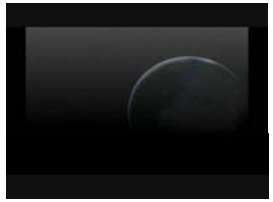


NC codes and fabricated part I



NC codes and fabricated part II

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 2006

- **Budget and used process for each team**
  - RP
  - Machining
  - Injection molding
  - Laser cutting

Manufacturing cost to use RP

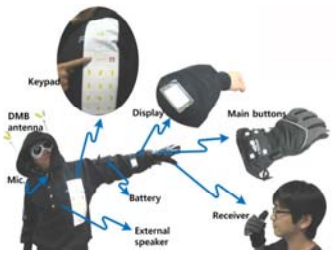
No.	Team	RP
1	IPO (Infinity Plus One)	**70,000**
2	C4	**90,000**
3	For The Reality	**10,000**
4	SK^3 SYSTEM	
5	KIMCHI International	**55,000**
6	C.A.D. (Creative, Active, Dynamic)	
7	Progressive	**60,000**
8	JiBrother	
9	∞	**40,000**
10	CAER UNITED	
11	H.A.D. (Human Aided Design)	**100,000**
12	GAUSS	
13	S-team♨	**80,000**
14	F.A.N. (For All Nations)	**200,000**
15	F.T.P. (For the Team Play)	**70,000**

Term project CAD CAM 2009

- **Form a group**
  - 3 or 4 members in each group
- **How to form a group**
  - Skills
  - Experience
  - Personality
- **Project subject proposal**
- **Making plans and schedule**

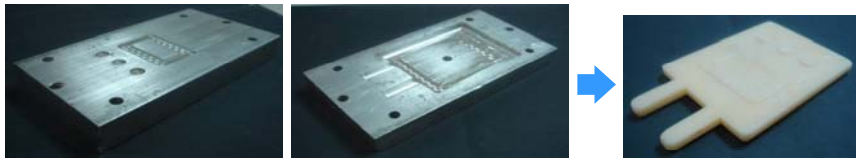
Possible subject areas of project

- **Rehabilitation engineering**
- **Sports engineering**
- **Bio-medical engineering**
- **Examples of DFM 2009**

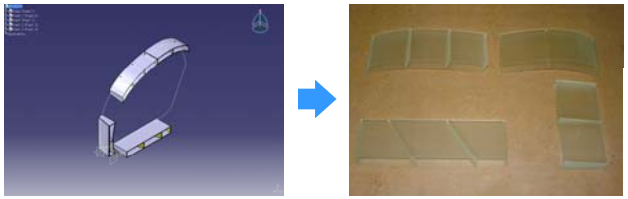


Cost examples in manufacturing

- **Injection molding: about 50,000 won**
  - 30 x 30 x 6, core & cavity



- **Rapid Prototyping: about 220,000 won**
  - 10 x 40 x 40 ~ 150 (x 4 pieces)

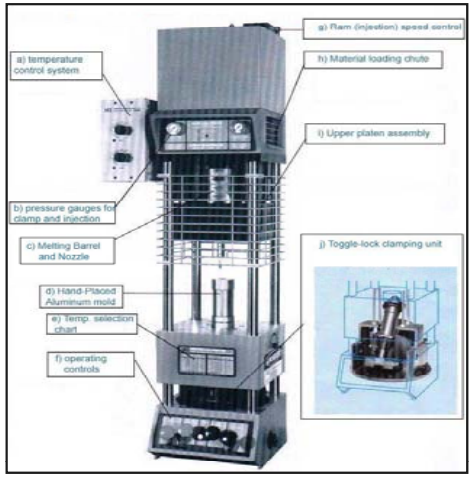


Materials for prototypes

- **Metal**
  - Aluminum
  - Steel
- **Acrylate board**
- **Wood**
- **ABS**
  - Injection molding
- **(Standard parts)**

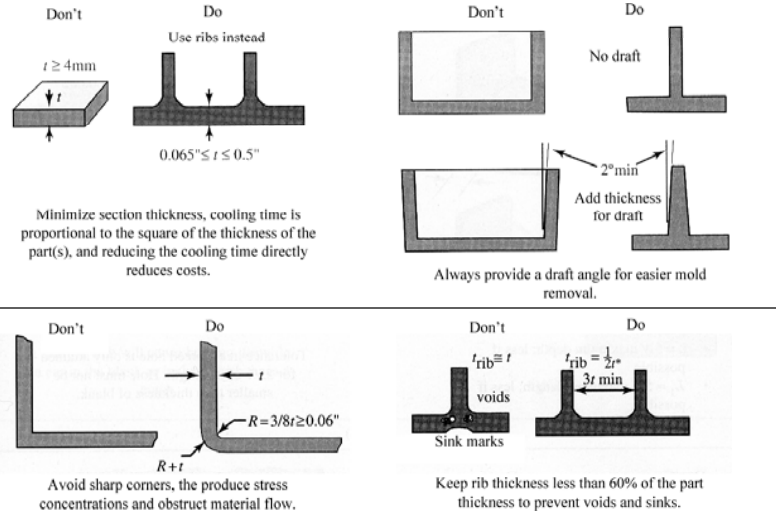
Manufacturing Equipments

- **Injection Molding**
  - Morgan G-100T Press
  - In IDIM lab.
    301- Room 1255-1
  - 6 cu. in. (4 oz.) Max.
  - Single shot 20 ton max.
  - Clamping force (toggle).
  - 12,000 psi max.
    injection pressure



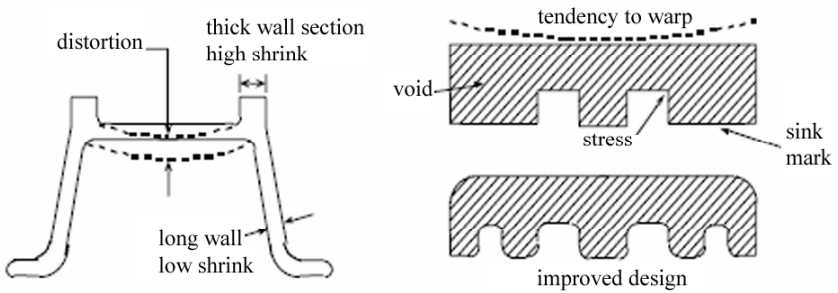
< Schematic of the Morgan G-100T press >

DFM in Injection Molding



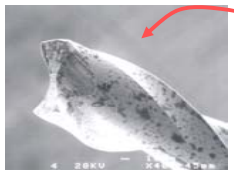
DFM in Injection Molding (cont.)

- **Avoid thick "hot spots"**



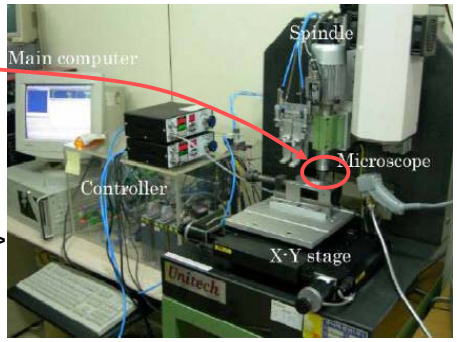
Manufacturing Equipments (cont.)

- **3 axis machining – macro / micro scale**
  - 301- Room 1255-1



< 100 mm endmill >

< Micro endmills >

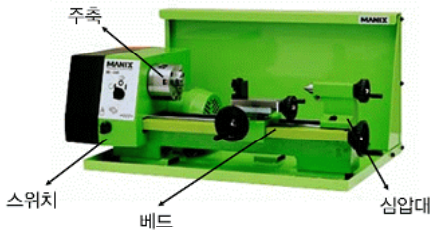


< Precision 3-axis stage >

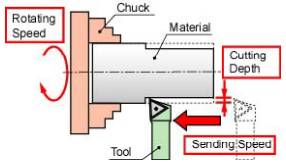
- Standard input: STL
- High spindle speed: 46,000 RPM
- Resolution of x-y-z stages: 1 micrometer
- Tool material: HSS (TiN / Diamond) coating
- Work piece: Metal, Polymer, etc.

Manufacturing Equipments (cont.)

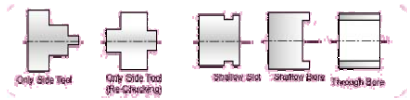
- **Table lathe**
  - For small scale part
  - 301- Room 1255-1



< Table lathe >



< Basic operation >

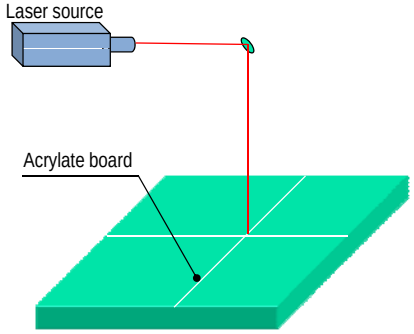


< Machined part >

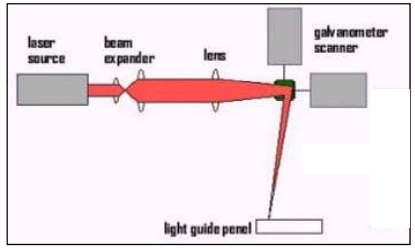
Manufacturing Equipments (cont.)

- **Manual Milling machines and Lathes**
  - for large scale parts

Laser Cutting – new for this year



< Laser cutting process >



< Operating diagram >