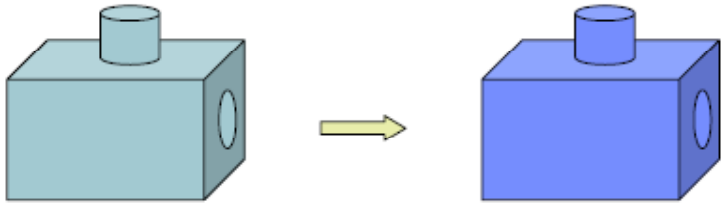
Outline

From Design to Manufacturing

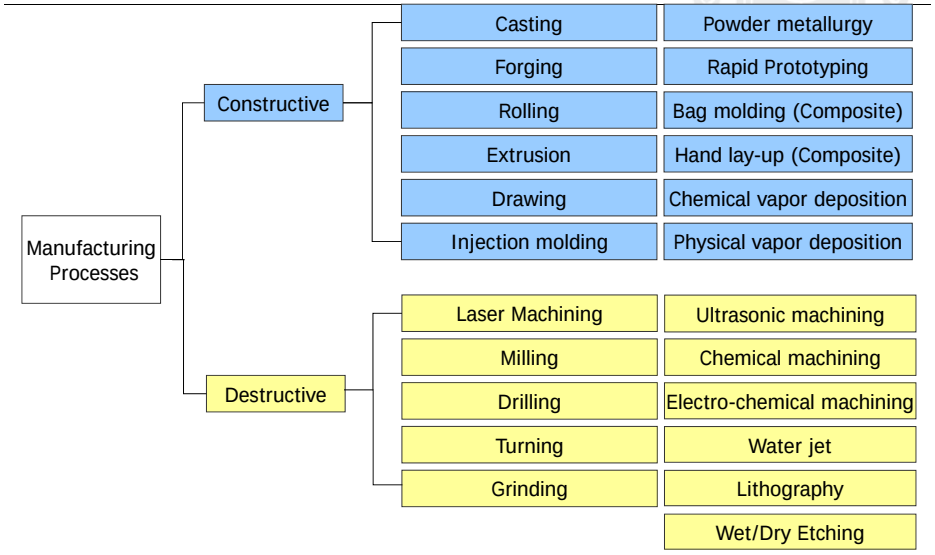
- **Now we are in the Manufacturing domain**



Design domain:
How to create geometry

Manufacturing domain:
How to make part
Need to consider
- Manufacturing process
- Material
- Machine

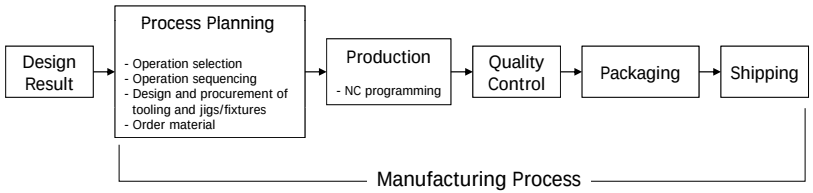
Taxonomy of Manufacturing Processes



Example Product: Self-made Vehicle

Computer-Aided Manufacturing (CAM)

- **Definition**
  - The technology concerned with the use of computer systems to plan, manage, and control manufacturing operations through either direct or indirect computer interface with the plant's production resources.



< Main Phases of discrete part manufacturing >

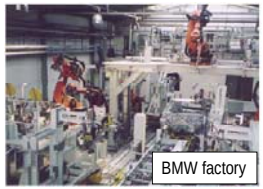
CAM Software

- **NC software**
  - NC is a system in which actions are controlled by direct insertion of numerical data at some point. The system must automatically interpret at least some portion of this data

    - Electronic Industries Association (EIA)
  - Computer Numerical Control (CNC)

- **Robot programming software**
  - Selecting and positioning tools and work-pieces for NC machines


Hyundai factory


BMW factory

CAM Software (cont.)

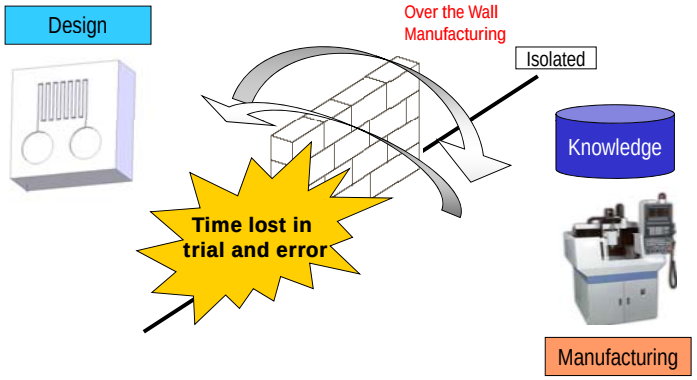
- **Process planning software**
  - The act of preparing detailed work instructions to machine or assemble a part of parts

    - Computer-Aided Manufacturing, Chang et al., 1998
  - Process plan; operation sheet; route sheet
  - Computer-Aided Process Planning (CAPP)

- **Inspection software**
  - Coordinate Measuring Machine (CMM)

Problems in Traditional Production

- **Some barriers Between design and manufacturing process**

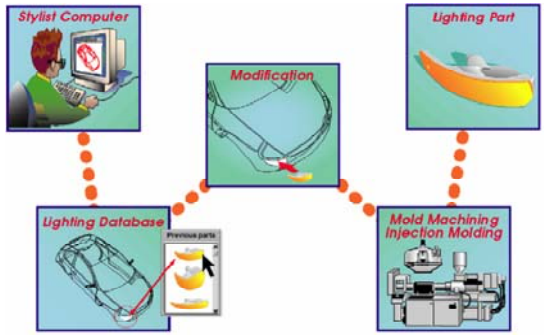


< Diagram of tradition design and manufacturing process >

CAD/CAM Integration

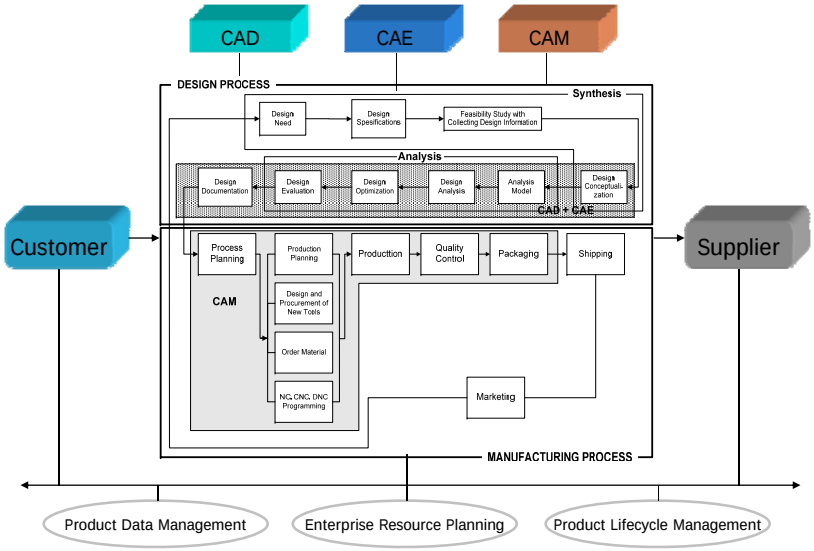
- **Goal of integration**
  - To facilitate coordination of work and information flow across organizational boundaries

– "Enterprise Integration Modeling", Charles J. Petrie, The MIT Press

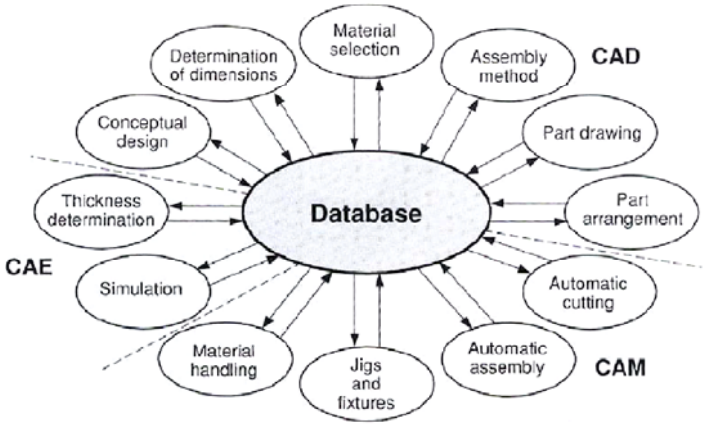


< Example concept of CAD/CAM integration >

Integration in Product Cycle Level



Integration in Database Level



Integration in Commercial Package Level

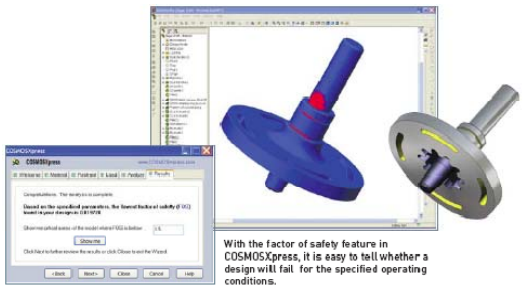
- **Integrated CAD/CAE/CAM/PDM/...**
- **All in one package**
  - Dassult systems: CATIA, DELMIA, INOVIA...
    SolidWorks, CosmosWorks...
  - PTC: Pro/Engineering, Windchill...
  - UGS: Unigraphics, Teamcenter, Technomatix...

Trends of Commercial Solutions

- **Dassault systems: CATIA**

Trends of Commercial Solutions (cont.)

- **Dassault systems: SolidWorks**
  - COSMOSXpress; simple analysis
  - COSMOSWorks Designer; simulation



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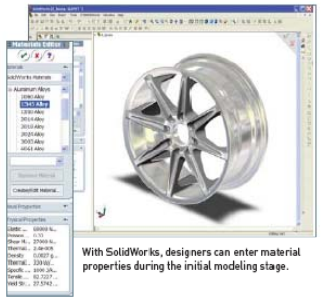


< COSMOSWorks Designer >

Trends of Commercial Solutions (cont.)

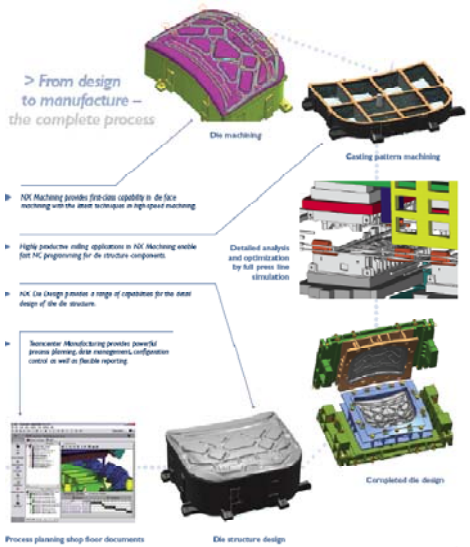
- **PTC: ProEngineering**

- 2D sketching
- 3D modeling
- Drawing
- Freeform surfacing
- Large Assemblies
- Analysis
- Simulation
- Sheetmetal
- CAM
- Data sharing
- Maintenance
- ...

Trends of Commercial Solutions (cont.)

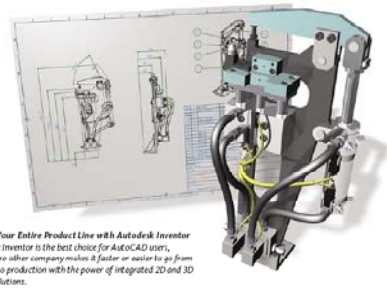
- **UGS: NX (Unigraphics)**
  - All in NX

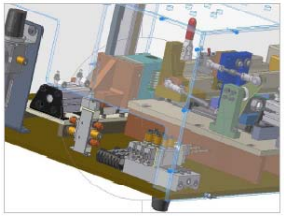
< Main concept >



Trends of Commercial Solutions (cont.)

- **Autodesk: Inventor**
  - Move to 3D from 2D (AutoCAD)
  - Content center
  - Virtual prototyping
  - Bill of Material (BOM)





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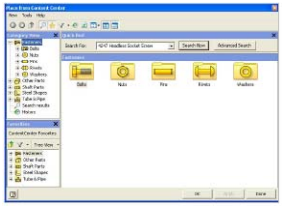
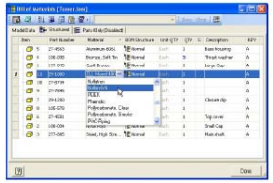


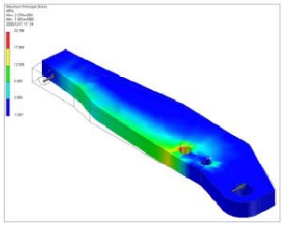
< Virtual prototyping >



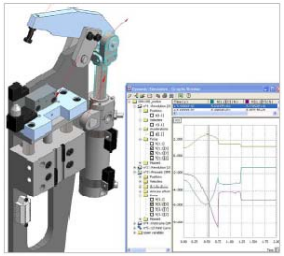
< Bill of Material (BOM) >

Trends of Commercial Solutions (cont.)

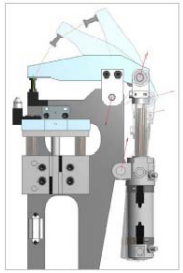
- **Embedded CAE ANSYS & Solid Dynamics**
  - Stress analysis (ANSYS)
  - Dynamic Simulation (Solid Dynamics)
  - 3D visualization (Solid Dynamics)



< Stress analysis >



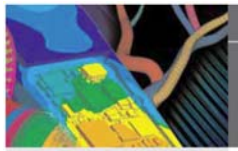
< Dynamic Simulation >



< 3D visualization >

Trends of Commercial Solutions (cont.)

- **ANSYS**
  - Multi-physics Analysis software
  - CAD supporting in pre-processing



	Complete Simulation Solutions									Meshing Solutions		
	Multiphysics™	Mechanical™	Structural™	Professional™	DesignSpace®	Emag™	CFX®	EDM®[C-12]	LS-DYNA™	Advanced Meshing	CFX® PrepPost™	ANSYS® PrepPost™
Pre-Processing												
Solid Modeling	•	•	•	•		•		•	•			•
Defeaturing	•	•	•	•		•		•	•			•
IGES Geometry Transfer	•	•	•	•		•		•	•			•
Geometry Repair	•	•	•	•		•		•	•			•
Topology Diagnosis										•		
Faceted Data Handling										•		
Mid-Surfacing	•	•	•	•				•	•			•
Variable Thickness Mid-Surfacing										•		
Tetra/Prism Meshing							•			•	•	
Structured Hex Meshing										•		
Automatic Free-Meshing	•	•	•	•	•			•	•	•		•
Automatic Hex-Meshing	•	•	•	•	•			•	•	•		•

Trends of Commercial Solutions (cont.)

- **ALGOR**
  - Multi-physics Analysis software
  - Direct CAD support

CAD Support (Direct)	Multiphysics	MES	Static/NLM	CFD	Designer	Static/LM	PipePak	Civil	ALG/NASTRAN	FEMPRO
Alibre Design	✓	✓	✓	✓	✓	✓			✓	✓
Autodesk Inventor	✓	✓	✓	✓	✓	✓			✓	✓
CADKEY	✓	✓	✓	✓	✓	✓			✓	✓
KeyCreator	✓	✓	✓	✓	✓	✓			✓	✓
Mechanical Desktop	✓	✓	✓	✓	✓	✓			✓	✓
Pro/ENGINEER	✓	✓	✓	✓	✓	✓			✓	✓
Rhinoceros	✓	✓	✓	✓	✓	✓			✓	✓
Solid Edge	✓	✓	✓	✓	✓	✓			✓	✓
SolidWorks	✓	✓	✓	✓	✓	✓			✓	✓
Full Associativity	✓	✓	✓	✓	✓	✓			✓	✓
Captures Exact Assembly or Part Geometry without File Translation	✓	✓	✓	✓	✓	✓			✓	✓
User-Controlled Feature Suppression	✓	✓	✓	✓	✓	✓			✓	✓

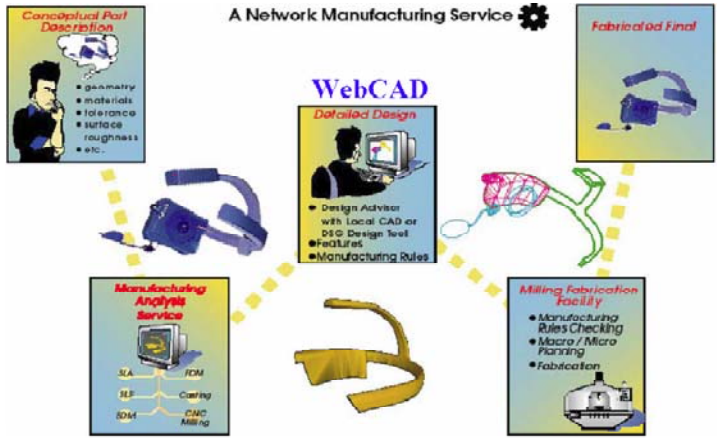
Coupling Modes in Integration

- **There are 3 types of coupling modes between design and manufacturing**

Coupling Mode	Pros	Cons	Example
Loose / Repetitive	Flexible design	Cost & delay for redesign	Conventional CAD/CAM
Stiff / One-way	Guaranteed Manufacturing	Less design freedom	CyberCut, MOSIS
Strong / Bidirectional	Moderately flexible design, guaranteed manufacturing	Some loss of design freedom	SmartLite, SmartFab

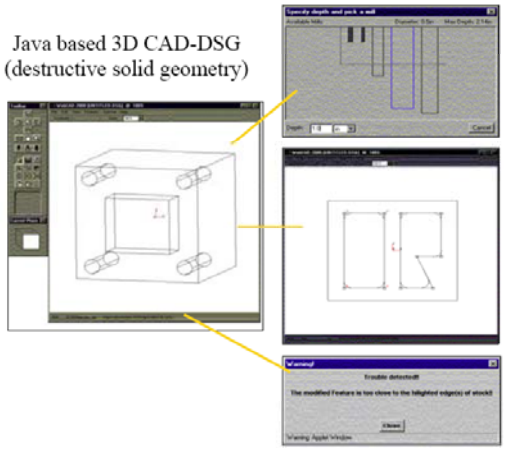
Example Solutions of Stiff mode

- **CyberCut paradigm**



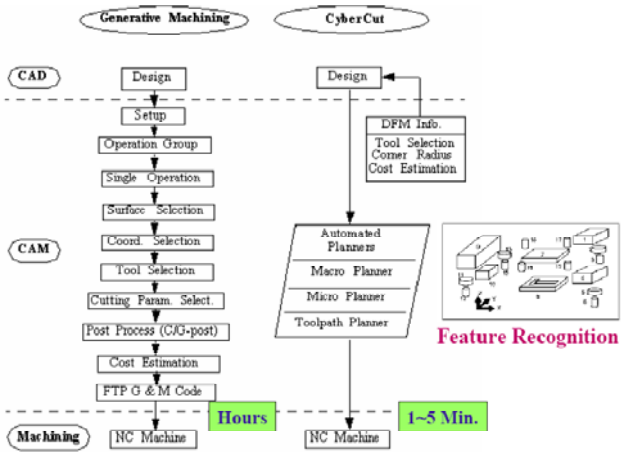
Example Solutions of Stiff mode (cont.)

- **CyberCut – Feature 1. WebCAD**



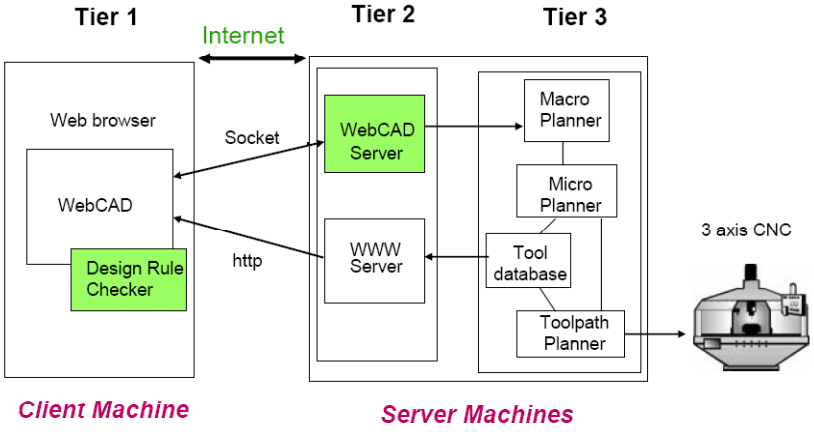
Example Solutions of Stiff mode (cont.)

- **CyberCut – Feature 2. Automated Process Planning**



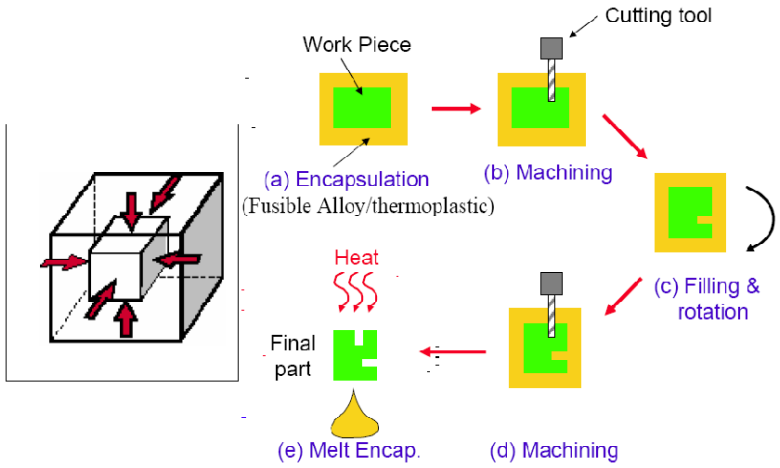
Example Solutions of Stiff mode (cont.)

- **CyberCut – Network communication**



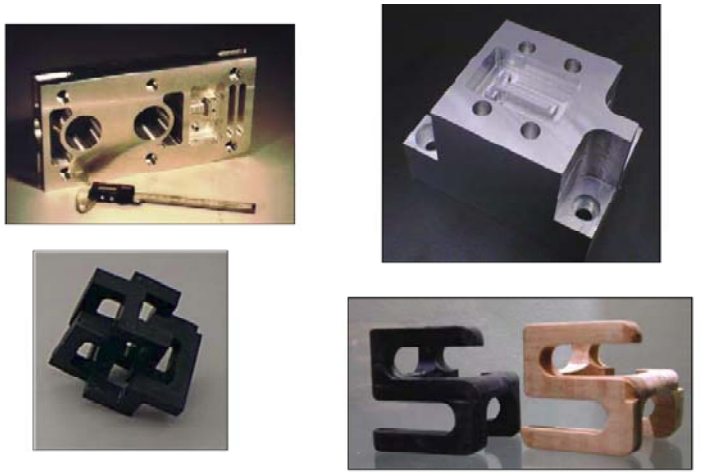
Example Solutions of Stiff mode (cont.)

- **CyberCut – Feature 3. Universal fixture**



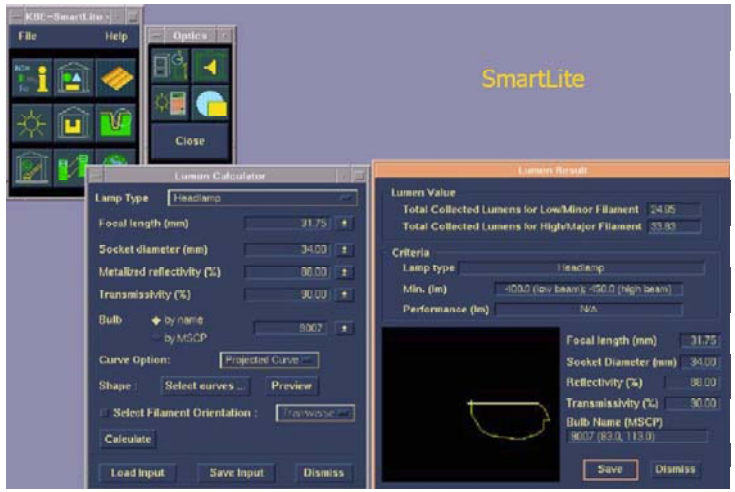
Example Solutions of Stiff mode (cont.)

- **CyberCut – Fabricated parts**



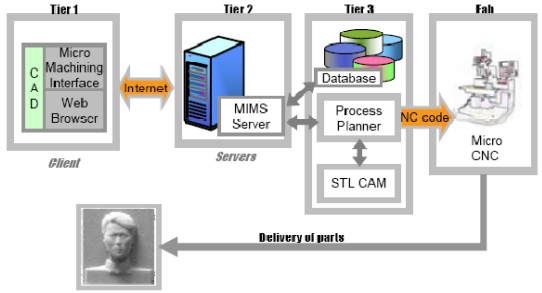
Example Solutions of Strong mode (cont.)

- **SmartLite: I-DEAS based tools**

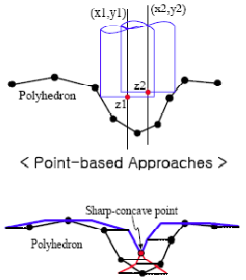


Web-based CAD/CAM Integration

- **Micro Machining System (MIMS)**
  - Micro machining service using the internet
  - Communication with 3-tier client-server model
  - Upload STL file



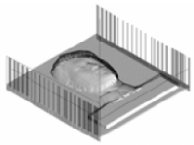
< Communication architecture >



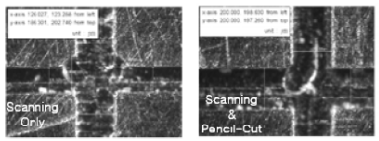
< Curve-based approaches >

Web-based CAD/CAM Integration (cont.)

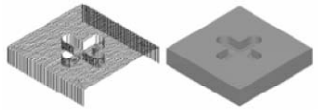
- **Micro Machining System (MIMS)**
  - Provide the NC code viewer
  - Fabricated by micro-endmill according to scanning and pencil-cut toolpath



< G&M codes on NC code viewer >

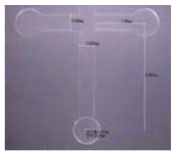


< Micro channel >



< Two types of toolpath >

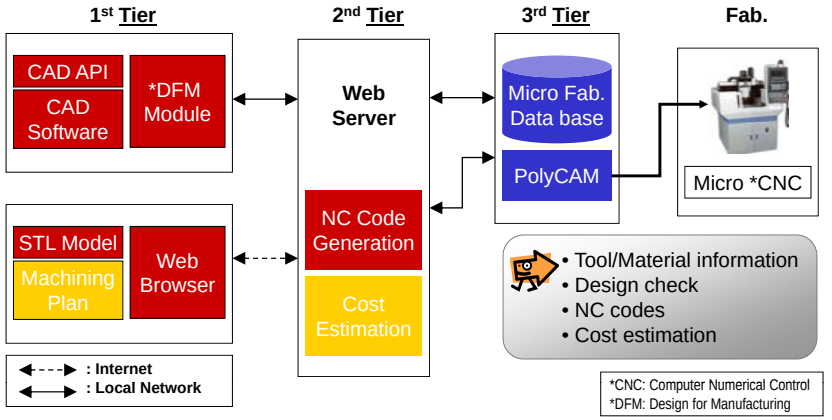
< 3D scanned head >



< Micro fluidic channel >

Web-based CAD/CAM Integration (cont.)

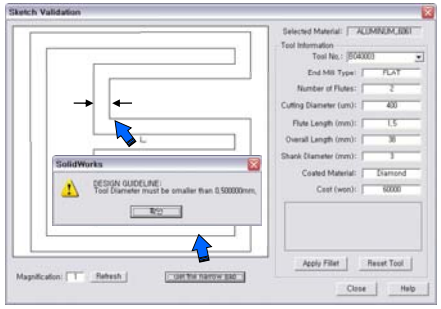
- **SmartFab**
  - Micro machining using SolidWorks



< Architecture of SmartFab >

Web-based CAD/CAM Integration (cont.)

- **SmartFab – Sketch validation**
  - Improve machinability
  - Based on the tool information and DFM philosophy



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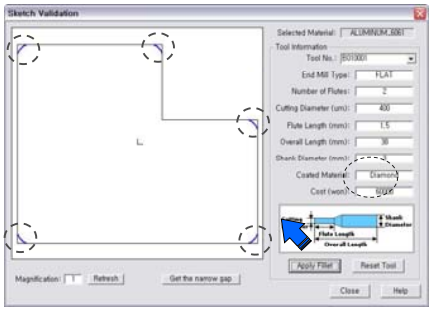
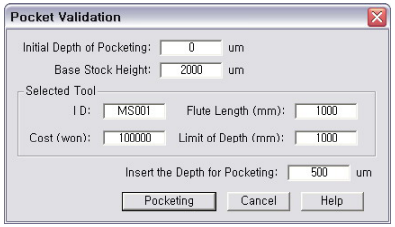
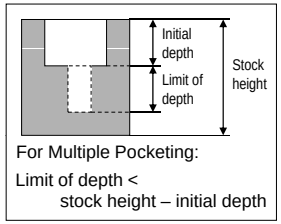


< Check for fillet >

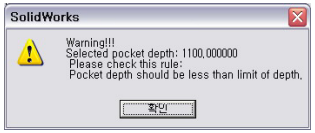
Web-based CAD/CAM Integration (cont.)

- **SmartFab – Pocket validation**

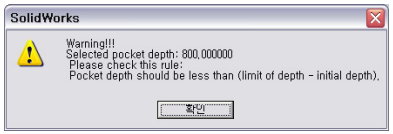




< DFM in pocketing >



Case I. Depth limit



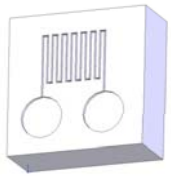
Case II. Depth limit and initial depth

Web-based CAD/CAM Integration (cont.)

- **SmartFab – Cost estimation**

Cost Estimation Service Calculate

1. Cw (Workpiece cost)	20
2. Cp (Preparaton cost)	875
3. Cm (Machining cost)	11275
4. Cn (Nonproductive cost)	0
Total cost (Ctotal = Cw + Cp + Cm + Cn) is	12170 (won)



Cp = Tp*W

Tp: Preparation time (0.35 hr)
W : Operator's wage (2500/hr)

Cm = Com+Ct = Tm*W+Ct

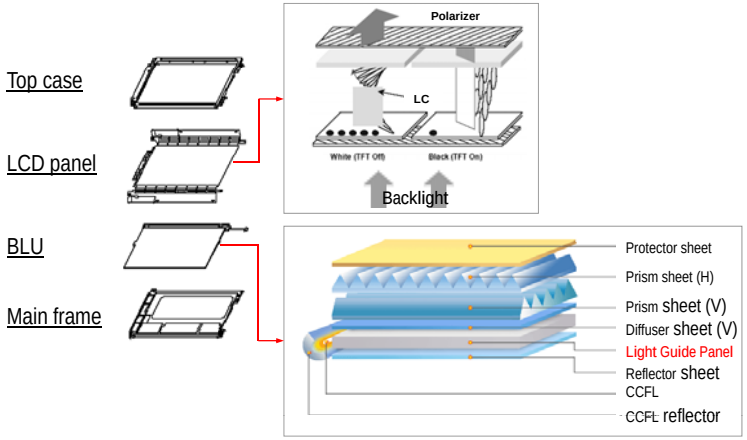
Tm: Machining time (0.41 hr)
W: Operator's wage (2500/hr)

Ct = y*(Tm/T) **(11,275 won, 92% of total cost)**

Ct: Tool usage cost
T: Tool life (4 hr)
y: tool cost (100,000)

Web-based CAD/CAM Integration (cont.)

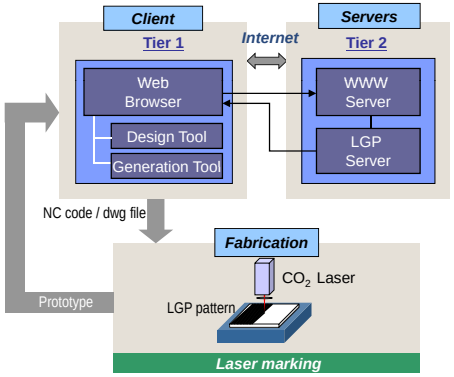
- **TFT LCD-LGP (Light Guide Panel) prototyping**



< Schematic Structure of LCD Unit >

Web-based CAD/CAM Integration (cont.)

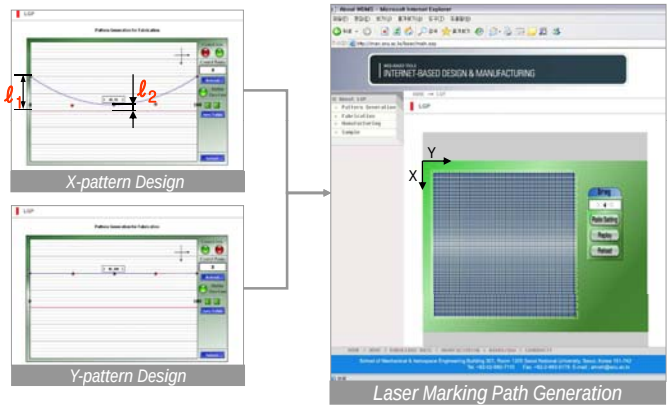
- **TFT LCD-LGP (Light Guide Panel) prototyping**
  - Patter design & NC code generation tool
  - Provide NC code or DWG file



< Communication Architecture of LGP Pattern Generator >

Web-based CAD/CAM Integration (cont.)

- **TFT LCD-LGP (Light Guide Panel) prototyping**
  - X and Y pattern generation service

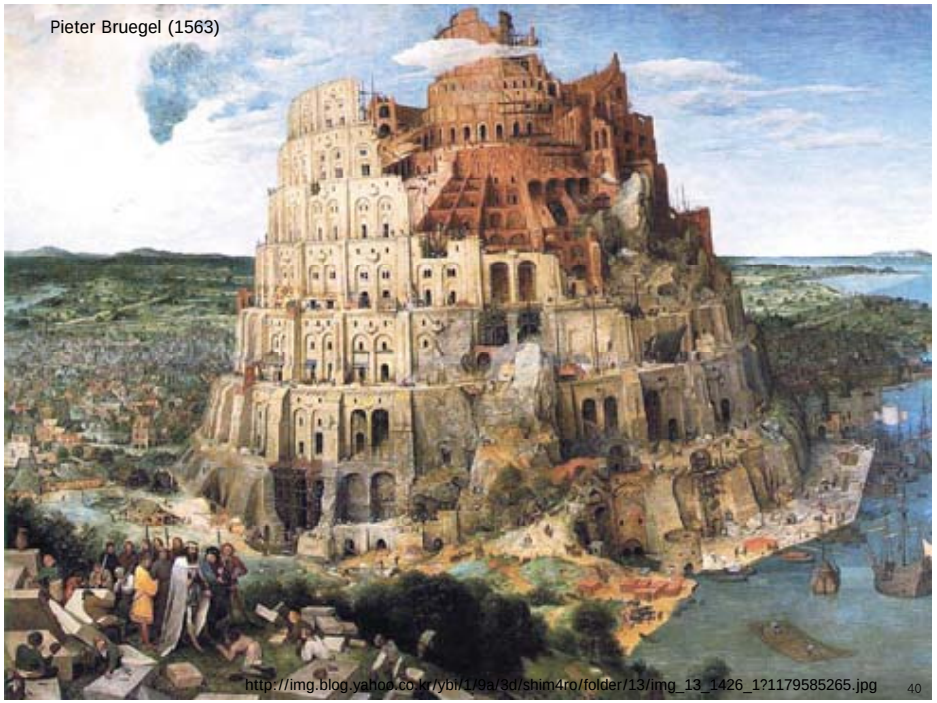


< Web-based Design Tool for LGP Pattern >

Broad Integration

- **PDM (Product Data Management)**
  - Control CAD file revisions
  - Manage all data related to project

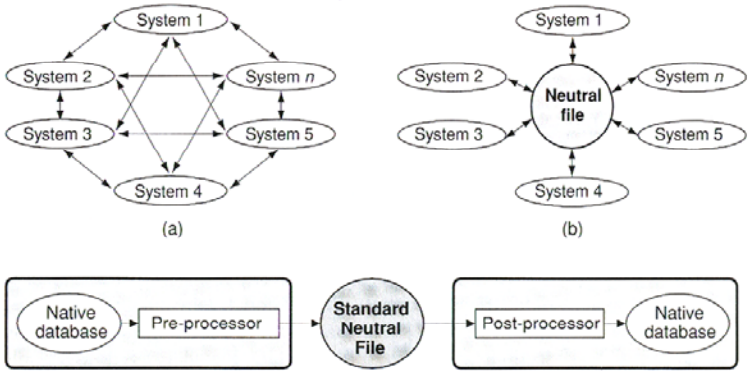
- **PLM (Product Life-cycle Management)**
  - Product Development Management (PDM)
  - Include all actors (company departments, business partners, suppliers, OEM, and customers)
  - Share product data
  - Apply common processes
  - Leverage corporate knowledge



Data Exchange

- **Standard formats for data exchange**
  - IGES (Initial Graphics Exchange Specification)
    - 3D CAD data
  - STEP (Standard for the Exchange of Product model data)
  - DFX (Drawing eXchange Format)
    - 2D drawing data
  - STL (Stereo Lithography)
    - De facto standard in rapid prototyping
  - VRML (Virtual Reality Modeling Language)
    - 3D model on web

Data Exchange (cont.)



CAD/CAM Award

- **Award to** the Best Team!!!
- **No money, but** Honor!


Seoul National University
School of Mechanical & Aerospace Engineering

Presents

The Best Product Development Award
to
Gil-Dong Hong
for his outstanding development achievement
in the 2006 CAD/CAM contest

December 10, 2006

Professor Gun-Woo Lee
Professor Sung-Hoon Ahn
School of Mechanical and Aerospace Engineering
Seoul National University

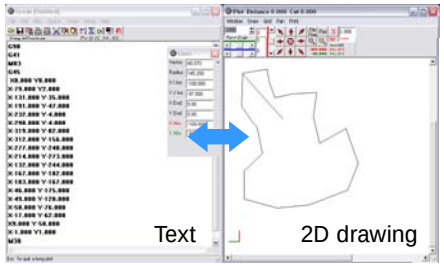
CATIA NC Lab

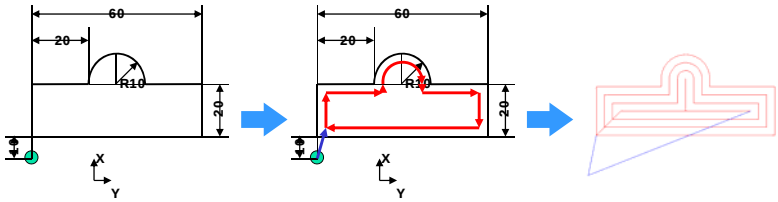
- **From CAD to CAM directly**
- **Model File Exchange**
  - From SolidWorks to CATIA, IGES format
- **CATIA V5 - NC Manufacturing Function**
  - Prismatic Machining
    - Contouring
    - Facing
    - Pocketing
  - Surface Machining
    - Roughing
    - Finishing

< Example part model >

Manual NC Lab

- **GCode2000**
  - Text NC support
  - 2D drawing support

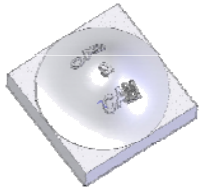




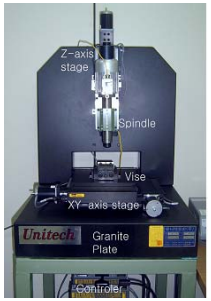
< Example 2d drawing and NC path >

CAM & Injection molding Lab

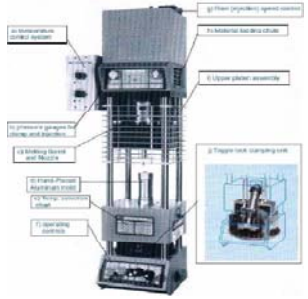
- **CATIA NC**
  - Model with surface
  - Roughing & Finishing



- **IDIM lab tour**
  - Micro machining

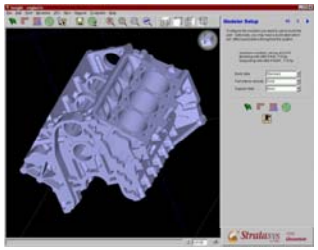


- Injection molding

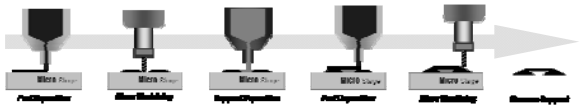


Rapid Prototyping Lab

- **FDM software: Insight**
  - STL format: CAD model
  - SSL format: Sliced layer
  - SML format: Deposition path



- **IDIM lab tour**
  - Nano Composite Deposition System
    - Rapid Prototyping + CNC machining



< Hybrid (depositing + machining) process of NCDS >