



2006-02 CAD/CAM

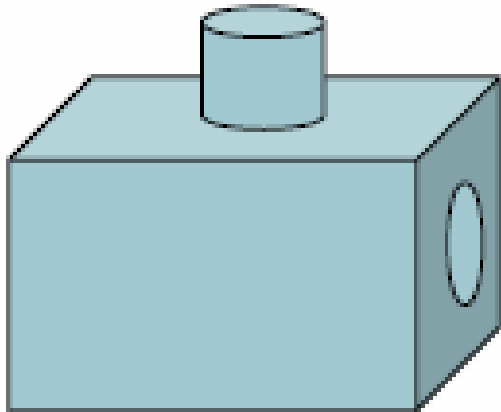
CAD/CAM Integration

Prof. Sung-Hoon Ahn

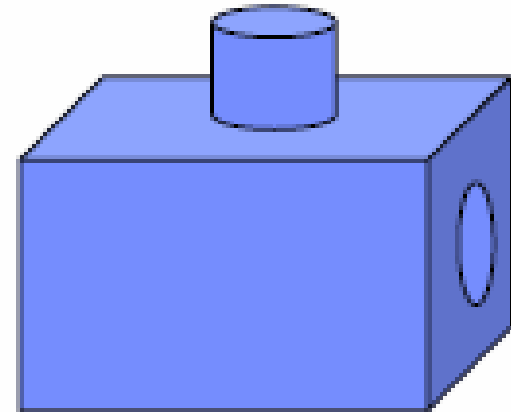
2006-10-16

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

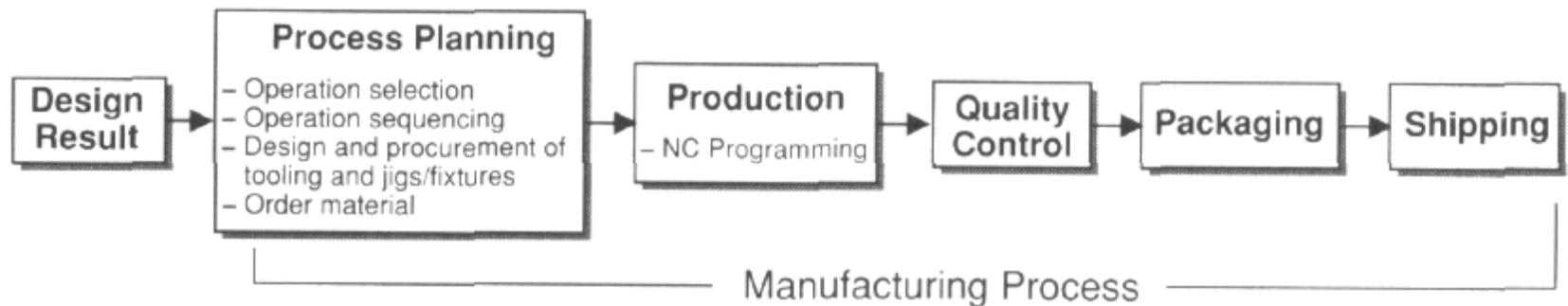
Example Product: Self-made Vehicle



Computer-Aided Manufacturing (CAM)

■ Definition

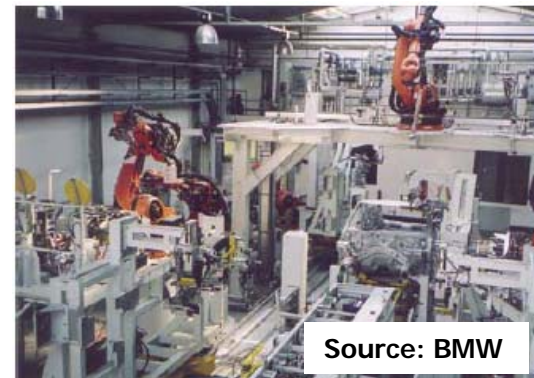
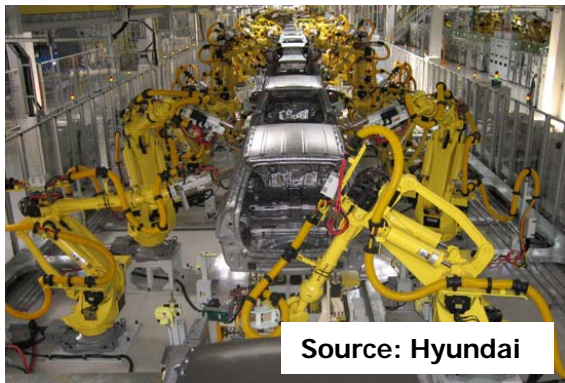
- The technology concerned with the use of computer systems to **plan, manage, and control manufacturing operations** through either direct or indirect computer interface with the **plant's production resources**.



< 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

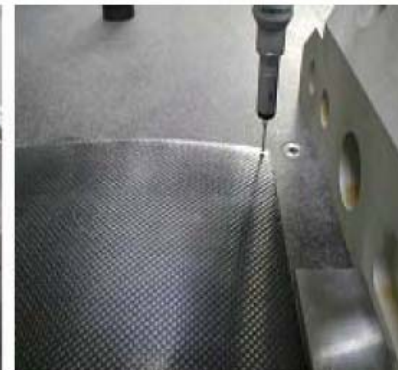
- The act of preparing detailed work instructions to machine or assemble a part of parts

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

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

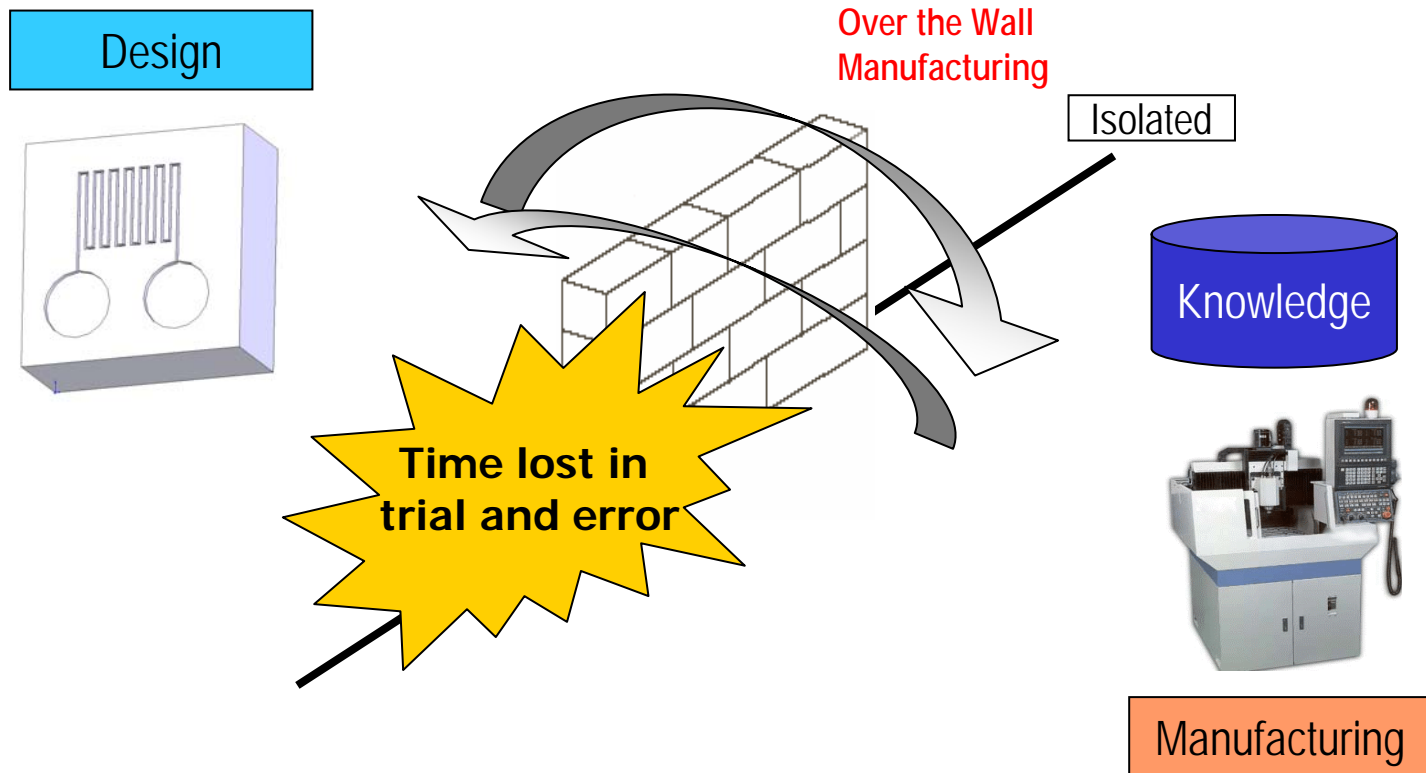
- Inspection software

- Coordinate Measuring Machine (CMM)



Problems in Traditional Production

- Some barriers Between design and manufacturing process



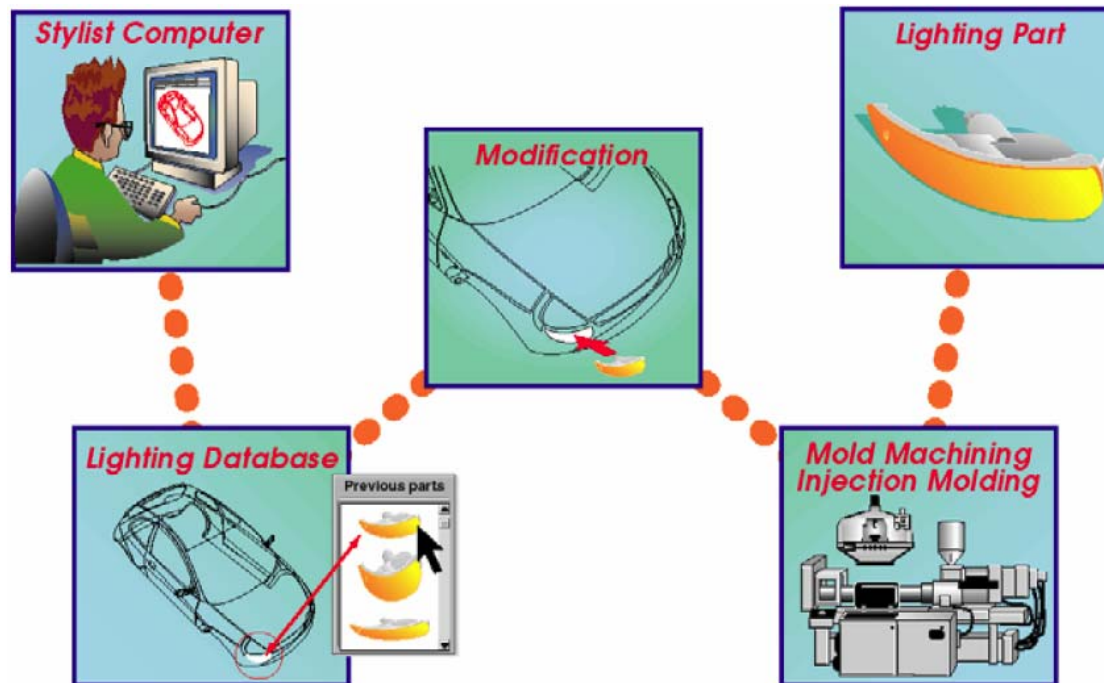
< Diagram of tradition design and manufacturing process >

CAD/CAM Integration

- Goal of integration

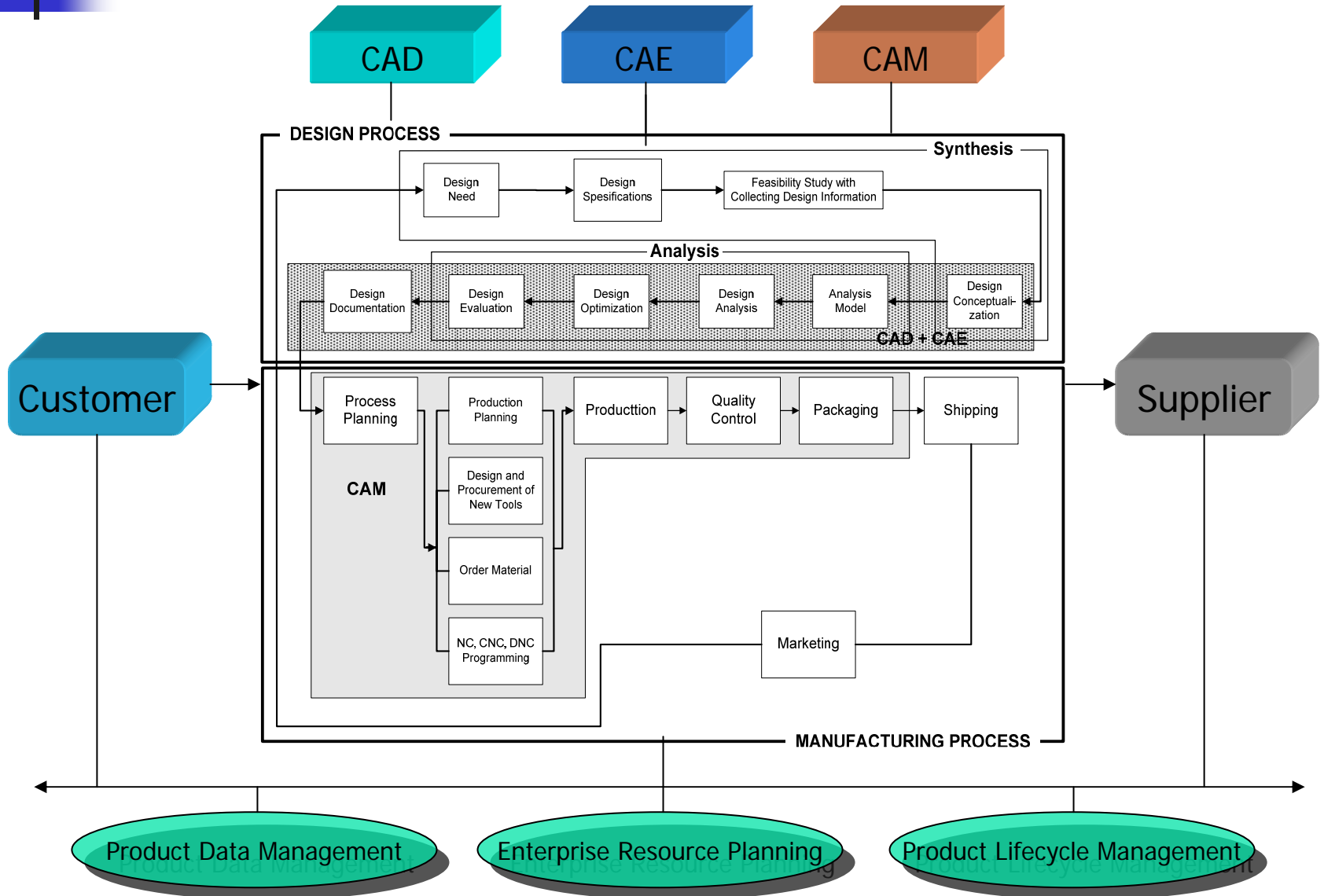
- To facilitate coordination of work and information flow across organizational boundaries

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

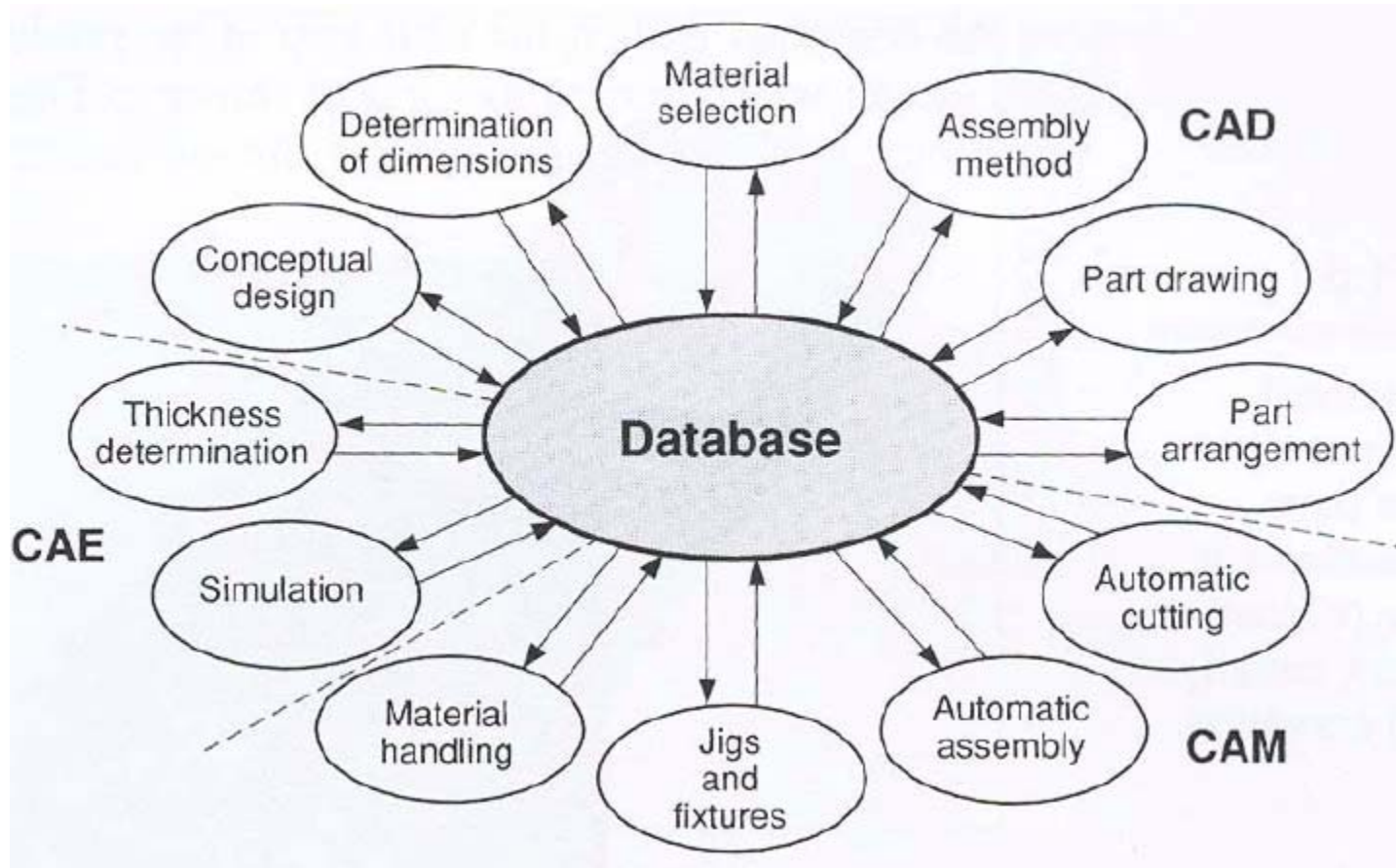


< Example concept of CAD/CAM integration >

Integration in Product Cycle Level



Integration in Database Level



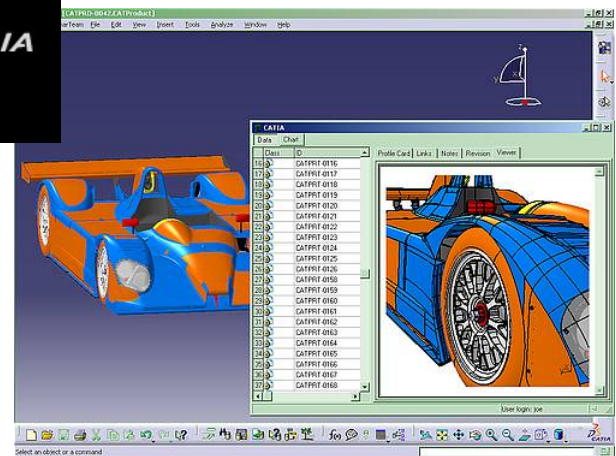
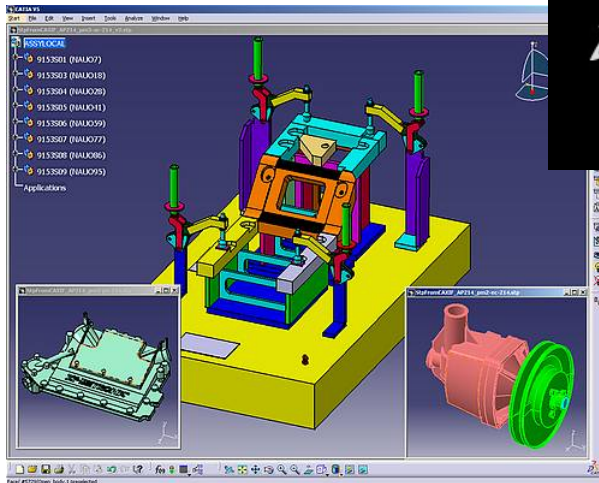
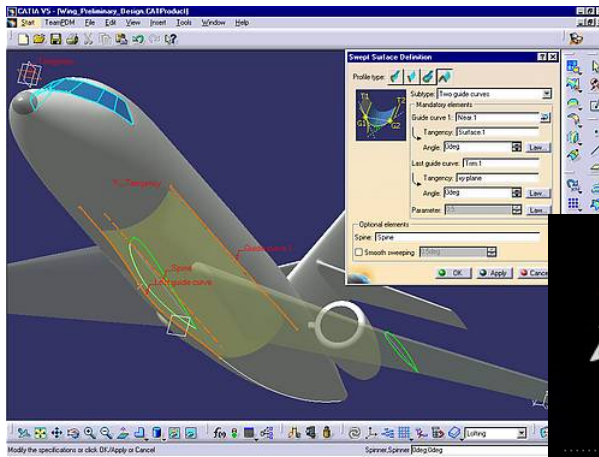
Integration in Commercial Package Level

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



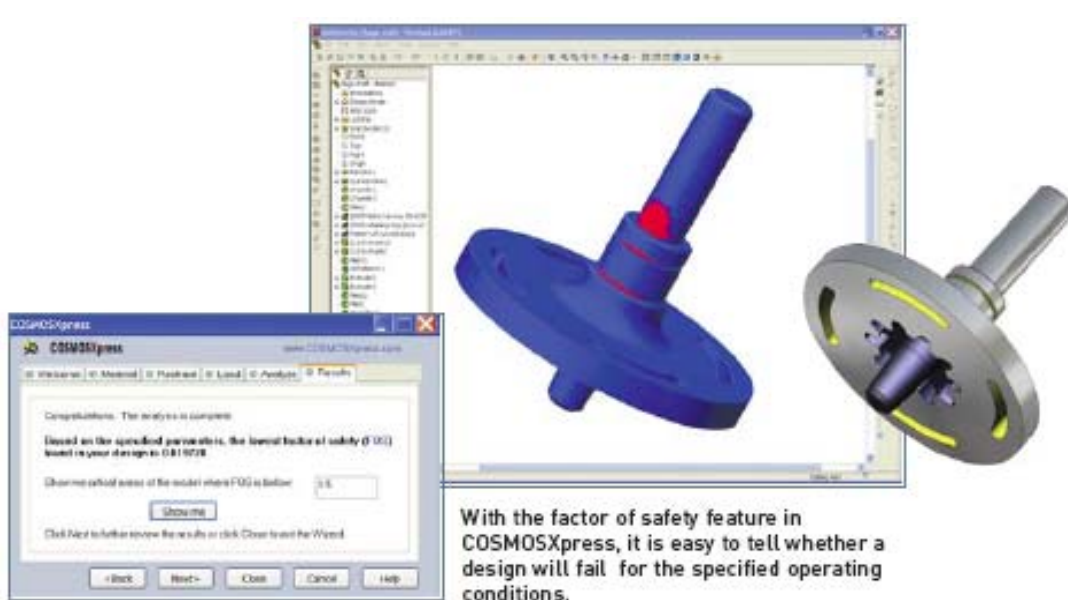
Trends of Commercial Solutions

- Dassault systems: CATIA

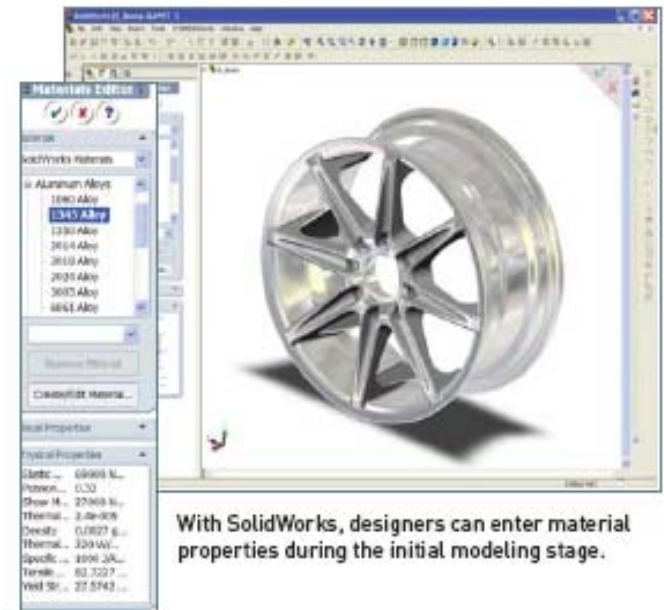


Trends of Commercial Solutions (cont.)

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



< 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.)

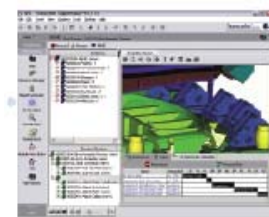
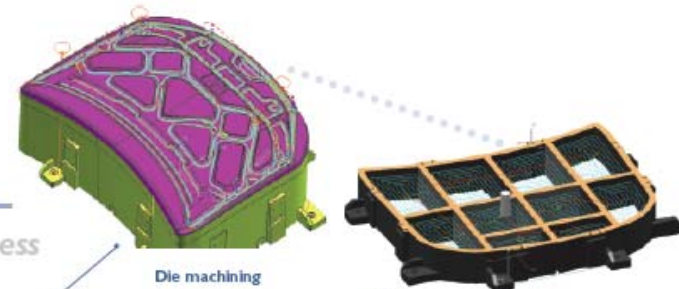
- UGS: NX (Unigraphics)
 - All in NX



< 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.

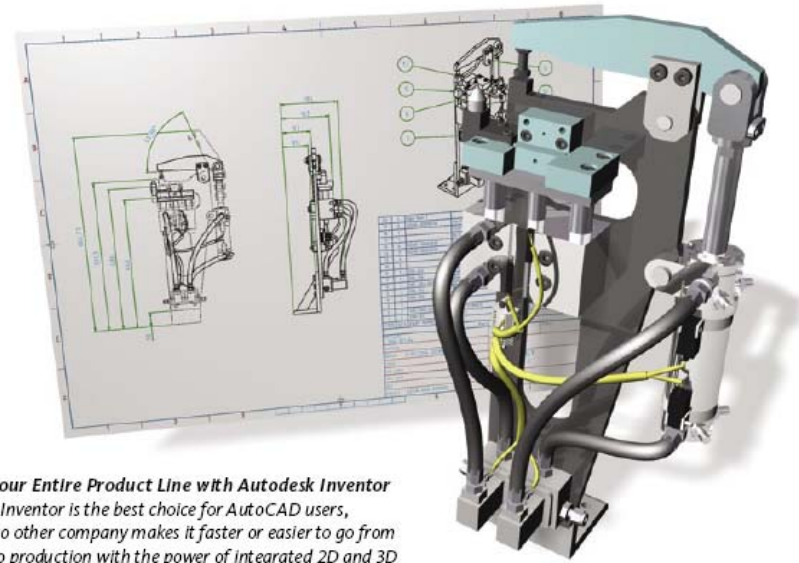


Process planning shop floor documents

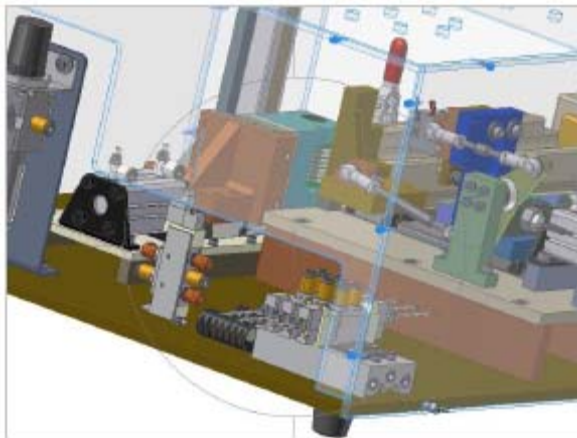
Die structure design

Trends of Commercial Solutions (cont.)

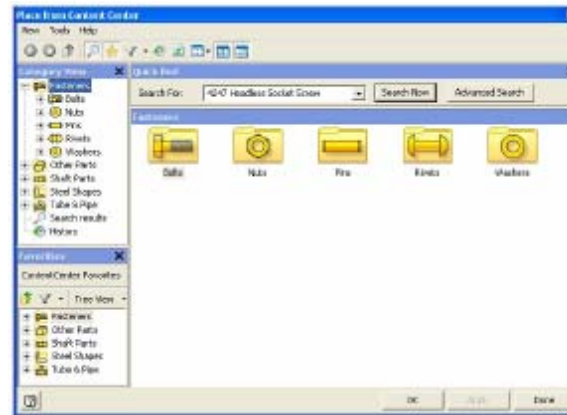
- Autodesk: Inventor
 - Move to 3D from 2D (AutoCAD)
 - Content center
 - Virtual prototyping
 - Bill of Material (BOM)



*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 >



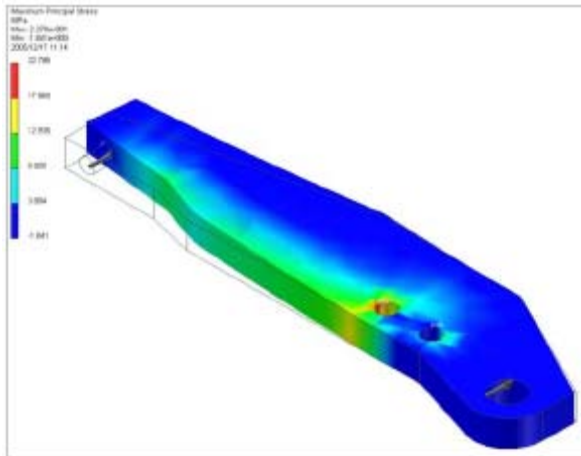
< Virtual prototyping >

Item	Part Number	Material	QUANTITY	Unit (U)	LT	Description	REV
5	21-4563	Aluminum 6061	1	Normal	Part	Base housing	A
4	106-030	Brass, Soft Tin	1	Normal	Part	Thrust washer	A
1	159-010	Cool Bronze	1	Normal	Each	Large Cap	A
1	109-1080	Oil Impregnated	1	Special	Each		5
18	2198734	Nylon	1	Normal	Part		A
9	21-7066	Nylon 6/6	1	Normal	Part		A
7	24-1280	PEEK	1	Normal	Part	Clamp clip	A
8	106-070	Polycarbonate, Clear	1	Normal	Part		A
6	21-4521	Polycarbonate, Smoke	1	Normal	Part	Top cover	A
2	106-004	PVC-Piping	1	Normal	Part	Small Cap	A
3	217-045	Steel, High Ste...	1	Normal	Part	Main shaft	A

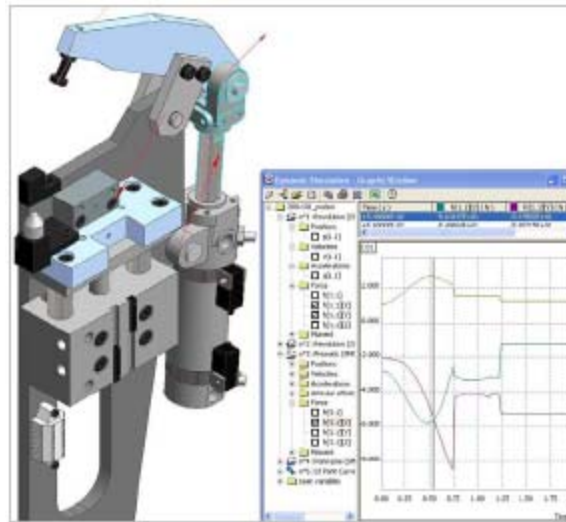
< Bill of Material (BOM) >

Trends of Commercial Solutions (cont.)

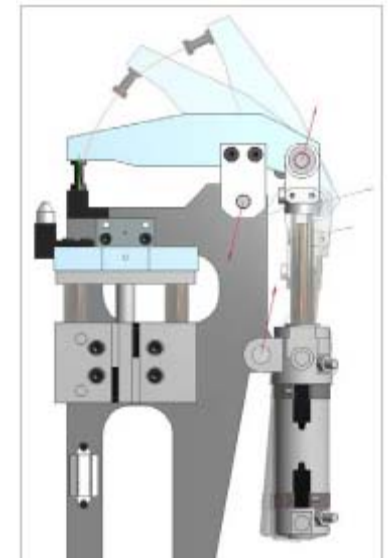
- Embedded CAE ANSYS & Solid Dynamics
 - Stress analysis (ANSYS)
 - Dynamic Simulation (Solid Dynamics)
 - 3D visualization (Solid Dynamics)



< Stress analysis >



< Dynamic Simulation >



< 3D visualization >

Trends of Commercial Solutions (cont.)

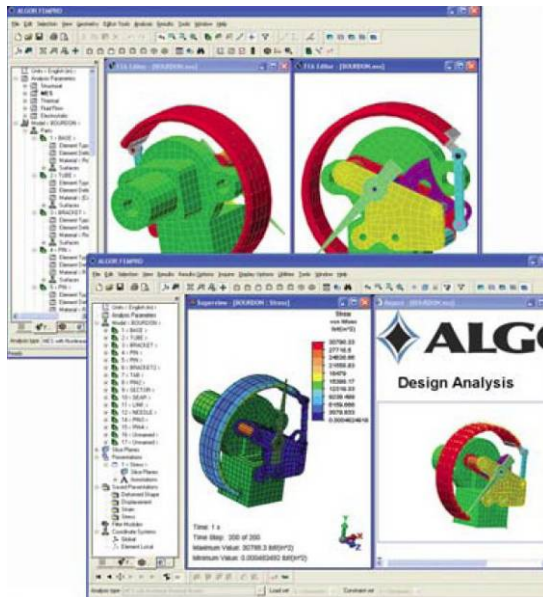
- ANSYS
 - Multi-physics Analysis software
 - CAD supporting in pre-processing

	Complete Simulation Solutions									Meshing Solutions		
	Multiphysics™	Mechanical™	Structural™	Professional™	DesignSpace®	E mag™	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	✓	✓	✓	✓	✓	✓			✓	✓



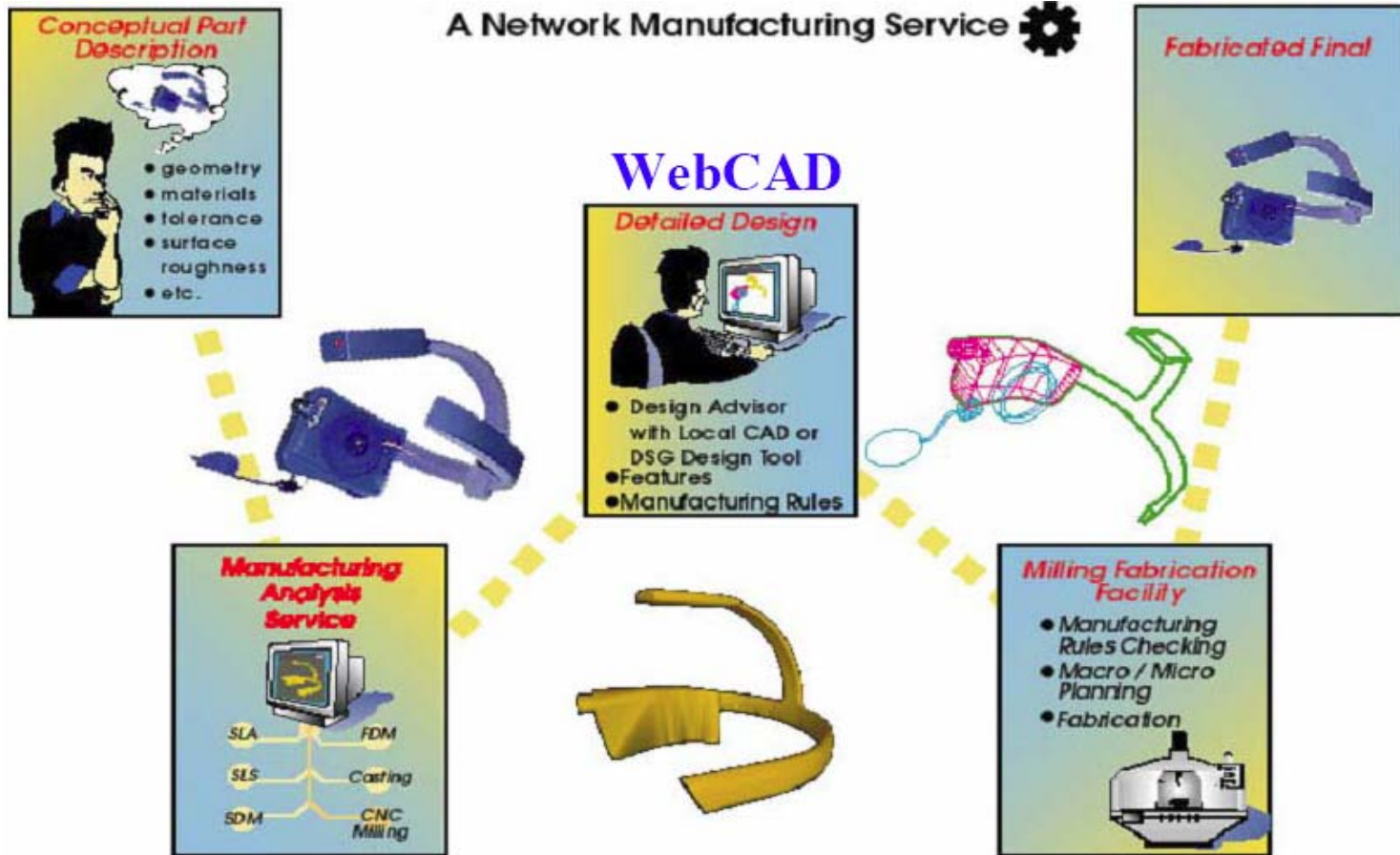
Coupling Modes in Integration

- 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

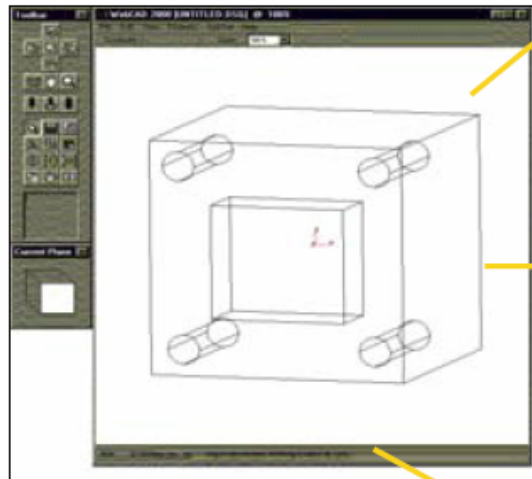
- CyberCut paradigm



Example Solutions of Stiff mode (cont.)

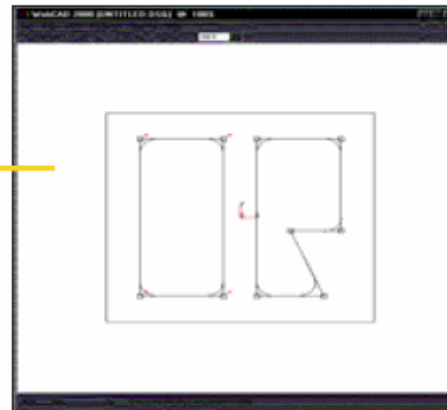
- CyberCut – Feature 1. WebCAD

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

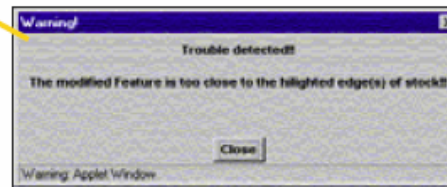


DFM paradigm

1. Tool diameter & Depth



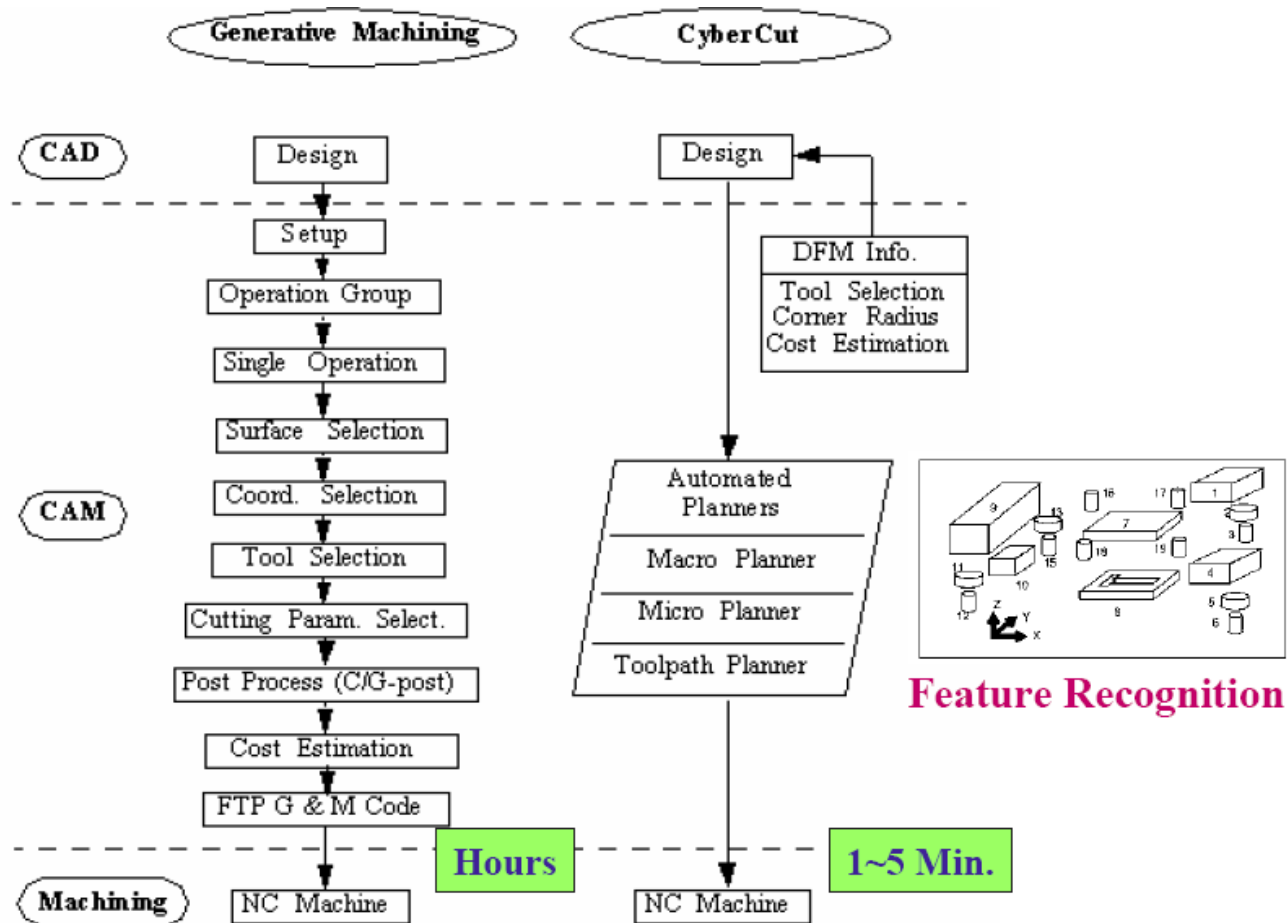
2. WYSIWYG:
Corner radius



3. Design Rule Checker

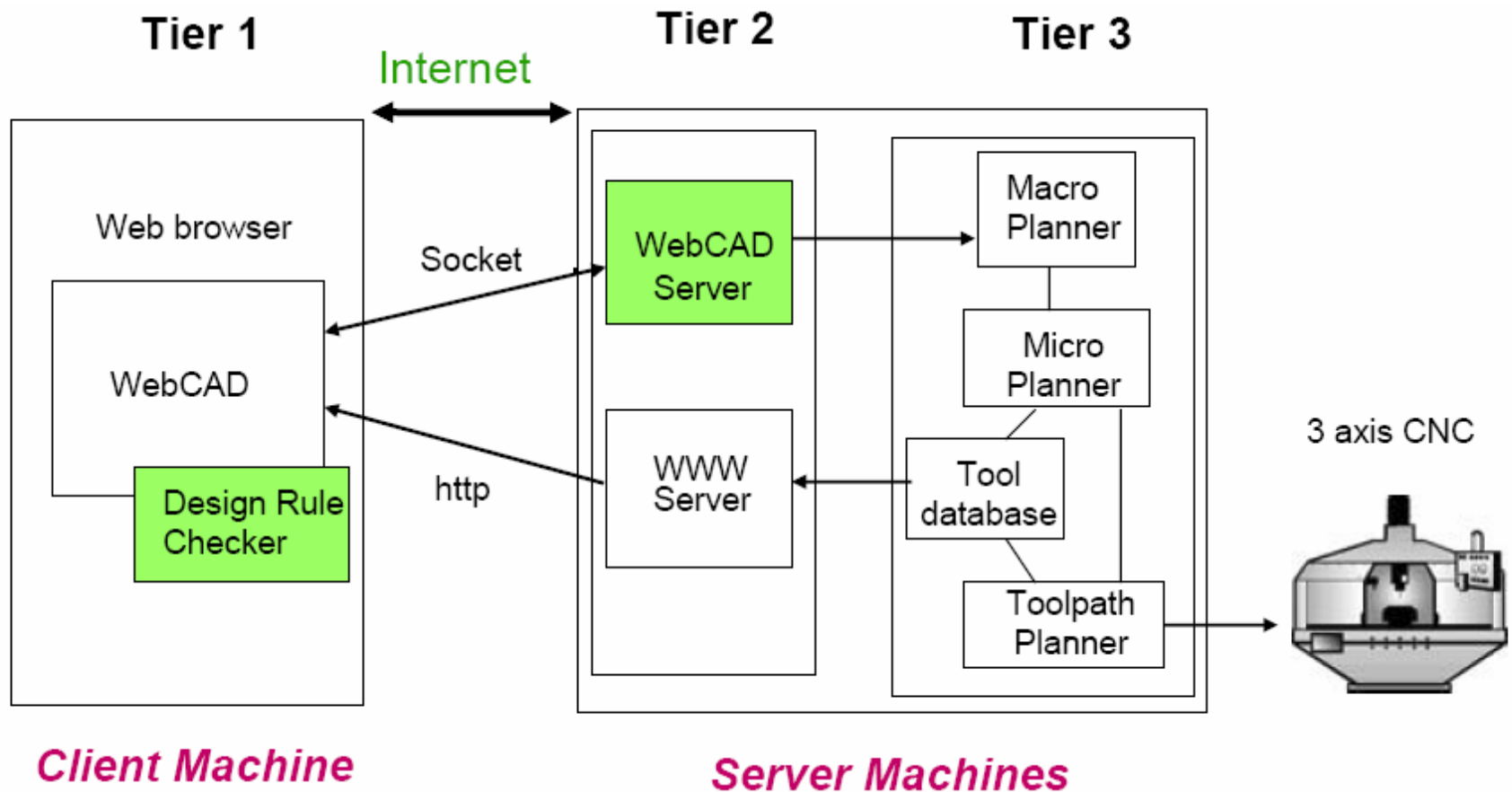
Example Solutions of Stiff mode (cont.)

- CyberCut – Feature 2. Automated Process Planning



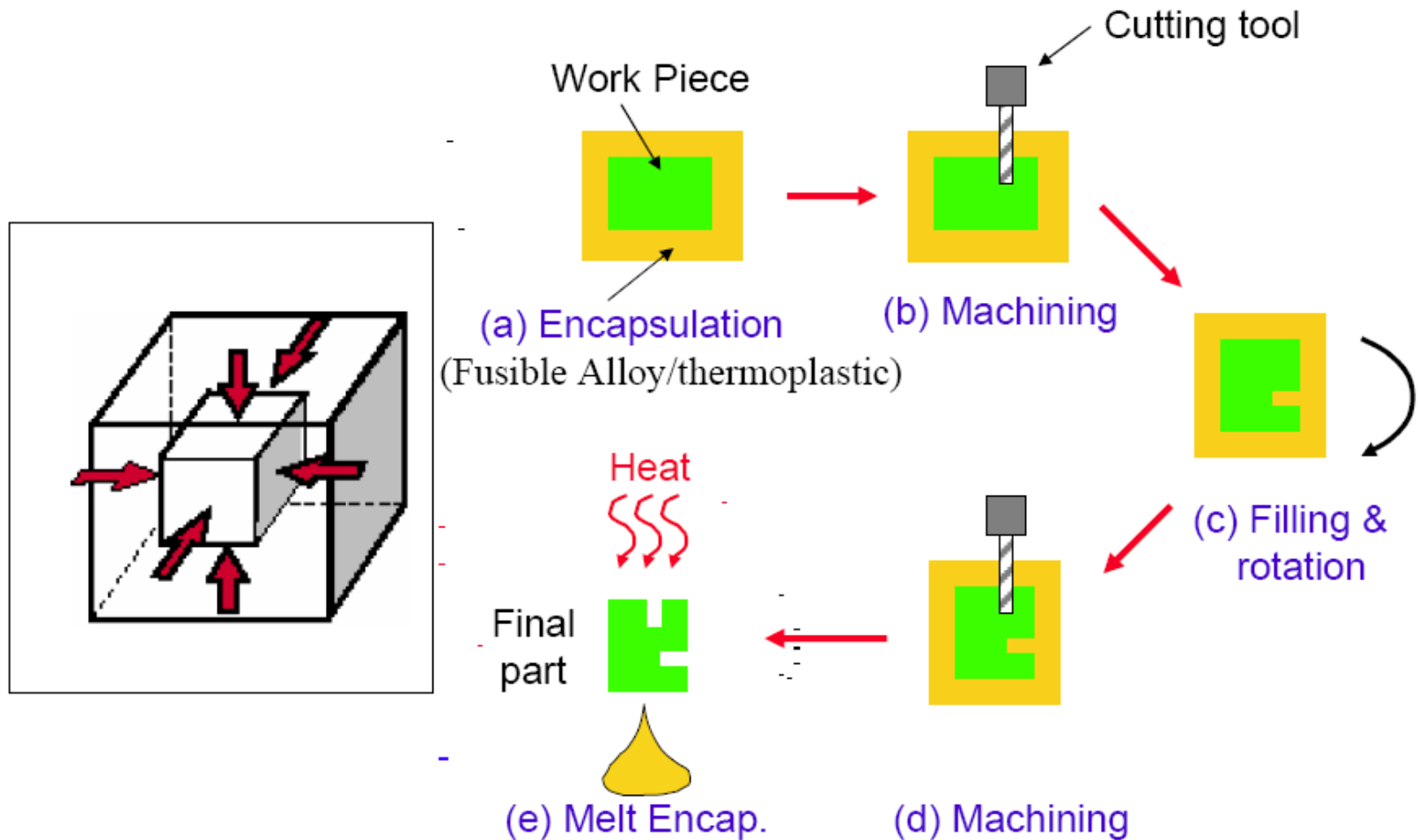
Example Solutions of Stiff mode (cont.)

- CyberCut – Network communication



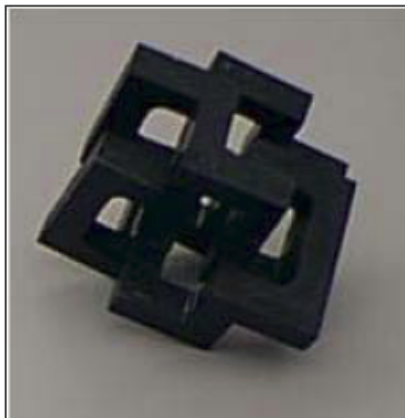
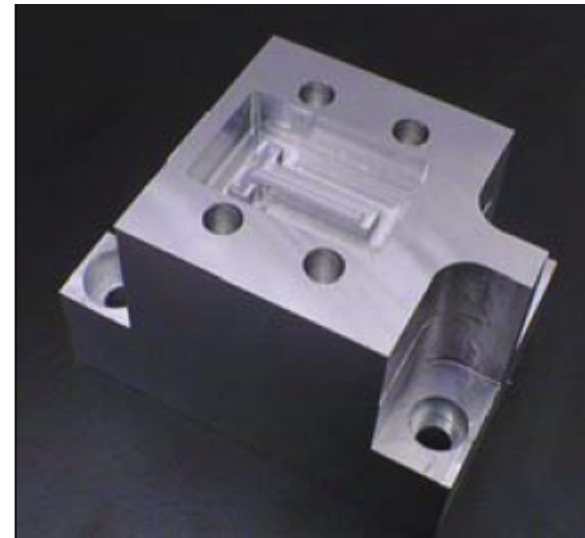
Example Solutions of Stiff mode (cont.)

- 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

The screenshot displays the SmartLite software interface. The main window is titled "SmartLite" and features a menu bar with "File" and "Help". Below the menu bar is a toolbar with various icons. A "Close" button is visible in the top right corner of the main window.

The "Lumen Calculator" window is open, showing the following settings:

- Lamp Type: Headlamp
- Focal length (mm): 31.75
- Socket diameter (mm): 34.00
- Metalized reflectivity (%): 88.00
- Transmissivity (%): 90.00
- Bulb: by name (9007)
- Curve Option: Projected Curve
- Shape: Select curves ... (Preview button)
- Select Filament Orientation: Transverse

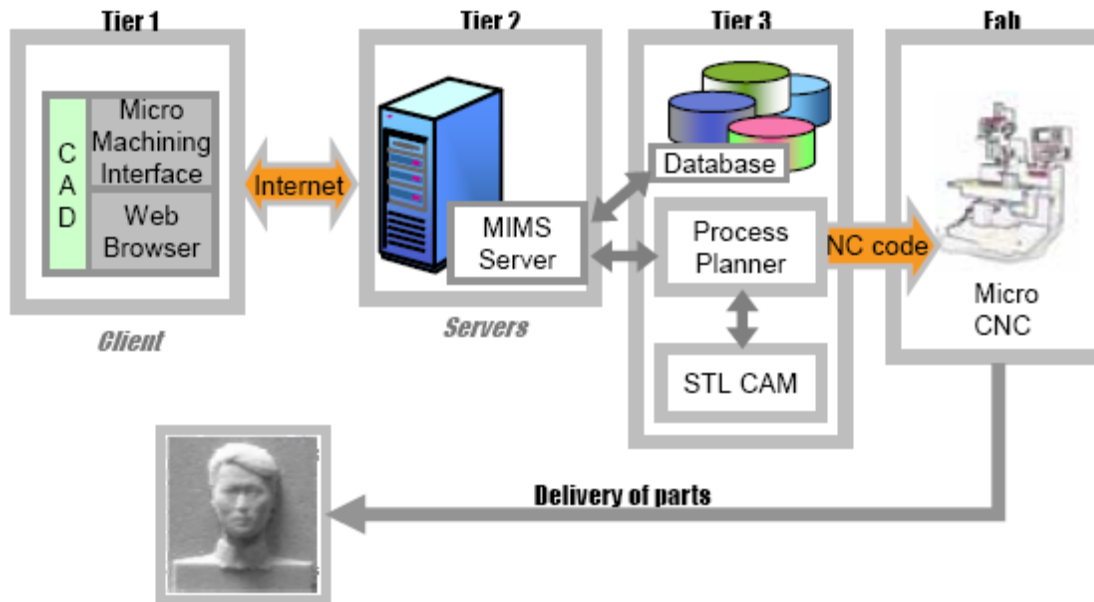
The "Lumen Result" window is also open, displaying the following results:

- Lumen Value:
 - Total Collected Lumens for Low/Minor Filament: 24.95
 - Total Collected Lumens for High/Major Filament: 33.83
- Criteria:
 - Lamp type: Headlamp
 - Min. (lm): 400.0 (low beam); 450.0 (high beam)
 - Performance (lm): N/A
- Summary:
 - Focal length (mm): 31.75
 - Socket Diameter (mm): 34.00
 - Reflectivity (%): 88.00
 - Transmissivity (%): 90.00
 - Bulb Name (MSCP): 9007 (83.0, 113.0)

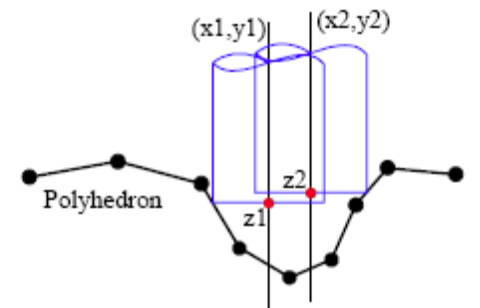
A preview image of the lamp's beam profile is shown in the bottom left of the Lumen Result window.

Web-based CAD/CAM Integration

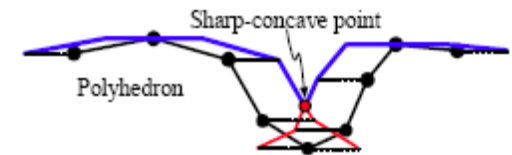
- Micro Machining System (MIMS)
 - Micro machining service using the internet
 - Communication with 3-tier client-server model
 - Upload STL file



< Communication architecture >



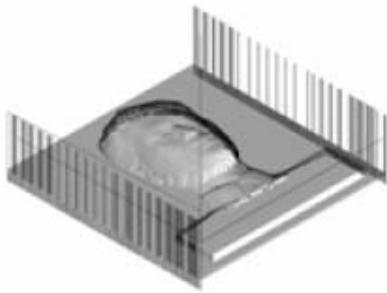
< Point-based Approaches >



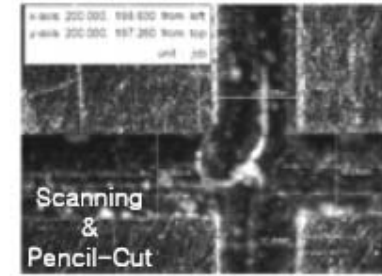
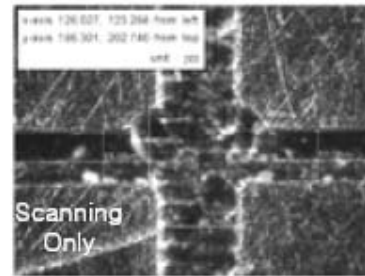
< Curve-based approaches >

Web-based CAD/CAM Integration (cont.)

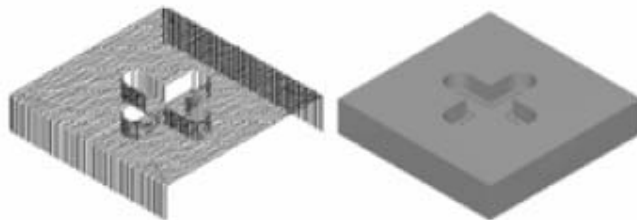
- Micro Machining System (MIMS)
 - Provide the NC code viewer
 - Fabricated by micro-endmill according to scanning and pencil-cut toolpath



< G&M codes on NC code viewer >



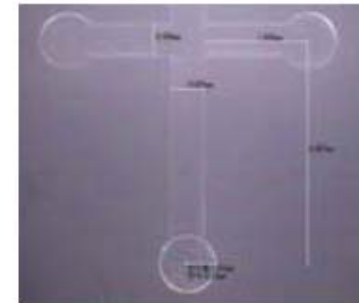
< Micro channel >



< Two types of toolpath >



< 3D scanned head >

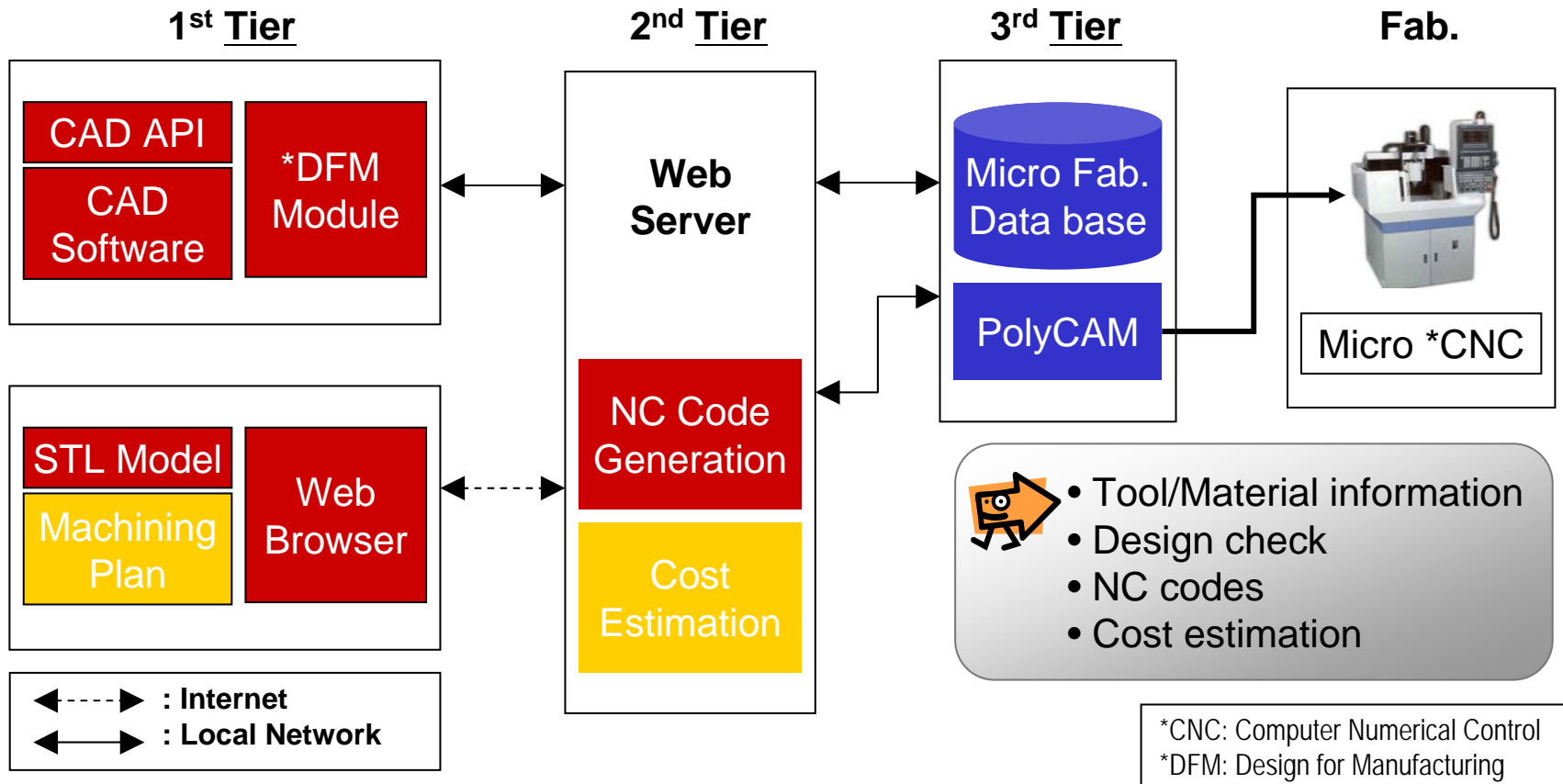


< Micro fluidic channel >

Web-based CAD/CAM Integration (cont.)

SmartFab

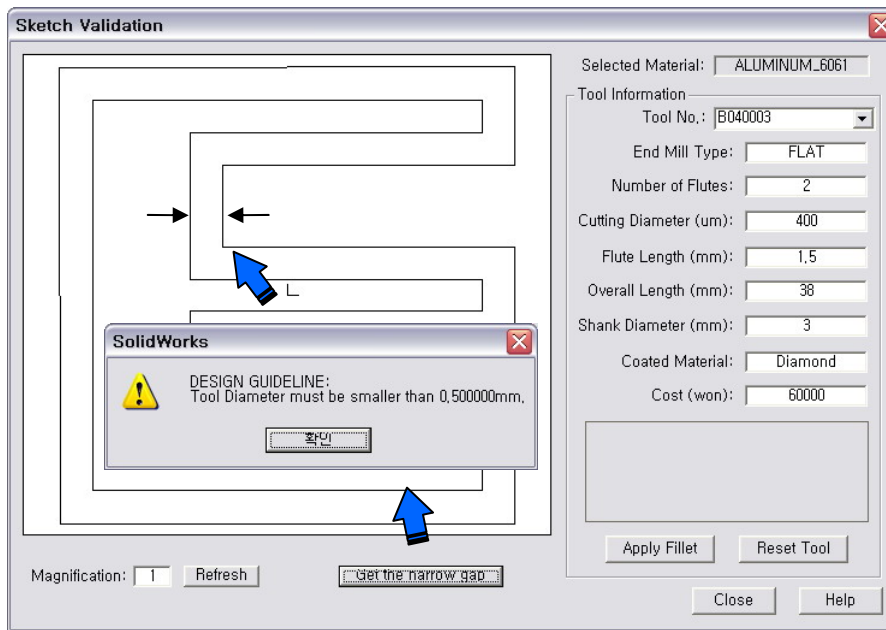
Micro machining using SolidWorks



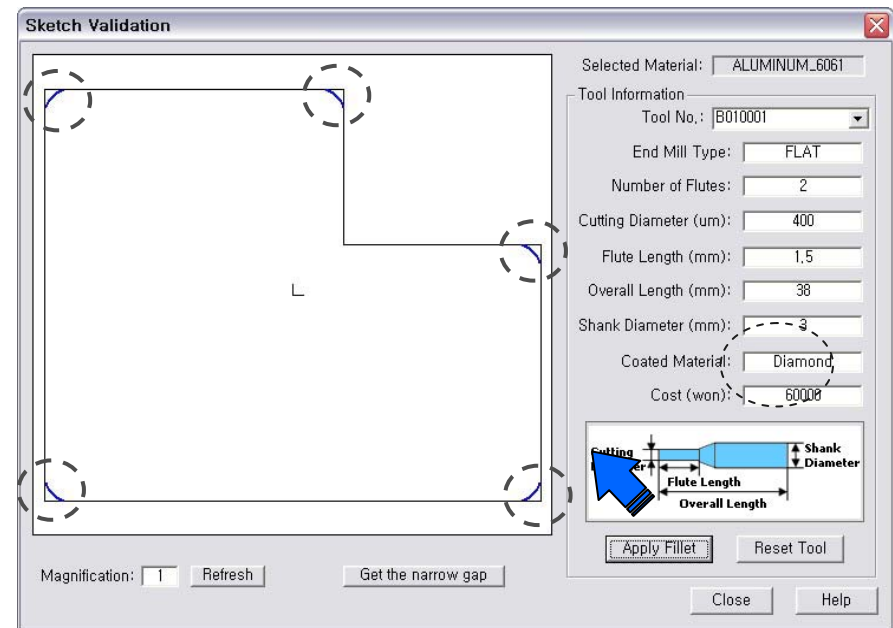
< Architecture of SmartFab >

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

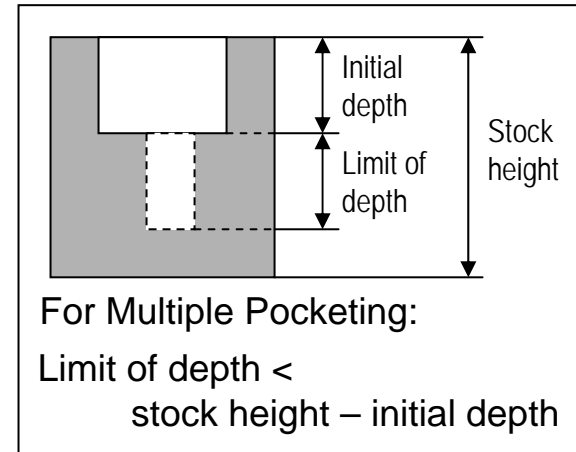
Base Stock Height: um

Selected Tool

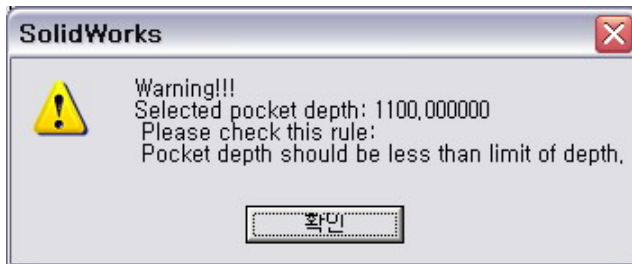
ID: Flute Length (mm):

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

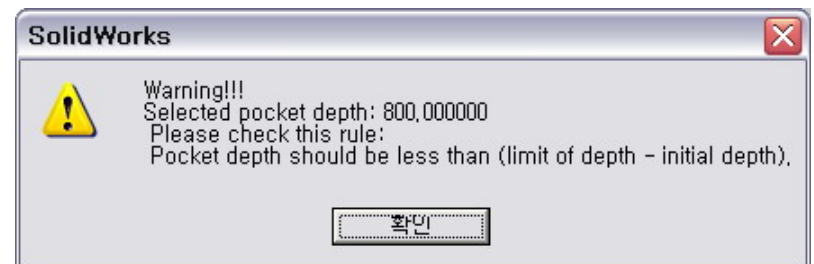
Insert the Depth for Pocketing: um



< DFM in pocketing >



Case I. Depth limit



Case II. Depth limit and initial depth

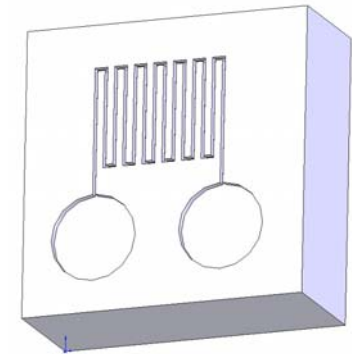
Web-based CAD/CAM Integration (cont.)

■ SmartFab – Cost estimation

Cost Estimation Service

Calculate

1. 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</u> (won)	



$$C_p = T_p * W$$

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)

$$C_t = y * (T_m / T)$$

(11275 won, 92% of total cost)

C_t: Tool usage cost

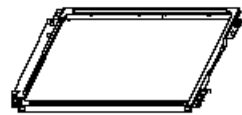
T: Tool life (4 hr)

y: tool cost (100,000)

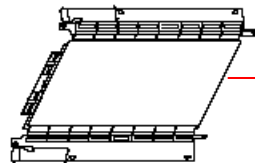
Web-based CAD/CAM Integration (cont.)

■ TFT LCD-LGP (Light Guide Panel) prototyping

Top case



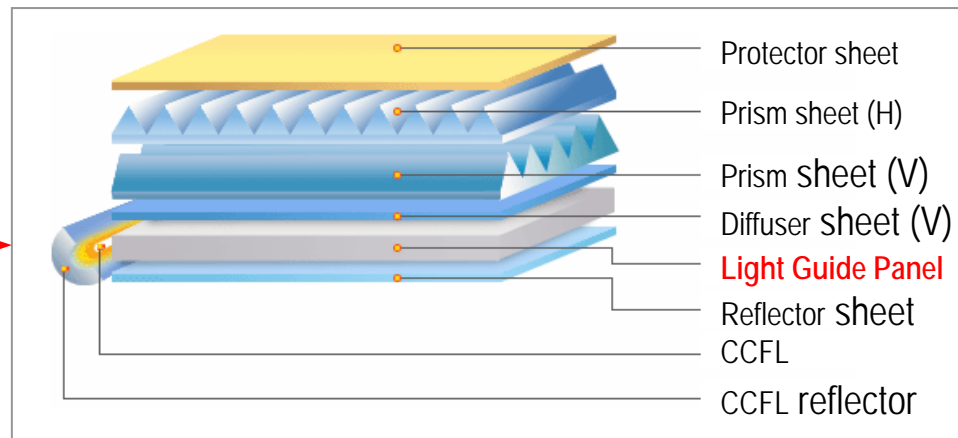
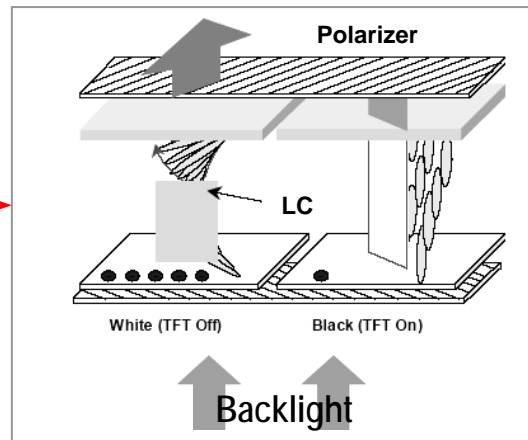
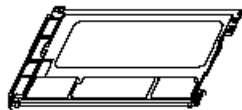
LCD panel



BLU



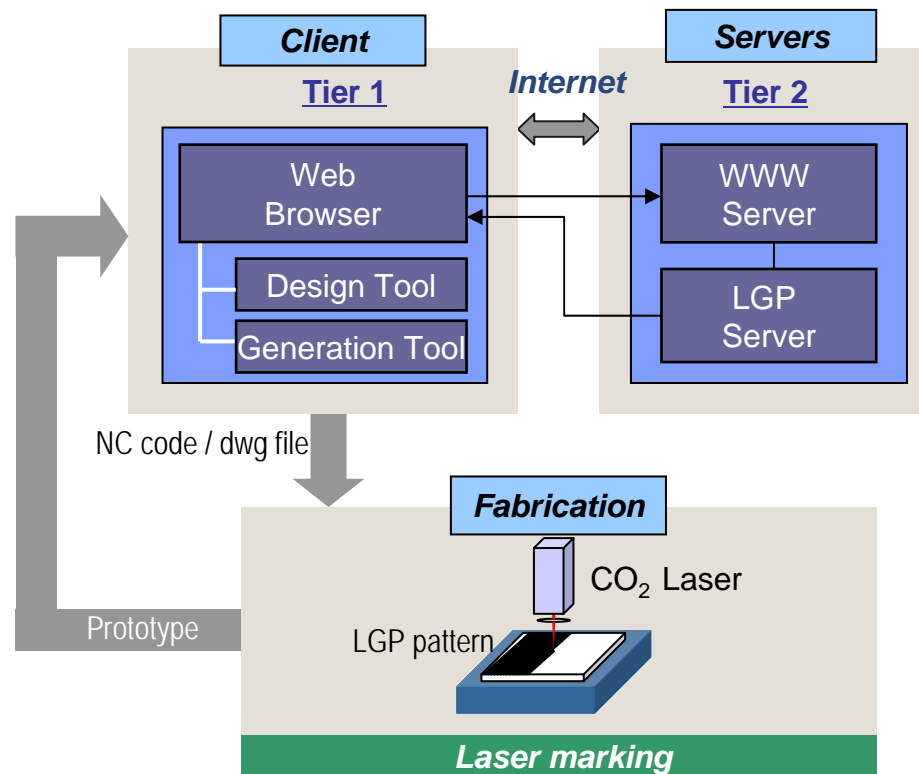
Main frame



< 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

The image displays a web-based design tool for LGP (Light Guide Panel) pattern generation. It is divided into three main sections:

- X-pattern Design:** Shows a graph with a blue curve and red dots. Handwritten red labels b_1 and b_2 indicate vertical dimensions. The control panel includes buttons for Refresh, Define Zero-Line, Save Value, and Submit.
- Y-pattern Design:** Shows a graph with a horizontal red line and red dots. The control panel is similar to the X-pattern design.
- Laser Marking Path Generation:** A screenshot of a web browser showing the tool's interface. It features a grid with X and Y axes, a 'Drag' button, and 'Ratio Setting', 'Replay', and 'Reload' buttons. The browser address bar shows <http://man.snu.ac.kr/laser/main.asp>.

< 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.)

