

446.326A CAD/CAM

CAD/CAM Integration

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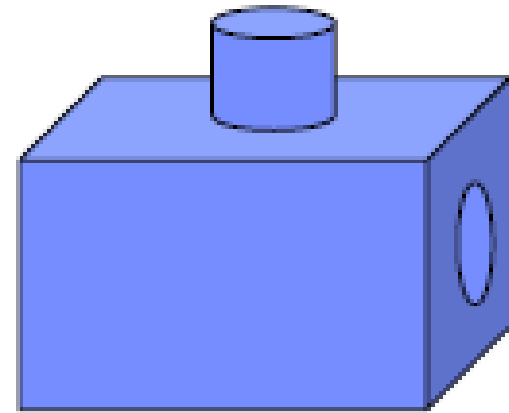
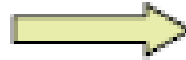
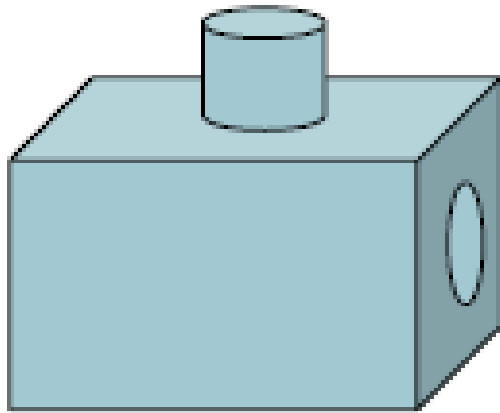
Integrated technologies



From Design to Manufacturing



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

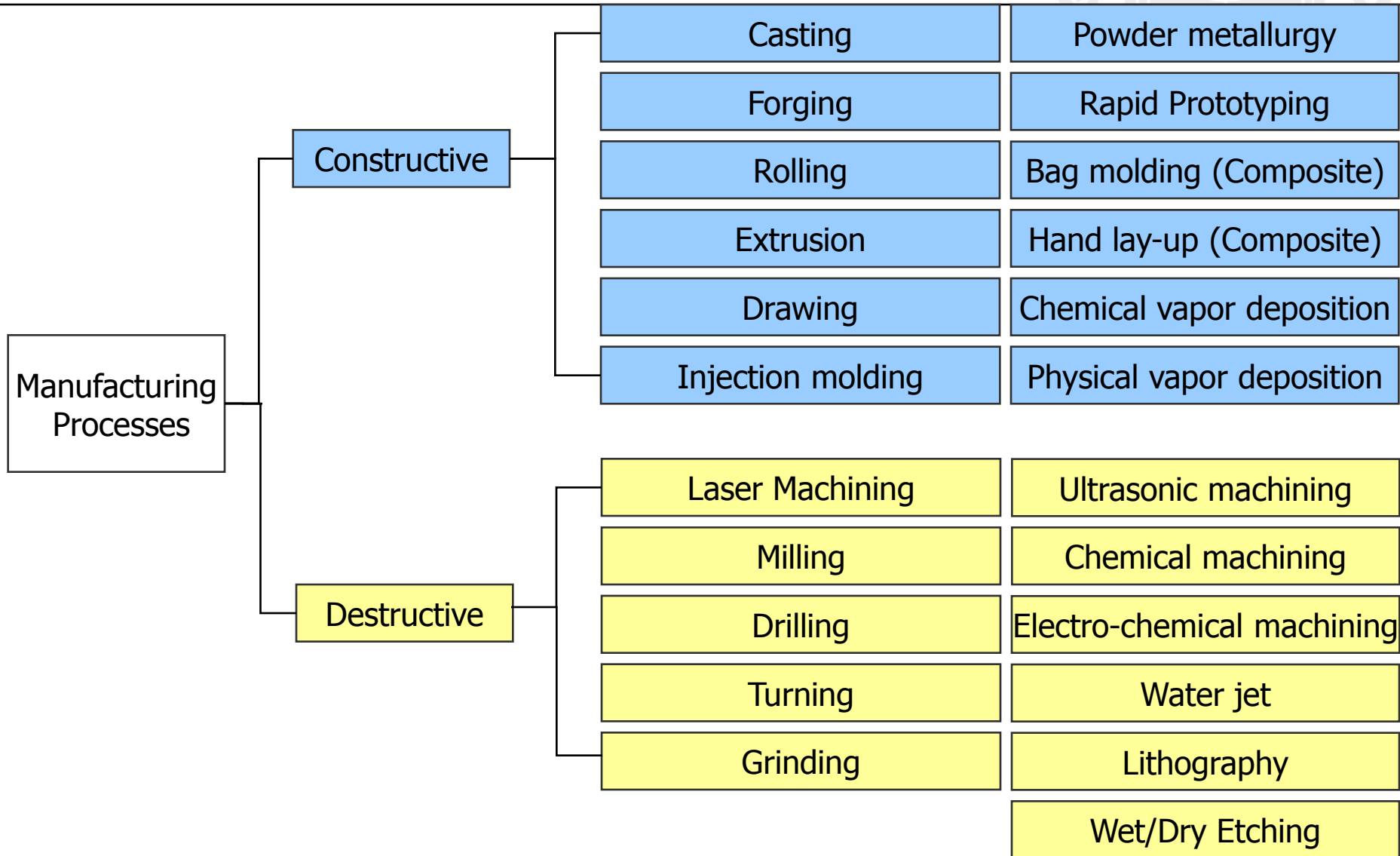


Design domain:
How to create geometry

Manufacturing domain:
How to make part
Need to consider

- Manufacturing process
- Material
- Machine

Taxonomy of Manufacturing Processes



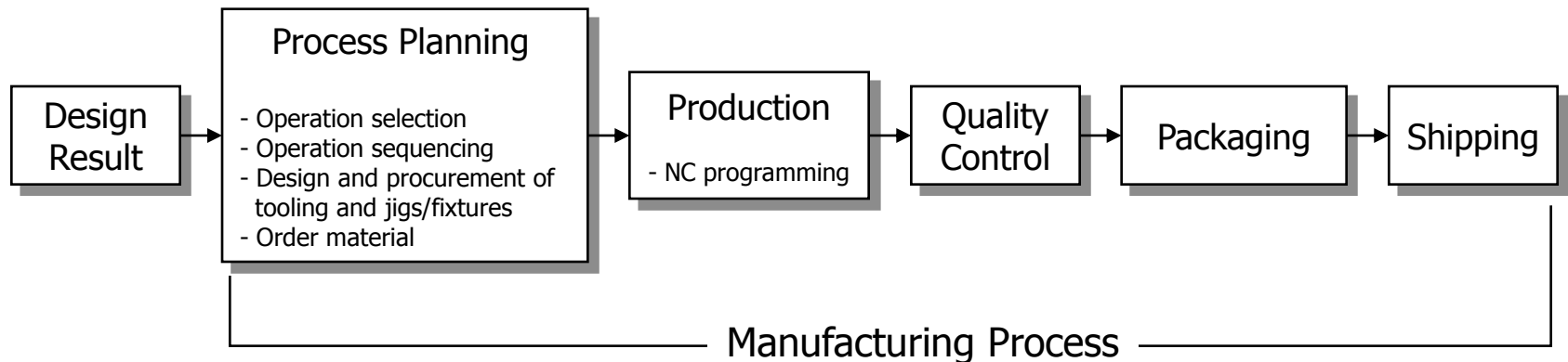
Example Product: Self-made Vehicle



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**

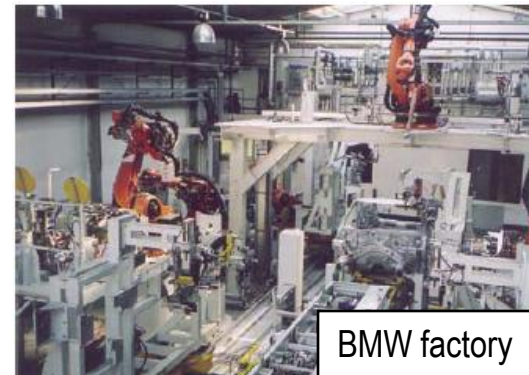
- NC is a system in which actions are controlled by direct insertion of numerical data at some point. The system must automatically interpret at least some portion of this data

- *Electronic Industries Association (EIA)*

- Computer Numerical Control (CNC)

- **Robot programming software**

- Selecting and positioning tools and work-pieces for NC machines



CAM Software (cont.)



- **Process planning software**

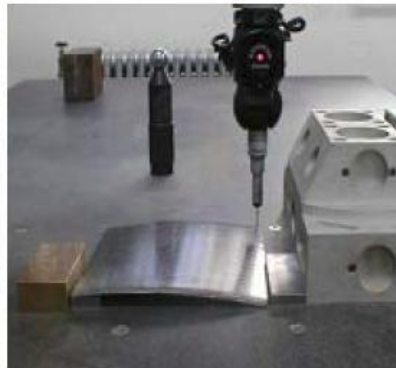
- The act of preparing detailed work instructions to machine or assemble a part or parts

- *Computer-Aided Manufacturing, Chang et al., 1998*

- Process plan; operation sheet; route sheet
- Computer-Aided Process Planning (CAPP)

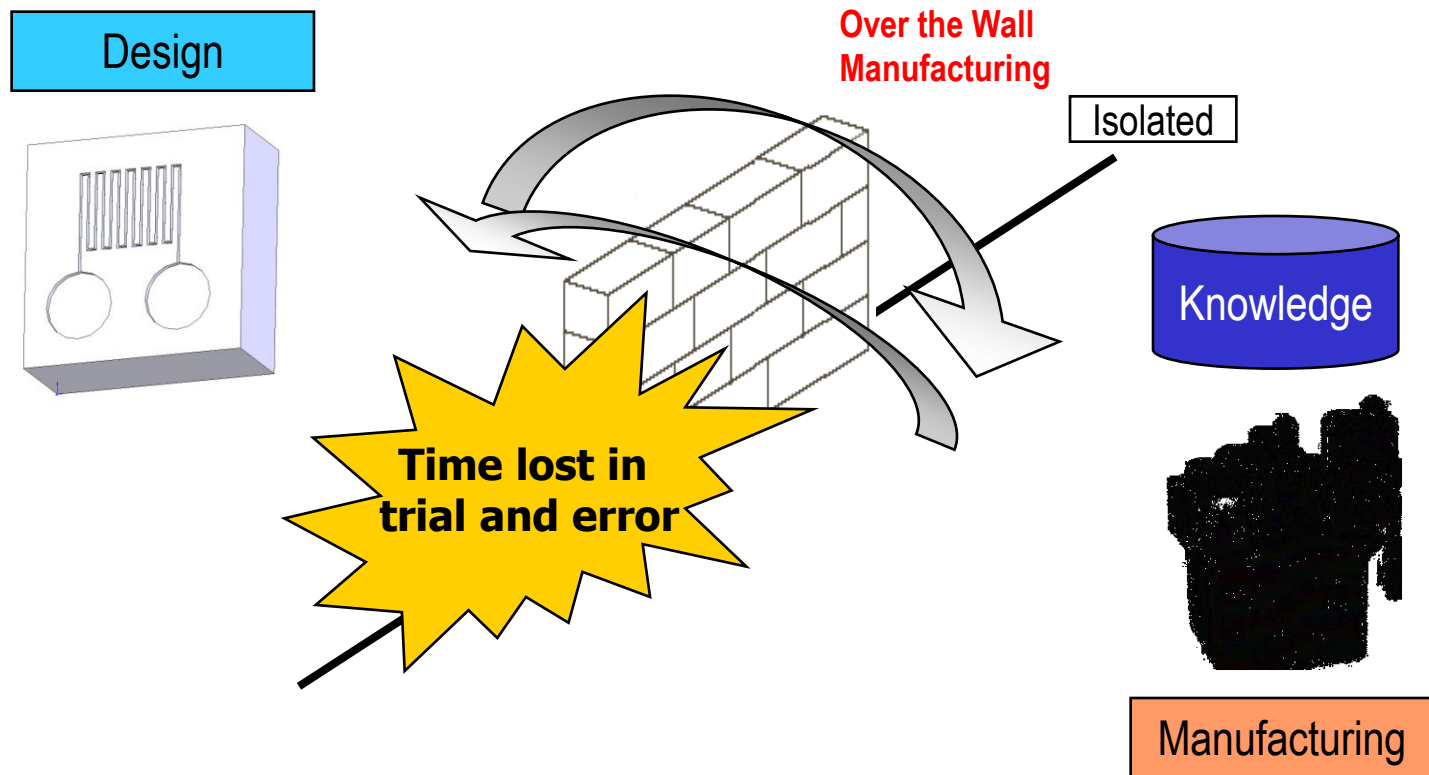
- **Inspection software**

- Coordinate Measuring Machine (CMM)



Problems in Traditional Production

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



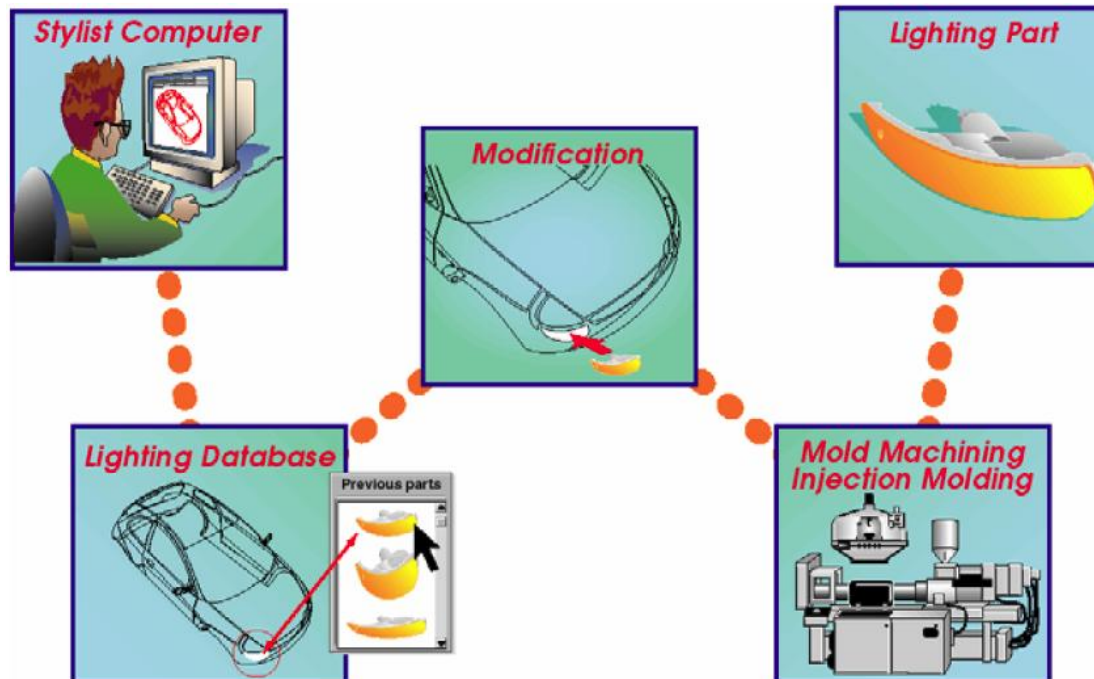
< Diagram of tradition design and manufacturing process >

CAD/CAM Integration

- **Goal of integration**

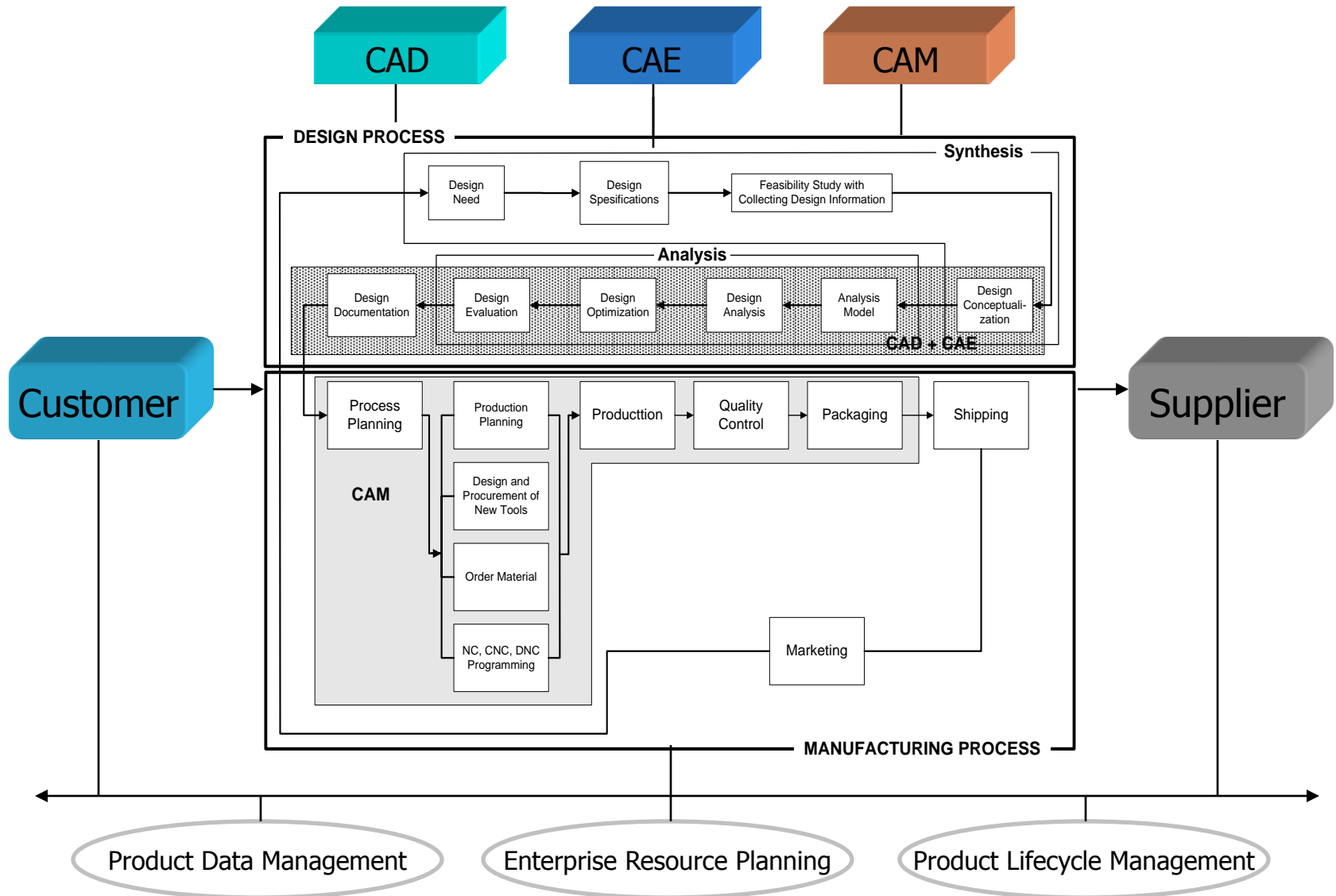
- To facilitate coordination of work and information flow across organizational boundaries

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

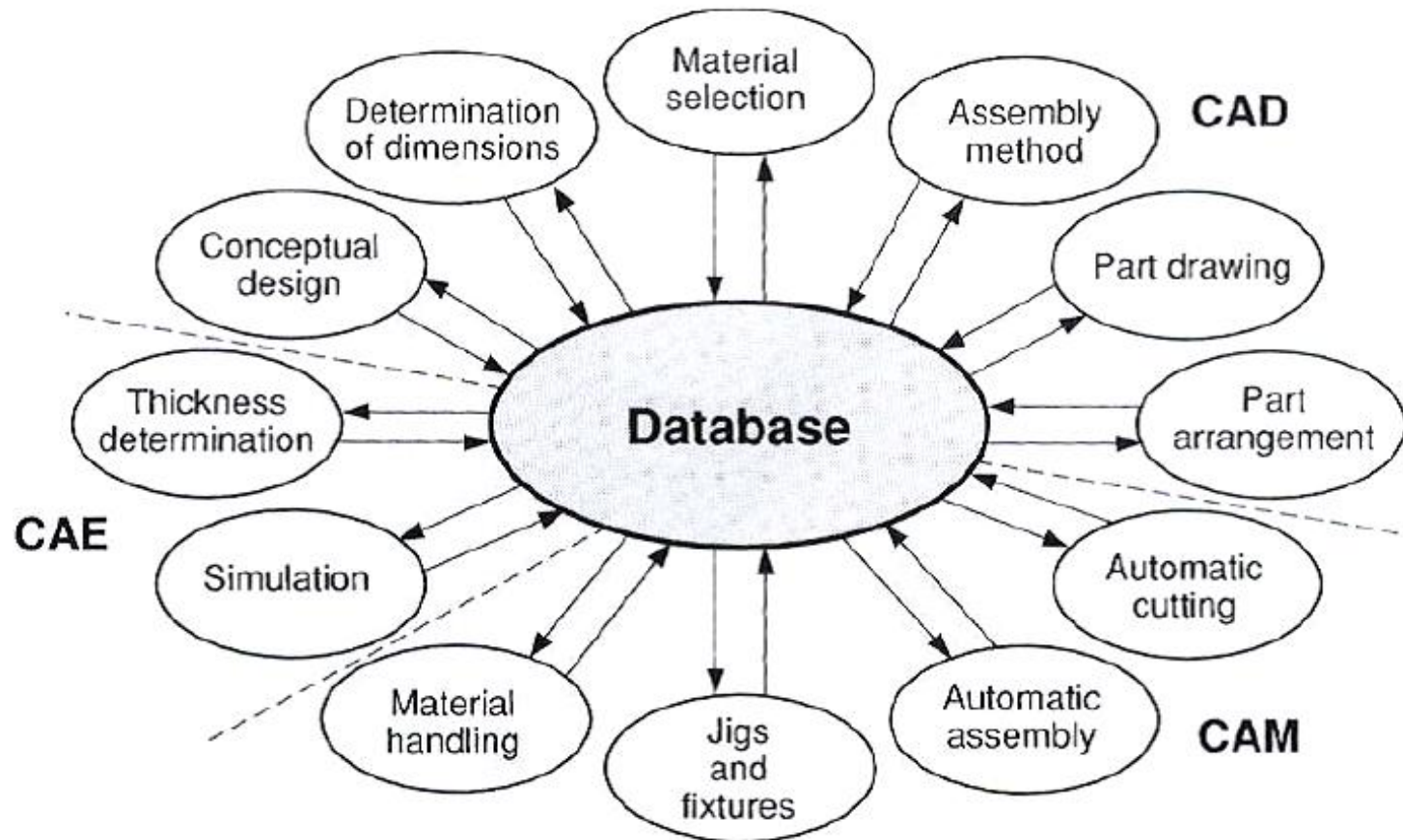


< Example concept of CAD/CAM integration >

Integration in Product Cycle Level



Integration in Database Level



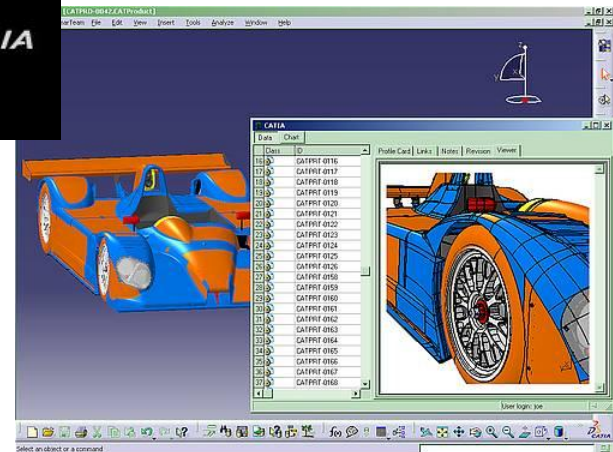
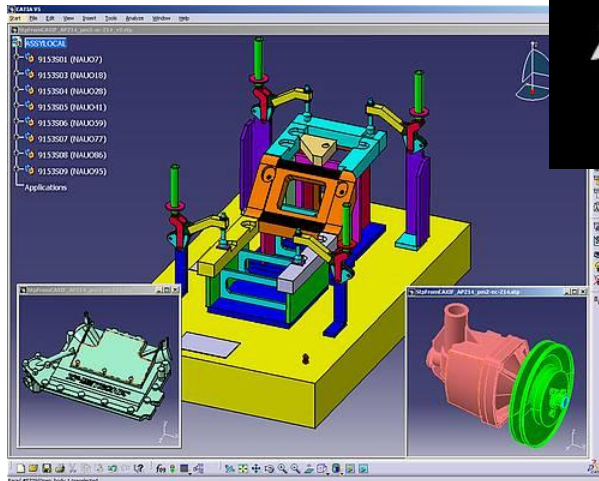
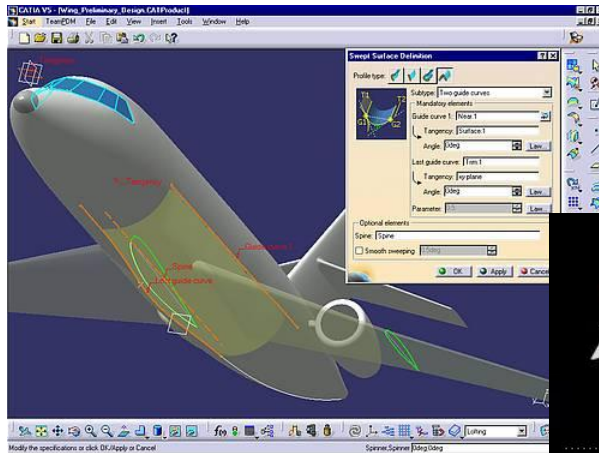
Integration in Commercial Package Level

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



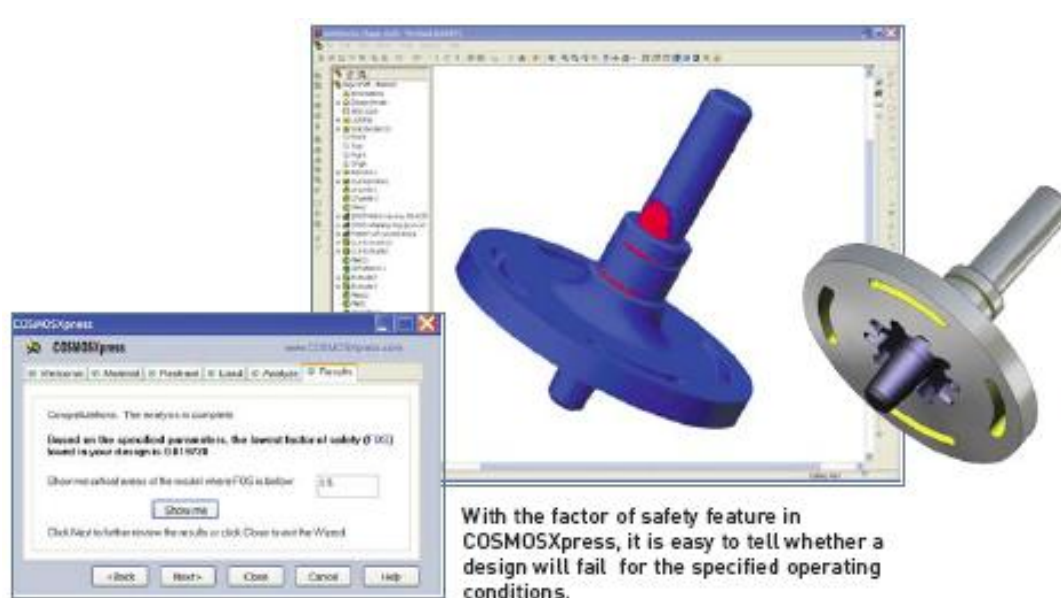
Trends of Commercial Solutions

- Dassault systems: CATIA

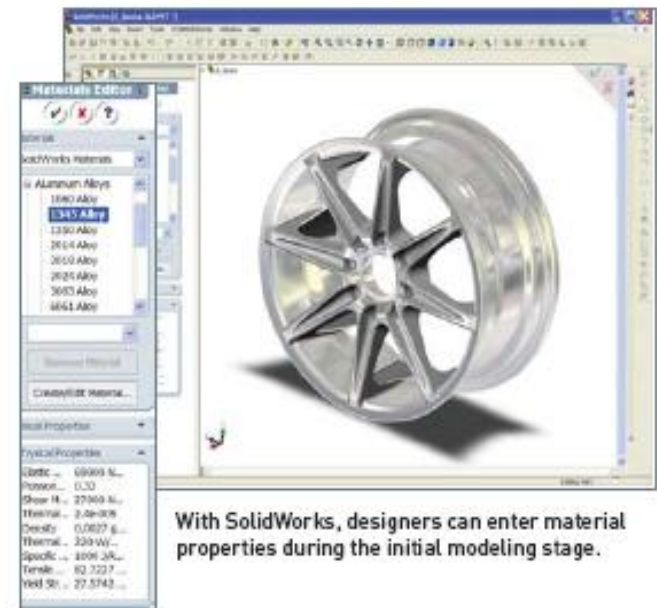


Trends of Commercial Solutions (cont.)

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



< COSMOSXpress >



< 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)**

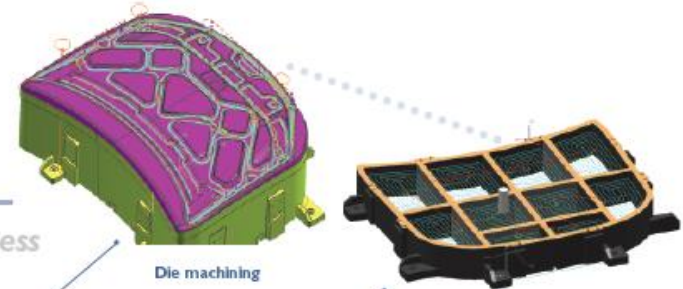
- All in NX



< Main concept >

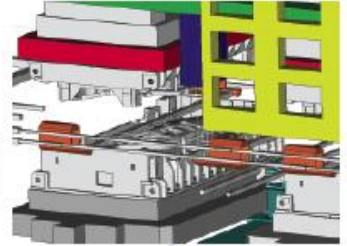
> From design to manufacture – the complete process

- ▶ NX Machining provides first-class capability in die face machining with the latest techniques in high-speed machining.
- ▶ Highly productive milling applications in NX Machining enable fast NC programming for die structure components.
- ▶ NX Die Design provides a range of capabilities for the detail design of the die structure.
- ▶ Teamcenter Manufacturing provides powerful process planning, data management, configuration control as well as flexible reporting.

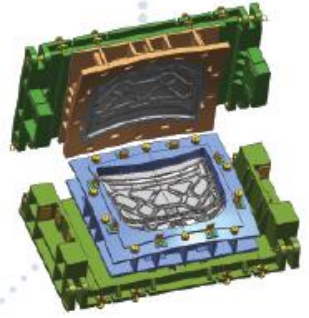


Die machining

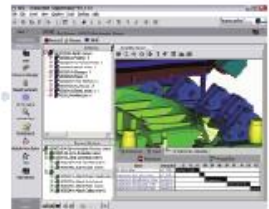
Casting pattern machining



Detailed analysis and optimization by full press line simulation



Completed die design



Process planning shop floor documents

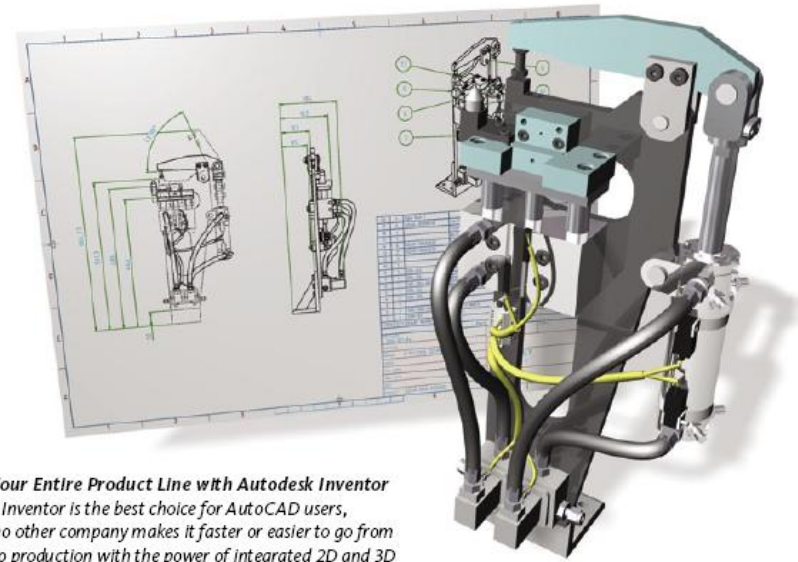


Die structure design

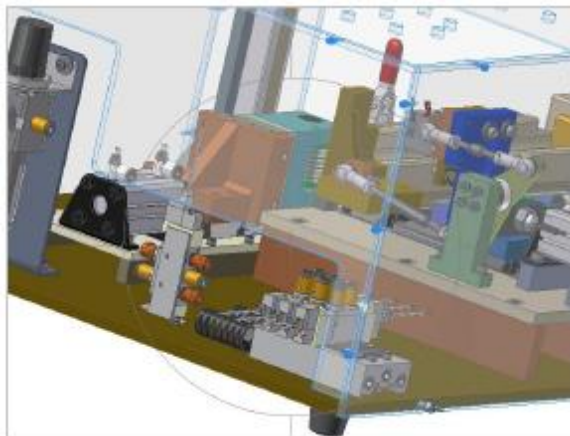
Trends of Commercial Solutions (cont.)

Autodesk: Inventor

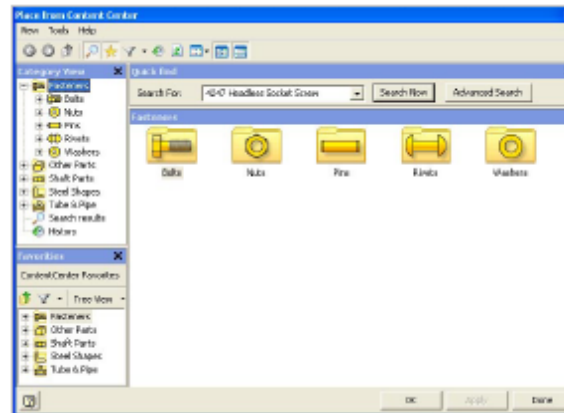
- Move to 3D from 2D (AutoCAD)
- Content center
- Virtual prototyping
- Bill of Material (BOM)



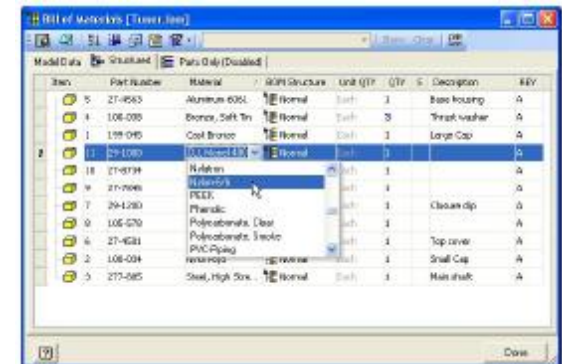
Design Your Entire Product Line with Autodesk Inventor
Autodesk Inventor is the best choice for AutoCAD users, because no other company makes it faster or easier to go from concept to production with the power of integrated 2D and 3D design solutions.



< Content center >



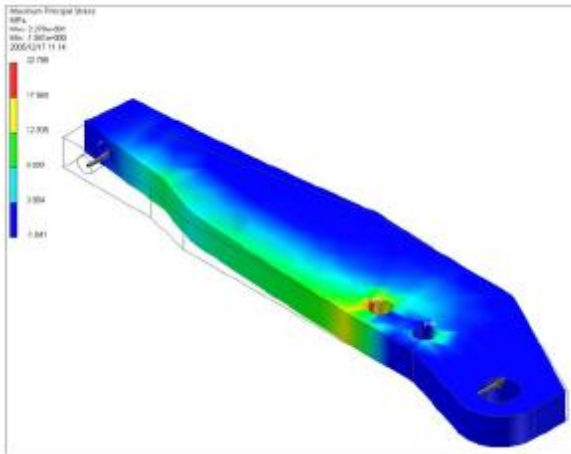
< Virtual prototyping >



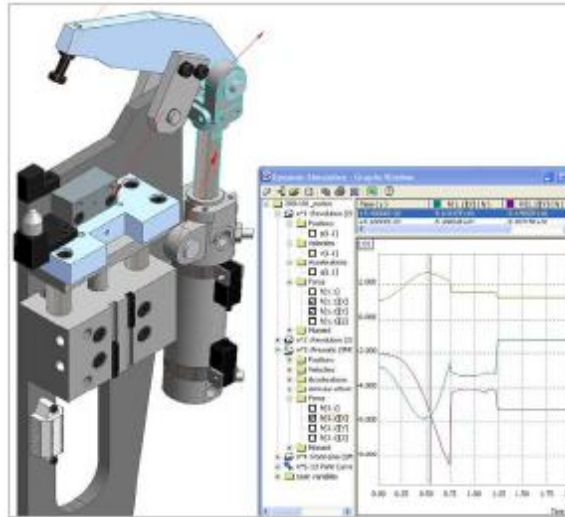
< Bill of Material (BOM) >

Trends of Commercial Solutions (cont.)

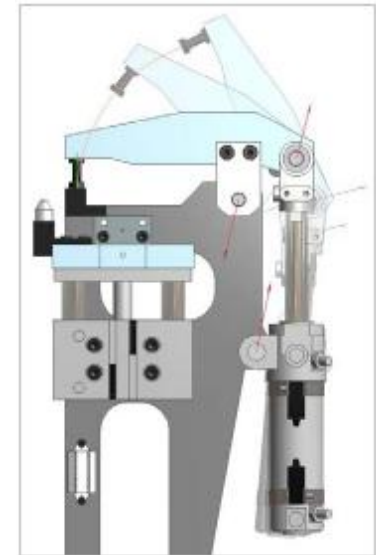
- **Embedded CAE ANSYS & Solid Dynamics**
 - Stress analysis (ANSYS)
 - Dynamic Simulation (Solid Dynamics)
 - 3D visualization (Solid Dynamics)



< Stress analysis >



< Dynamic Simulation >

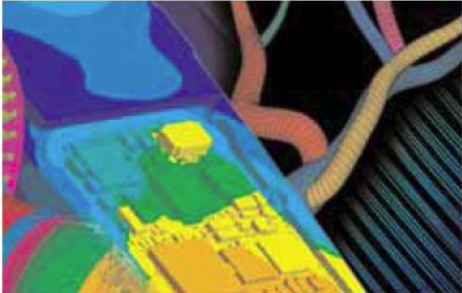


< 3D visualization >

Trends of Commercial Solutions (cont.)

ANSYS

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

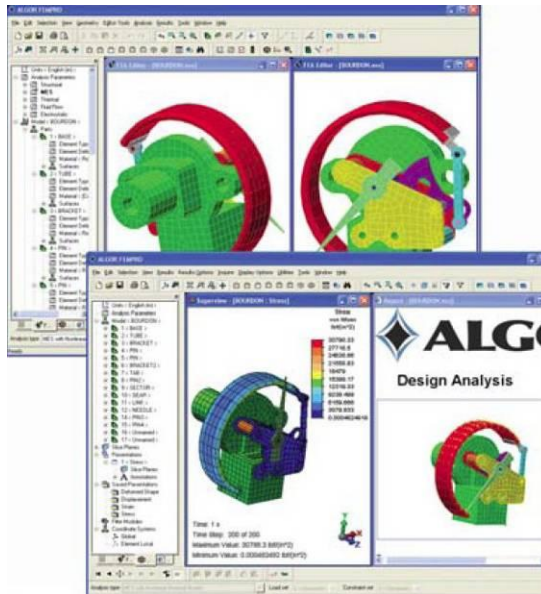


	Complete Simulation Solutions									Meshing Solutions		
	Multiphysics™	Mechanical™	Structural™	Professional™	DesignSpace®	Emag™	CFX®	ED™[C-12]	LS-DYNA™	Advanced Meshing	CFX® PrepPost™	ANSYS® PrepPost™
Pre-Processing												
Solid Modeling	•	•	•	•		•		•	•			•
Defeaturing	•	•	•	•		•		•	•	•		•
IGES 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



	Multiphysics	MES	Static/NLM	CFD	Designer	Static/LM	PipePak	Civil	ALG/NASTRAN	FEMPRO
CAD Support (Direct)										
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

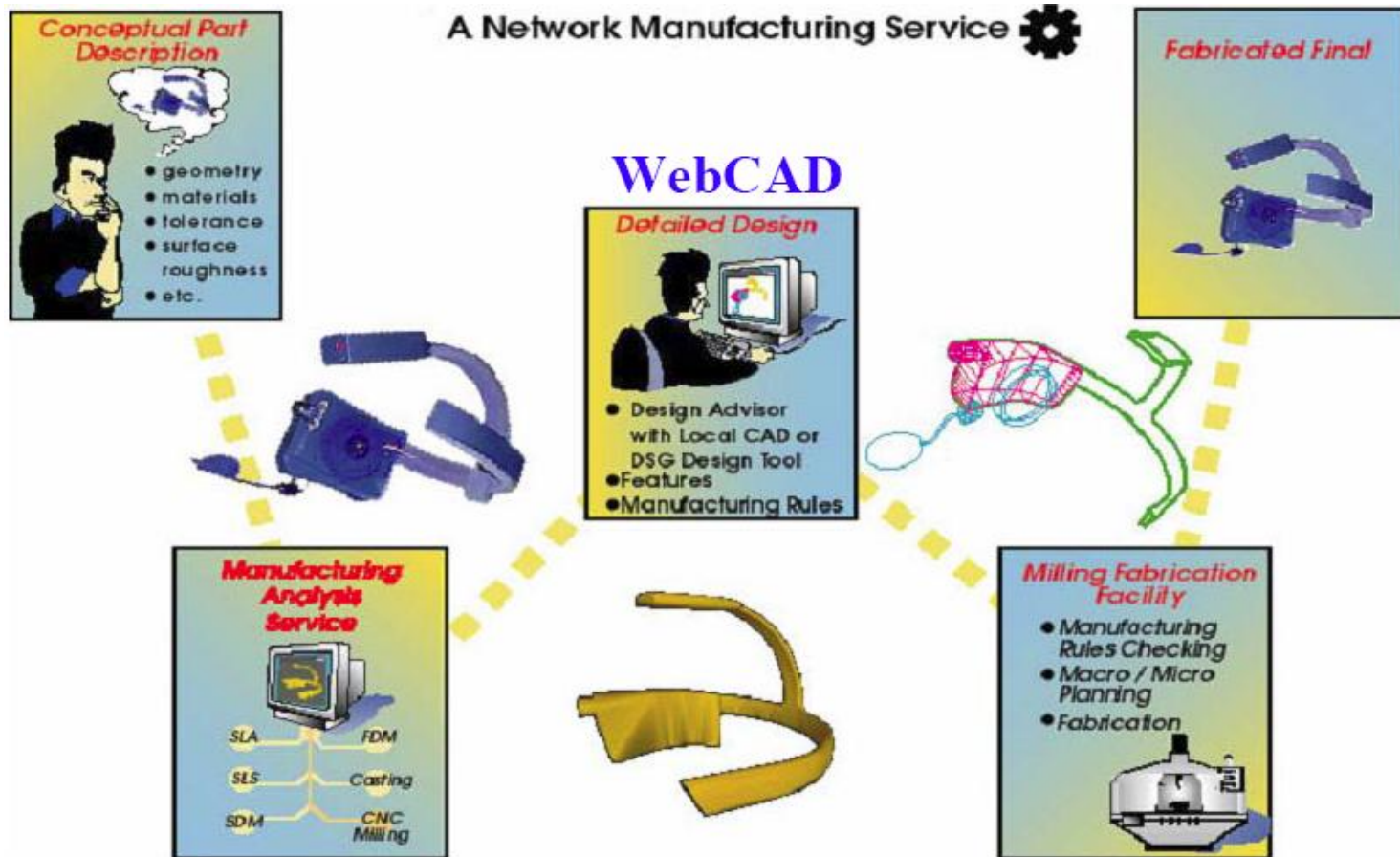


- There are 3 types of coupling modes between design and manufacturing

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

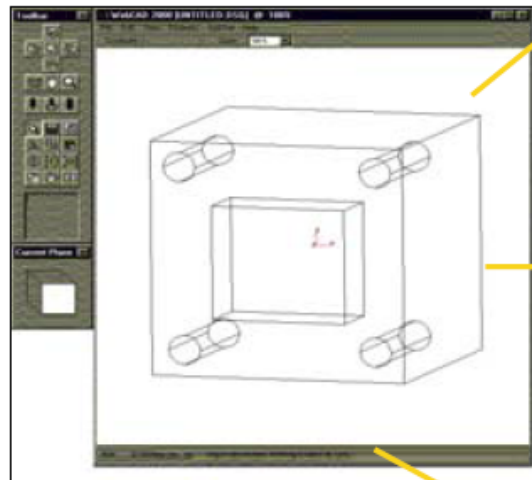
- CyberCut paradigm



Example Solutions of Stiff mode (cont.)

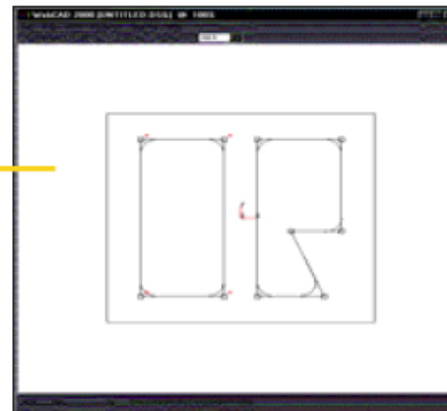
▪ CyberCut – Feature 1. WebCAD

Java based 3D CAD-DSG
(destructive solid geometry)

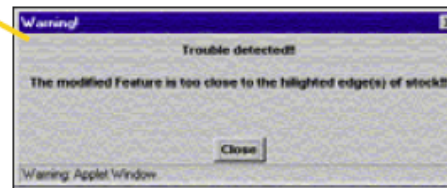


DFM paradigm

1. Tool diameter & Depth



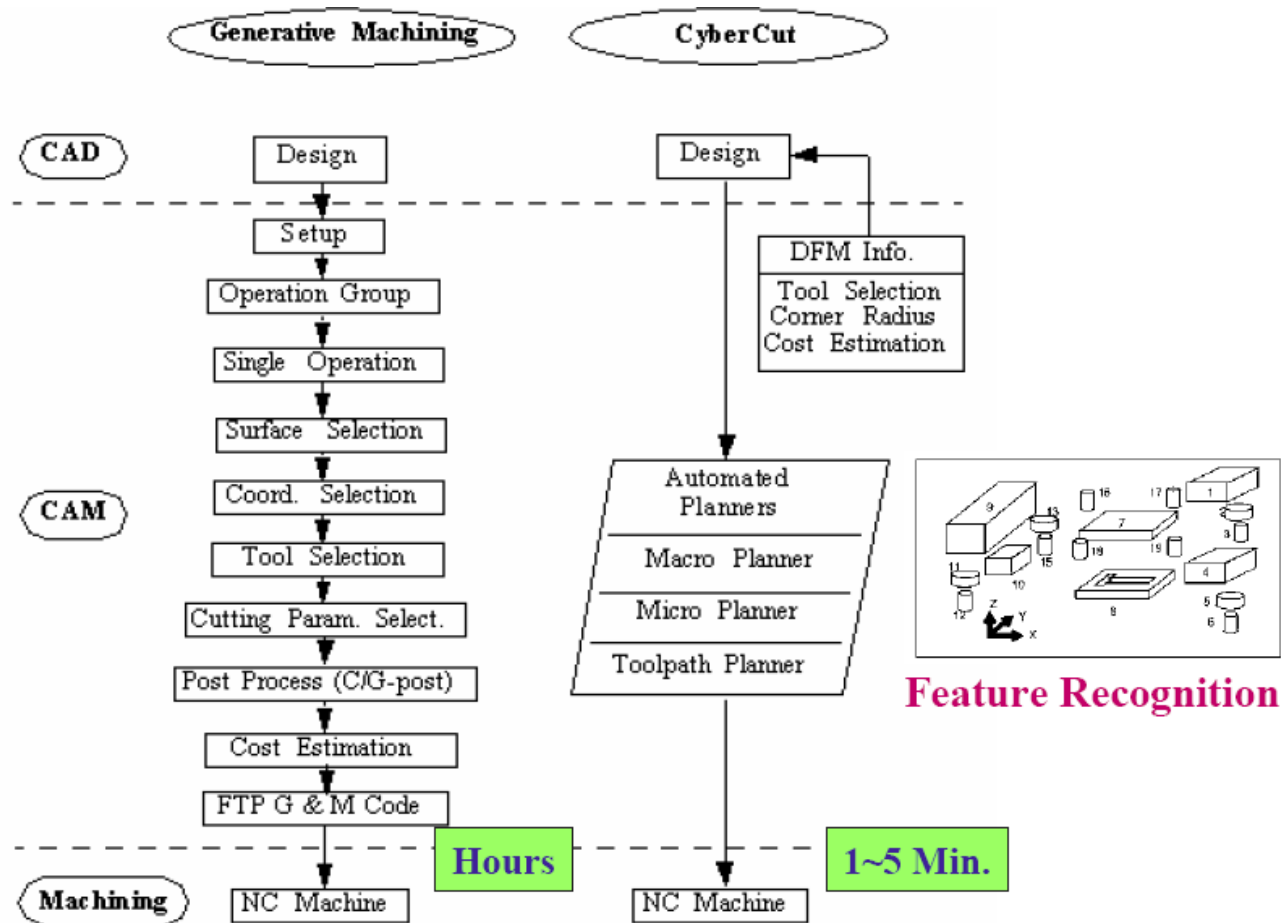
2. WYSIWYG:
Corner radius



3. Design Rule Checker

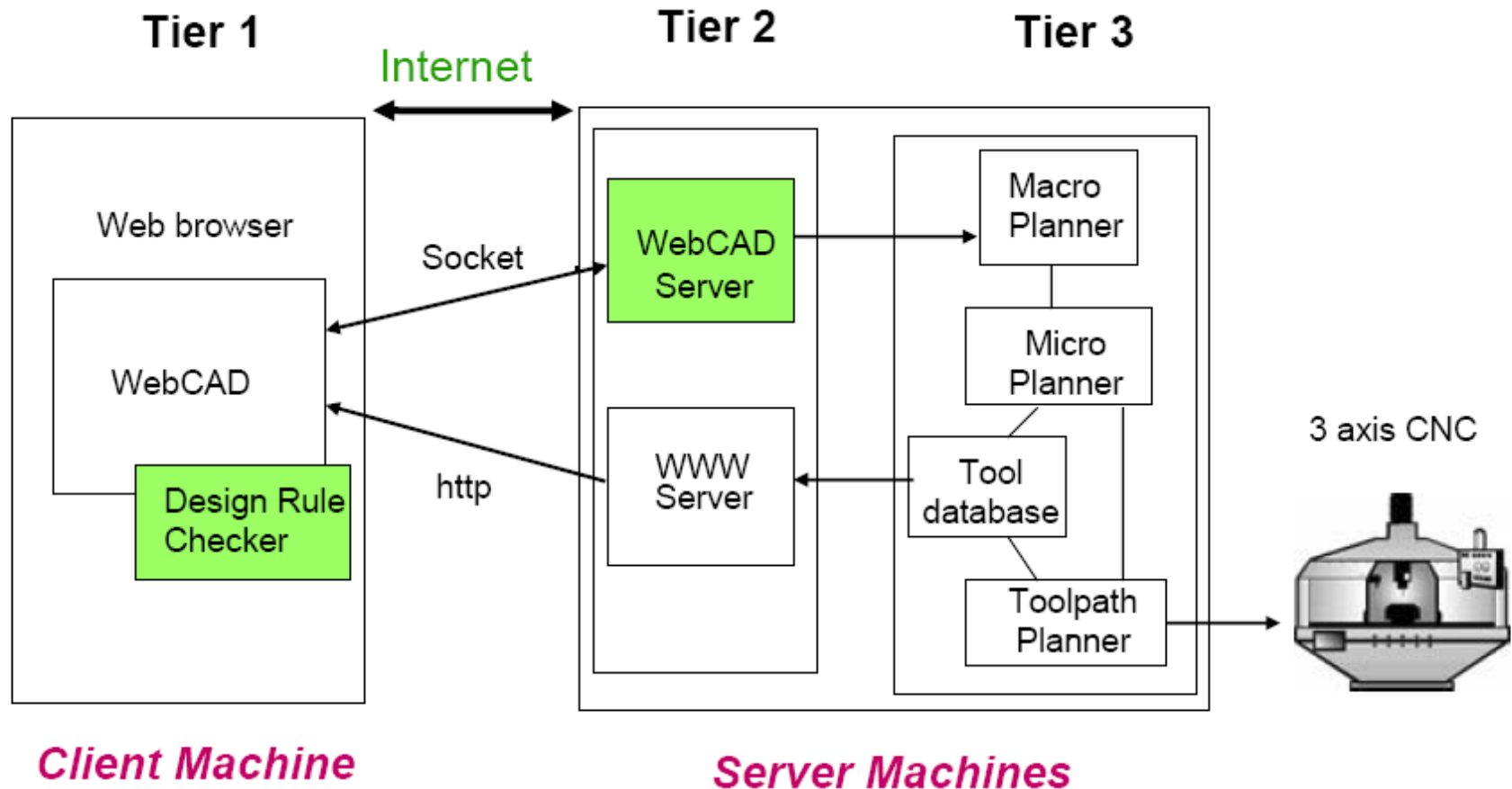
Example Solutions of Stiff mode (cont.)

▪ CyberCut – Feature 2. Automated Process Planning



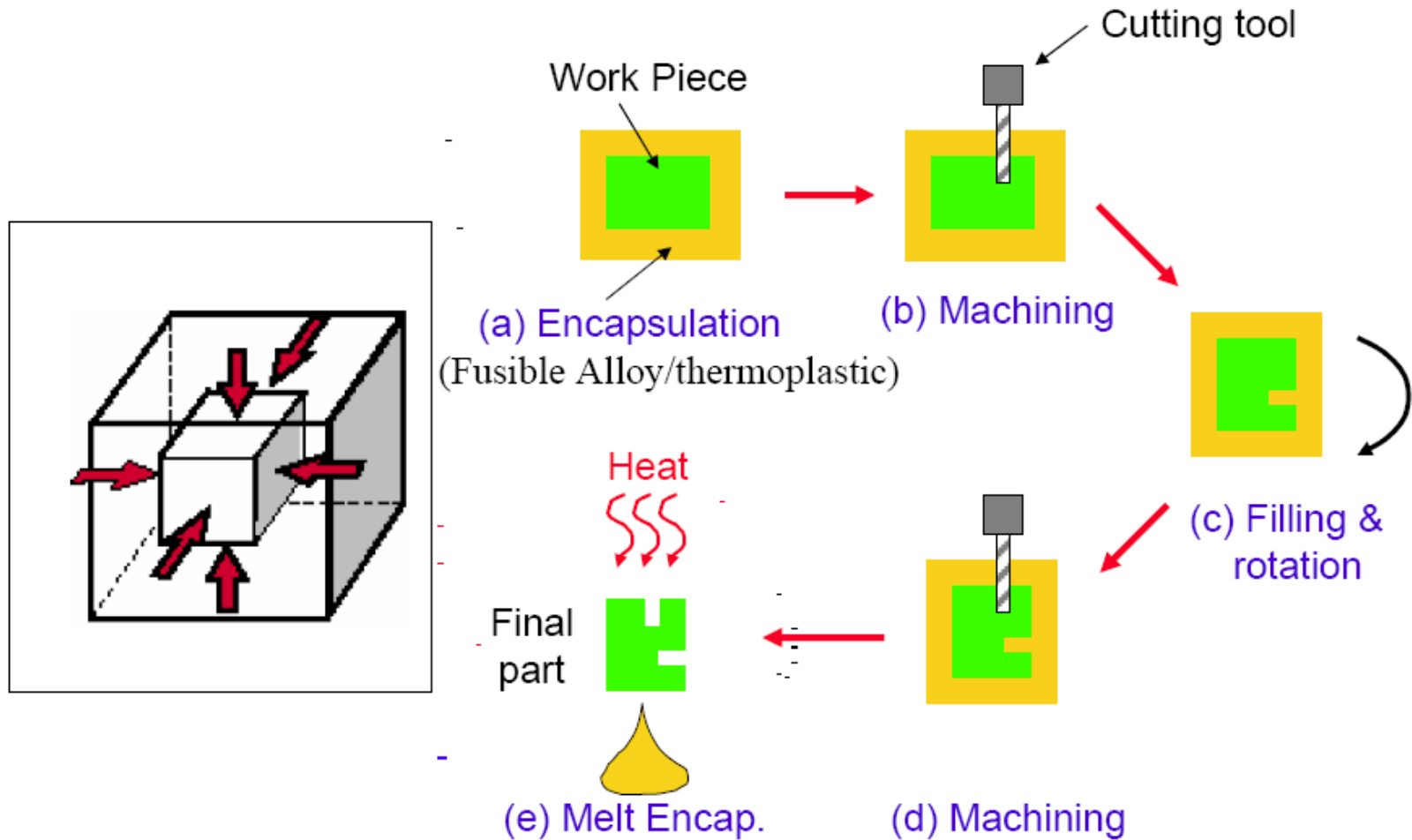
Example Solutions of Stiff mode (cont.)

- **CyberCut – Network communication**



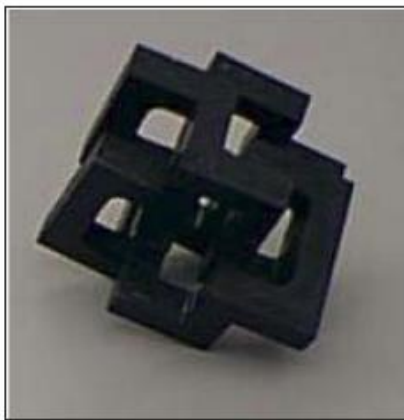
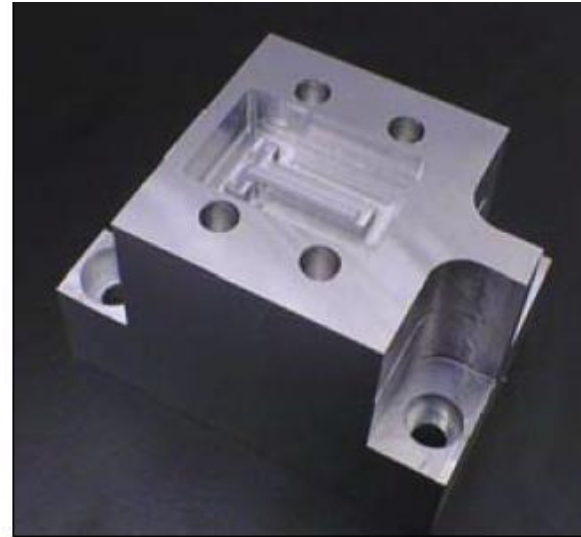
Example Solutions of Stiff mode (cont.)

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



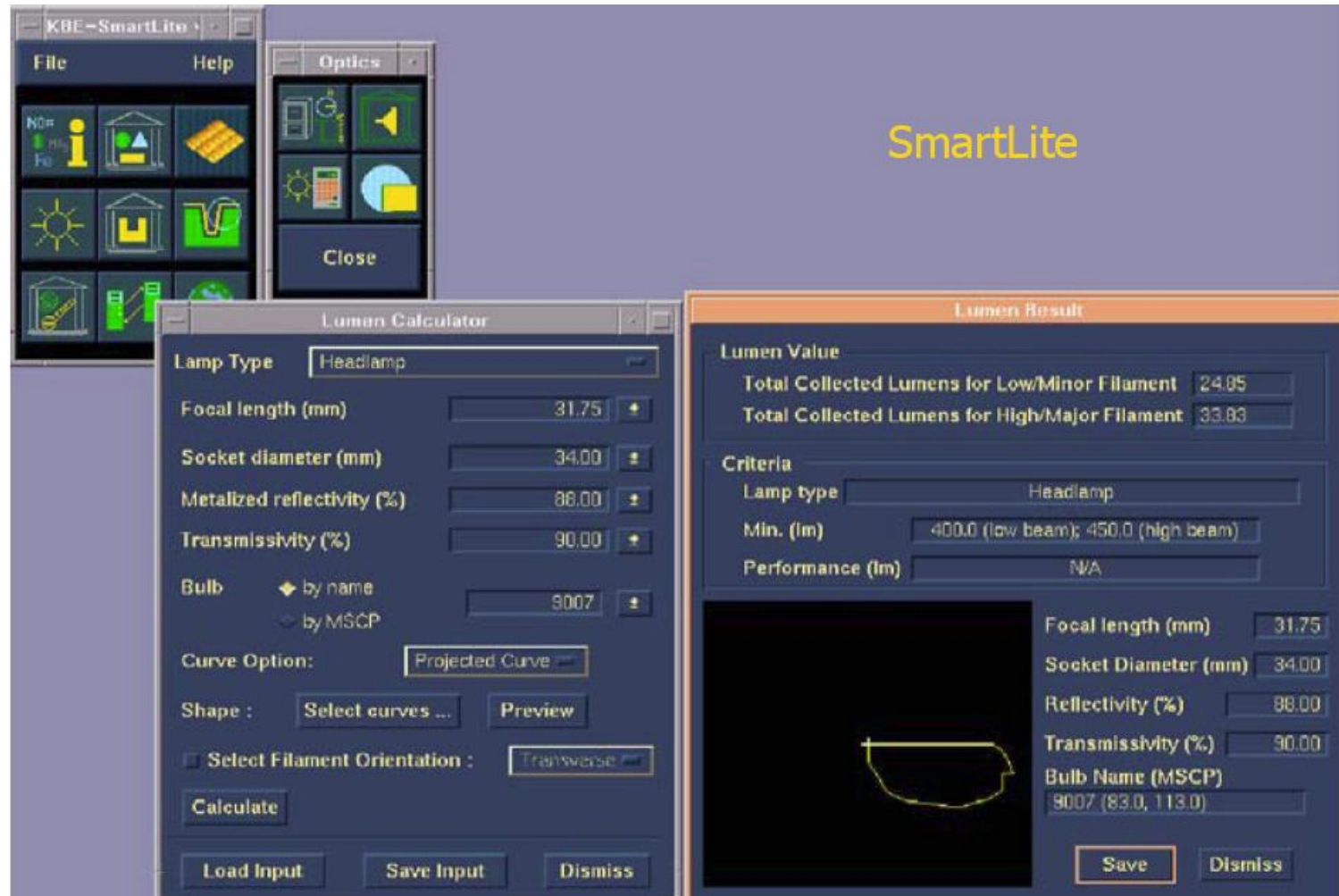
Example Solutions of Stiff mode (cont.)

- CyberCut – Fabricated parts



Example Solutions of Strong mode (cont.)

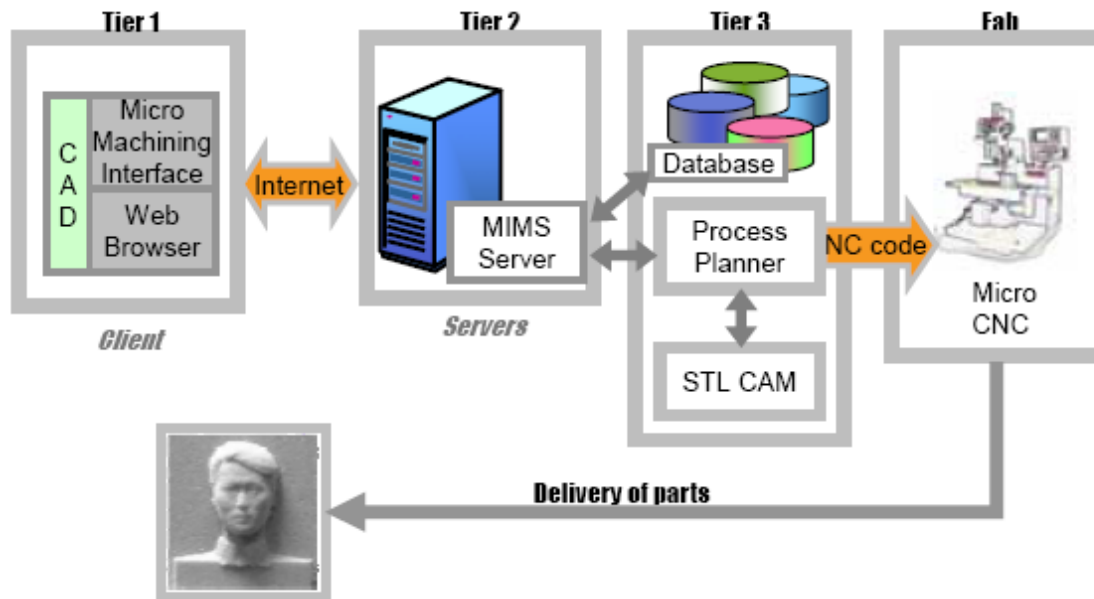
- SmartLite: I-DEAS based tools



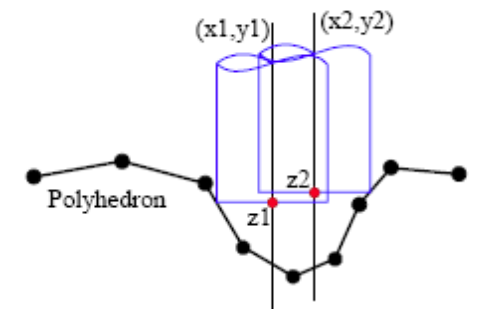
Web-based CAD/CAM Integration

▪ Micro Machining System (MIMS)

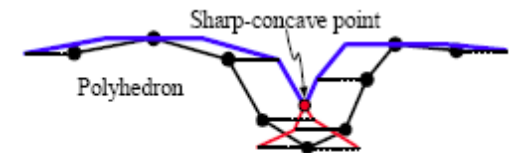
- Micro machining service using the internet
- Communication with 3-tier client-server model
- Upload STL file



< Communication architecture >



< Point-based Approaches >

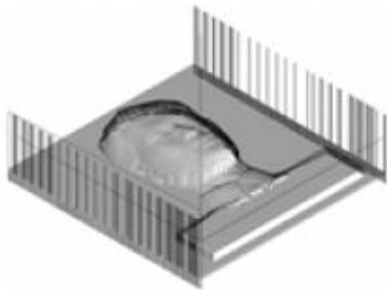


< Curve-based approaches >

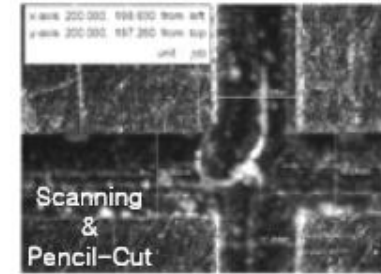
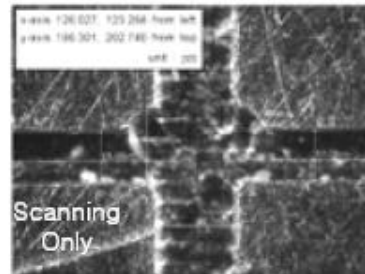
Web-based CAD/CAM Integration (cont.)

▪ Micro Machining System (MIMS)

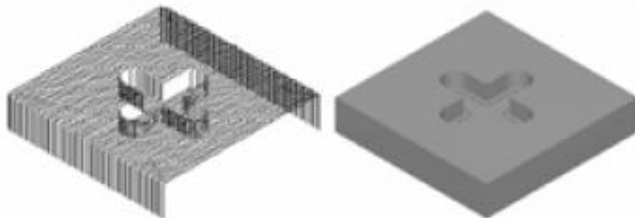
- Provide the NC code viewer
- Fabricated by micro-endmill according to scanning and pencil-cut toolpath



< G&M codes on NC code viewer >



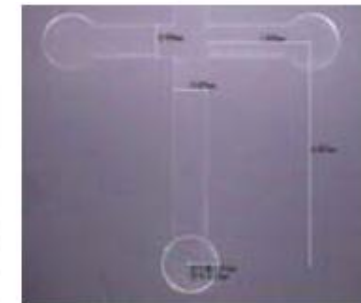
< Micro channel >



< Two types of toolpath >



< 3D scanned head >

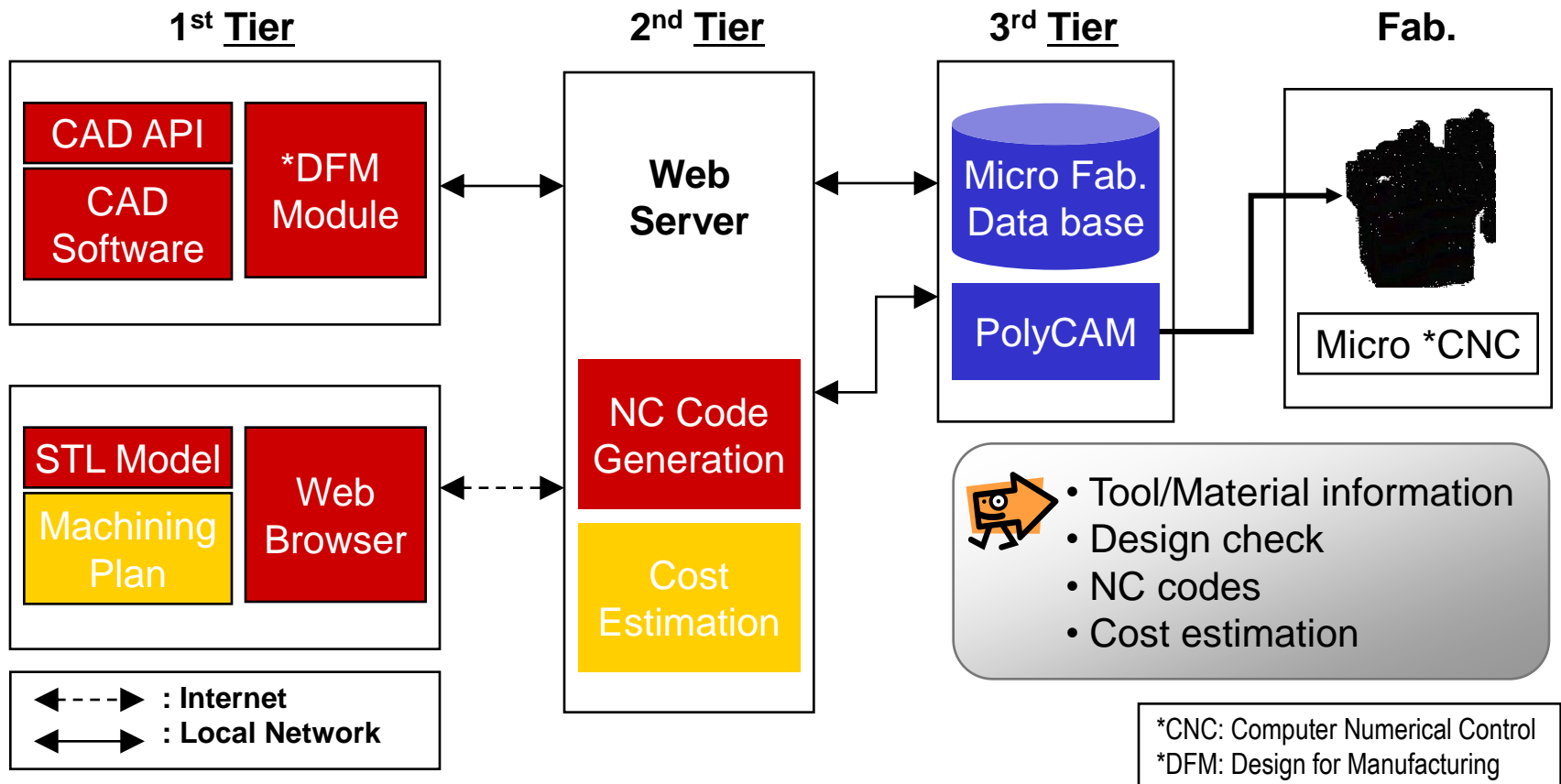


< Micro fluidic channel >

Web-based CAD/CAM Integration (cont.)

SmartFab

- Micro machining using SolidWorks

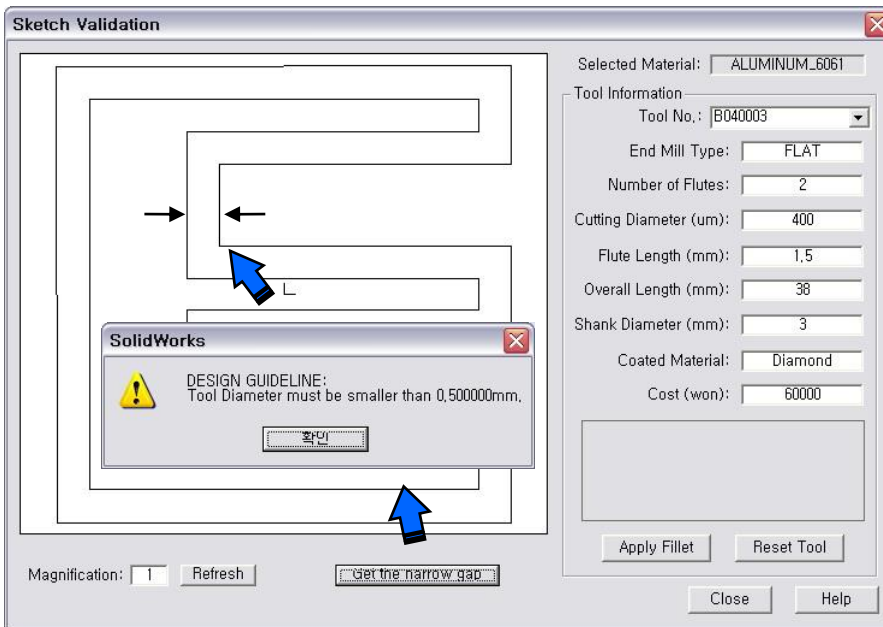


< Architecture of SmartFab >

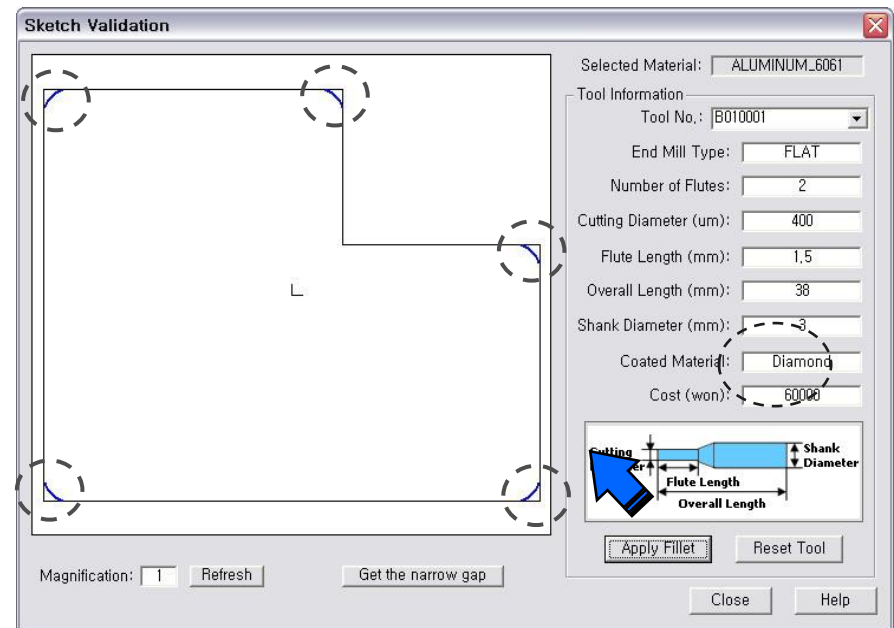
Web-based CAD/CAM Integration (cont.)

▪ SmartFab – Sketch validation

- Improve machinability
- Based on the tool information and DFM philosophy



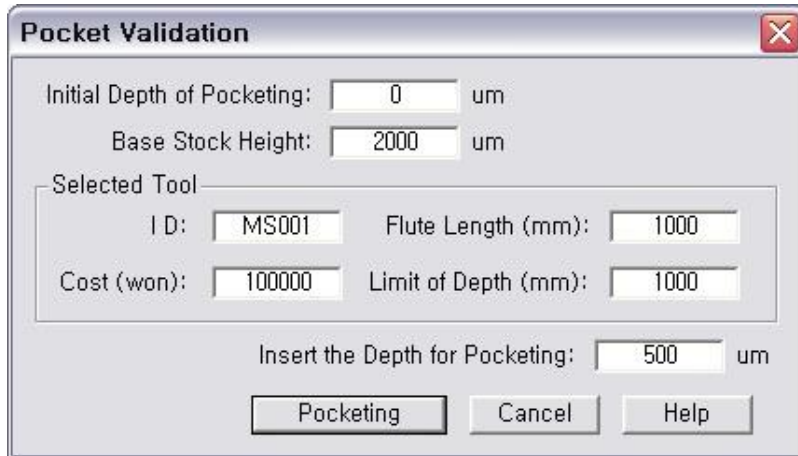
< Check for minimum Gap >



< Check for fillet >

Web-based CAD/CAM Integration (cont.)

SmartFab – Pocket validation



Pocket Validation

Initial Depth of Pocketing: um

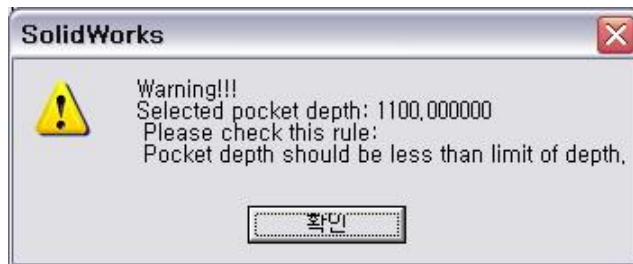
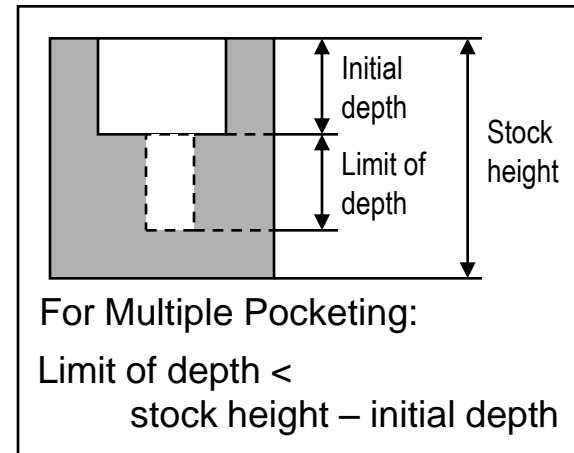
Base Stock Height: um

Selected Tool

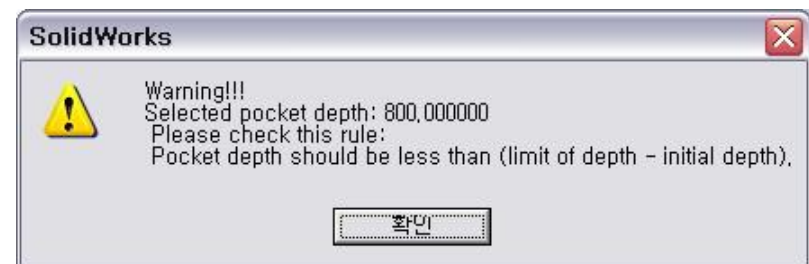
ID: Flute Length (mm):

Cost (won): Limit of Depth (mm):

Insert the Depth for Pocketing: um



Case I. Depth limit

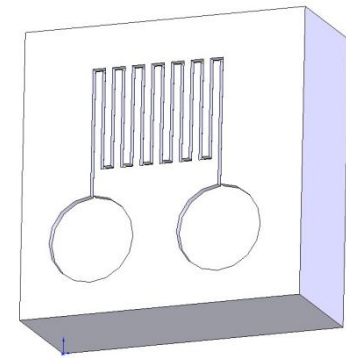


Case II. Depth limit and initial depth

Web-based CAD/CAM Integration (cont.)

SmartFab – Cost estimation

Cost Estimation Service		Calculate
1. C _w (Workpiece cost)	<u>20</u>	
2. C _p (Preparation cost)	<u>875</u>	
3. C _m (Machining cost)	<u>11275</u>	
4. C _n (Nonproductive cost)	<u>0</u>	
Total cost (C _{total} = C _w + C _p + C _m + C _n) is		<u>12170 (won)</u>



$$C_p = T_p * W$$

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

$$C_m = C_{om} + C_t = T_m * W + C_t$$

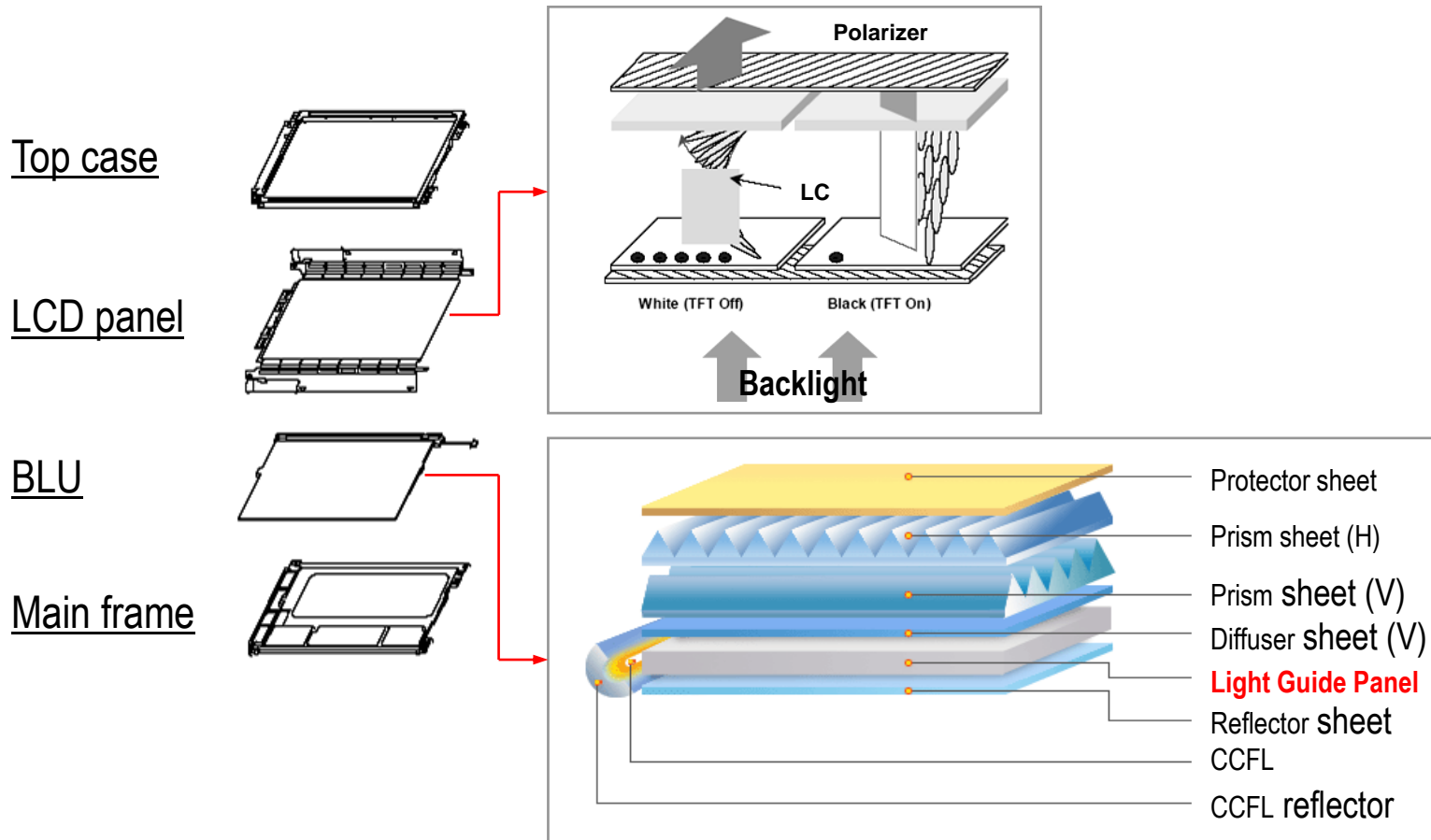
T_m: Machining time (0.41 hr)
W: Operator's wage (2500/hr)

$$C_t = y * (T_m / T) \quad \text{(11,275 won, 92% of total cost)}$$

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

Web-based CAD/CAM Integration (cont.)

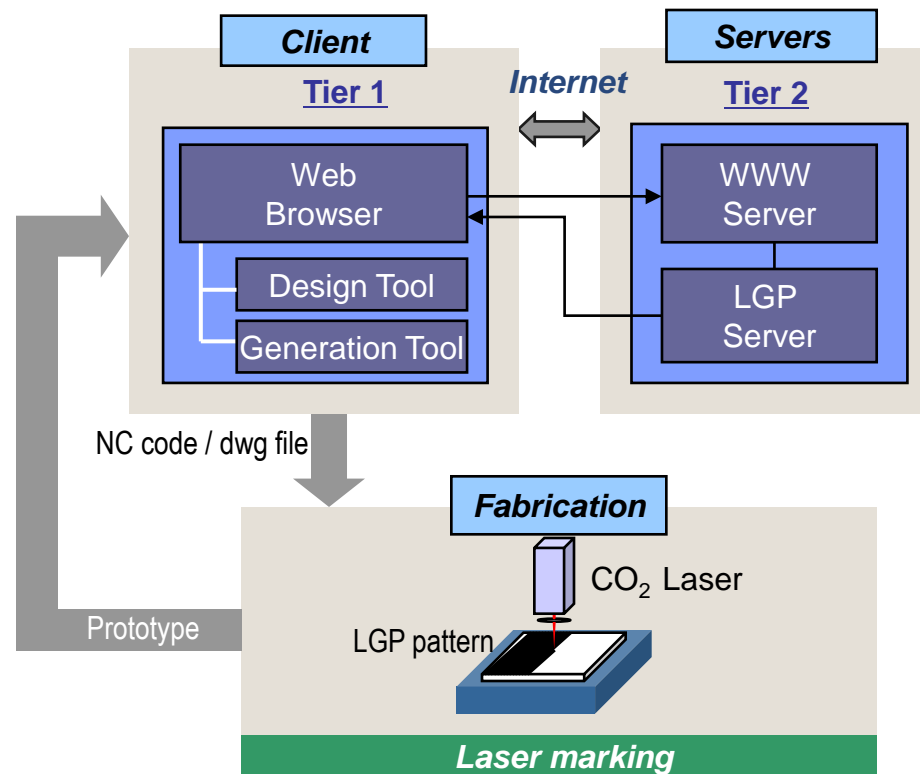
▪ TFT LCD-LGP (Light Guide Panel) prototyping



< Schematic Structure of LCD Unit >

Web-based CAD/CAM Integration (cont.)

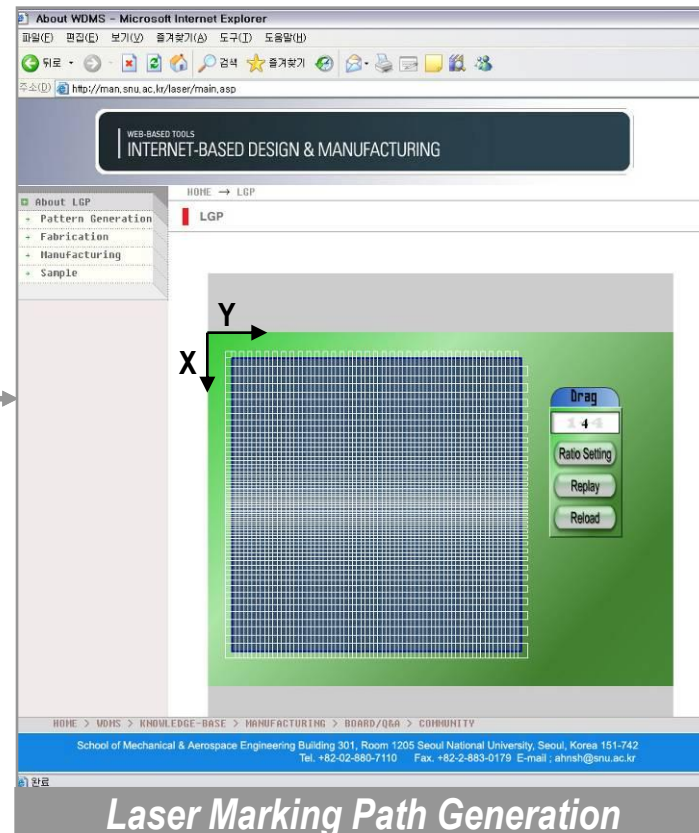
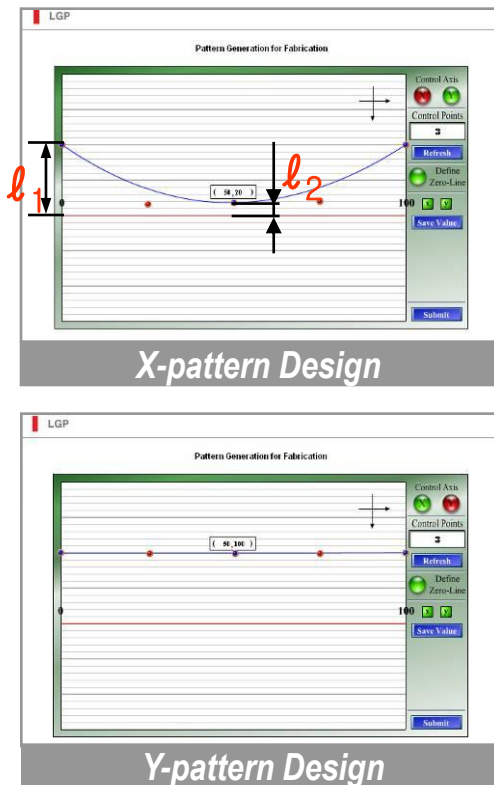
- **TFT LCD-LGP (Light Guide Panel) prototyping**
 - Patter design & NC code generation tool
 - Provide NC code or DWG file



< 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

Pieter Bruegel (1563)

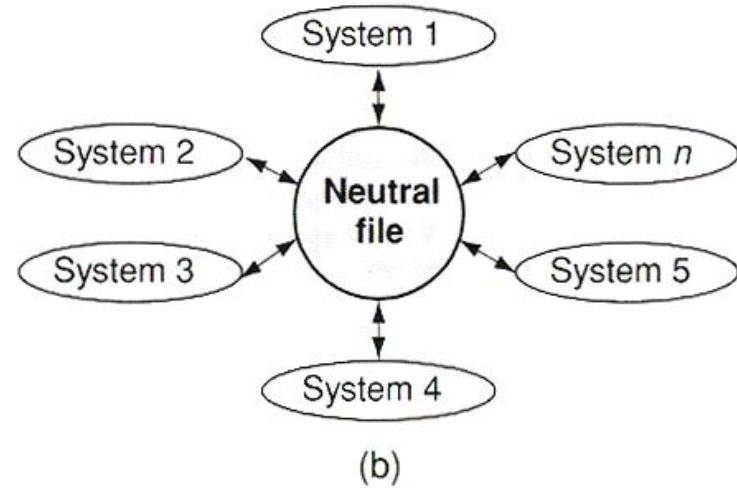
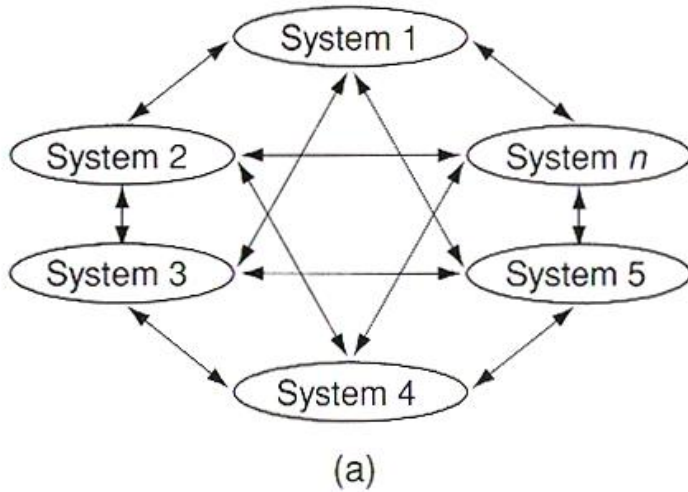


Data Exchange



- **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!**



You CAN do it!

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

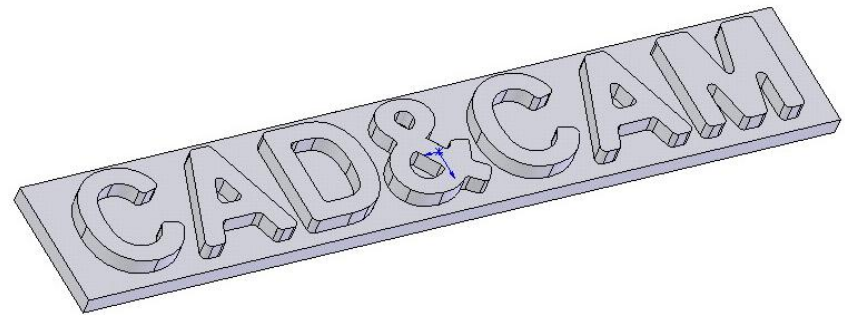
CATIA NC Lab



- **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

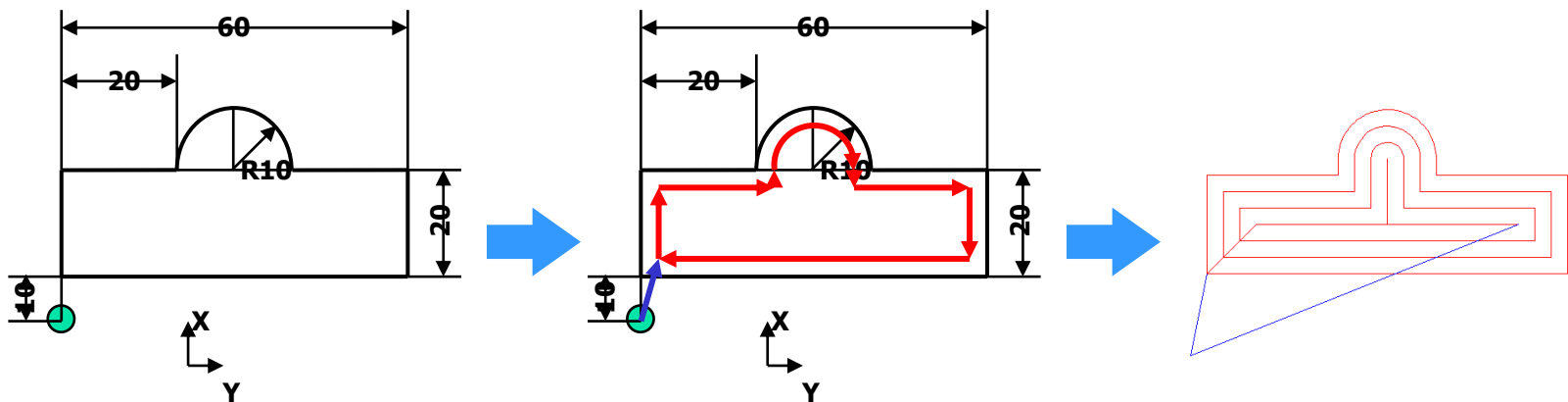
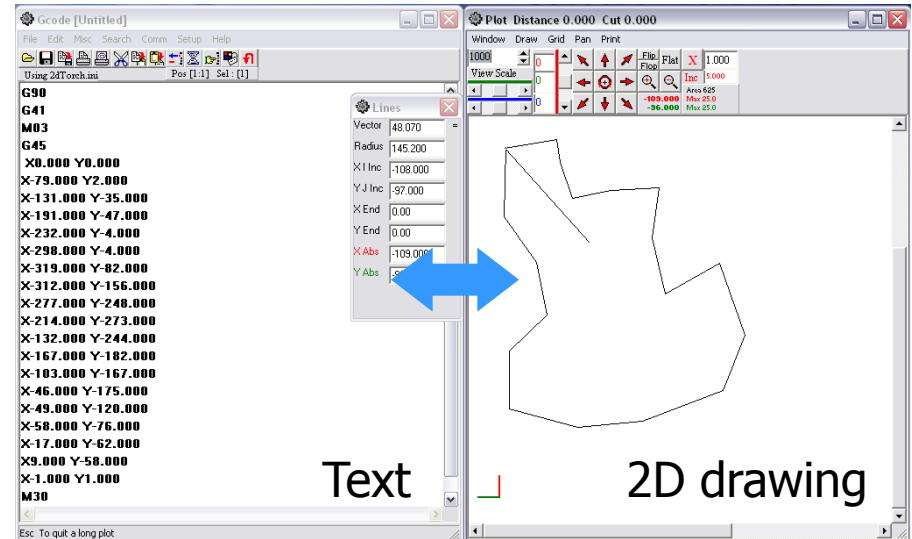


< Example part model >

Manual NC Lab

■ GCode2000

- Text NC support
- 2D drawing support



< Example 2d drawing and NC path >

CAM & Injection molding Lab

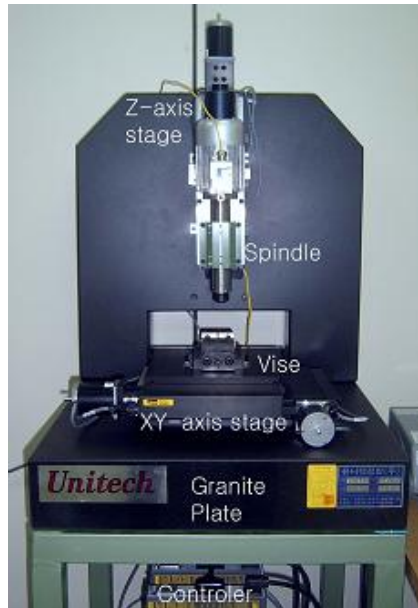
▪ CATIA NC

- Model with surface
- Roughing & Finishing

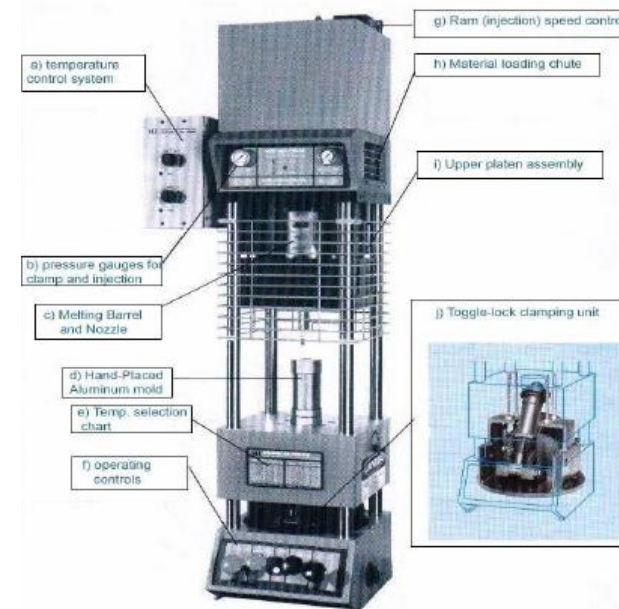


▪ IDIM lab tour

- Micro machining



▪ Injection molding



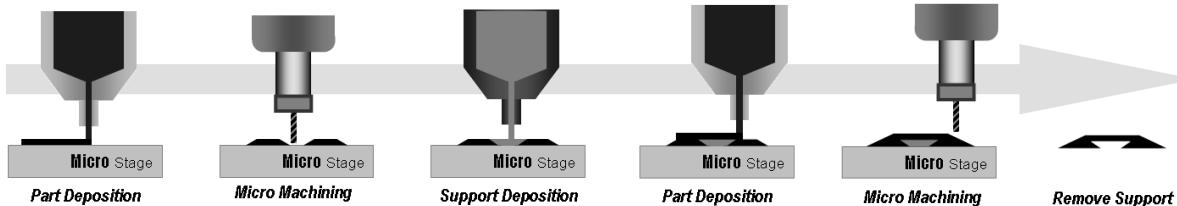
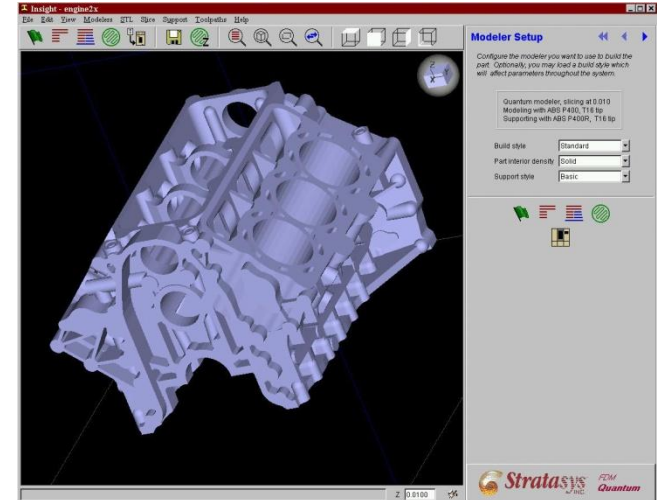
Rapid Prototyping Lab

■ 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 >

