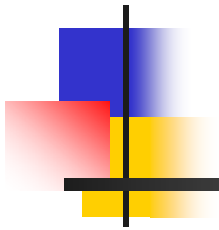


2006-02 CAD/CAM

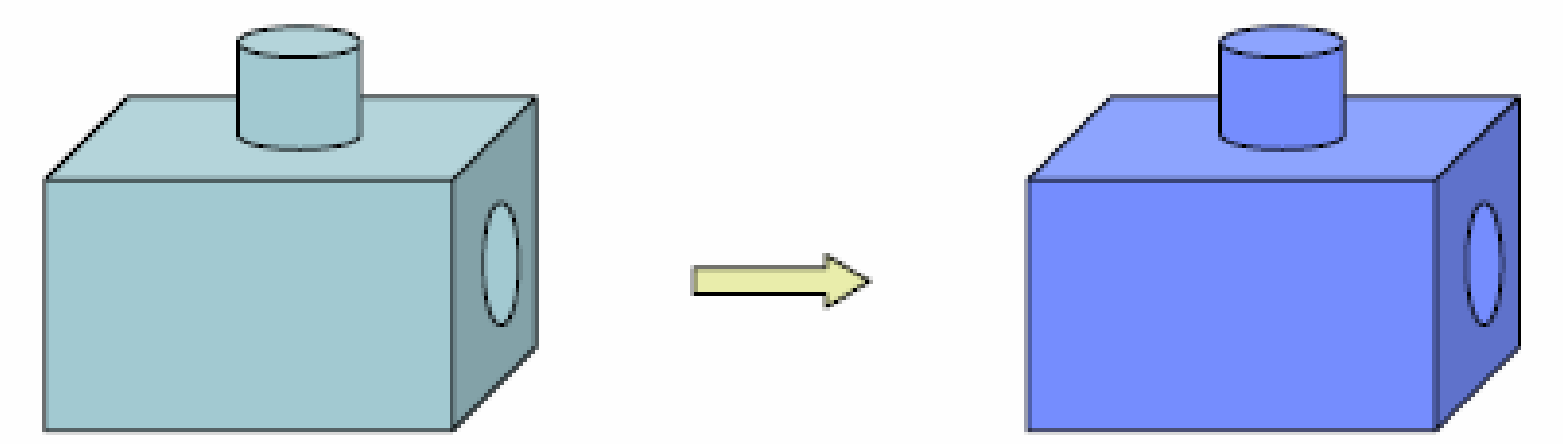
CAD/CAM Integration

Prof. Sung-Hoon Ahn

2006-10-16

From Design to Manufacturing

- Now we are in the Manufacturing domain



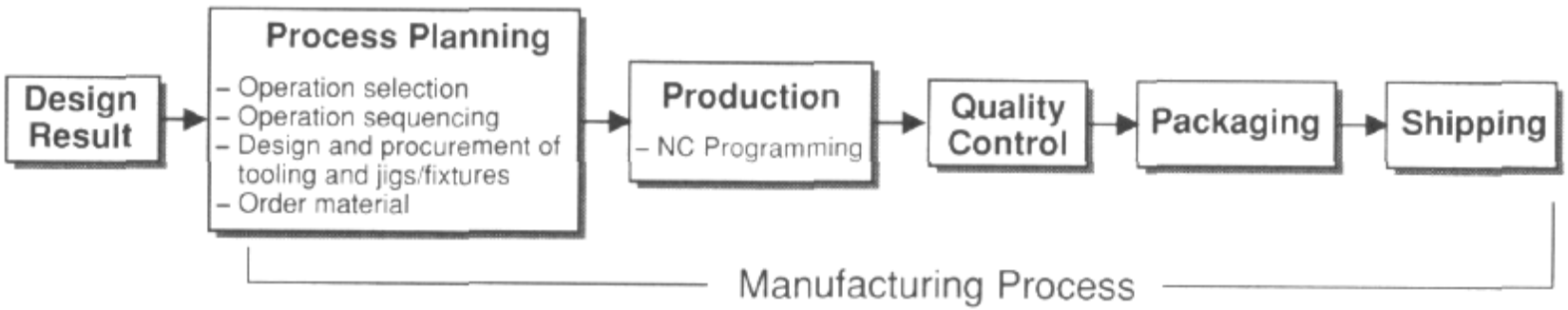
Design domain:
How to create geometry

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.



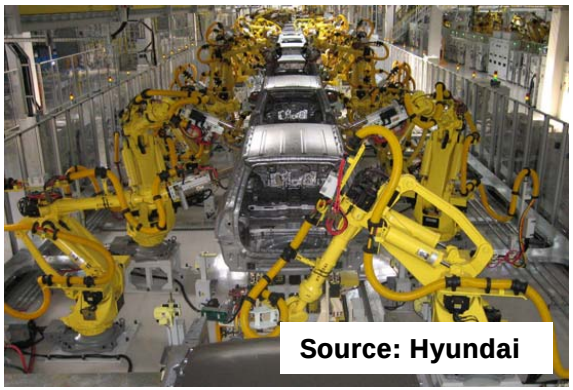
< Main Phases of discrete part manufacturing >

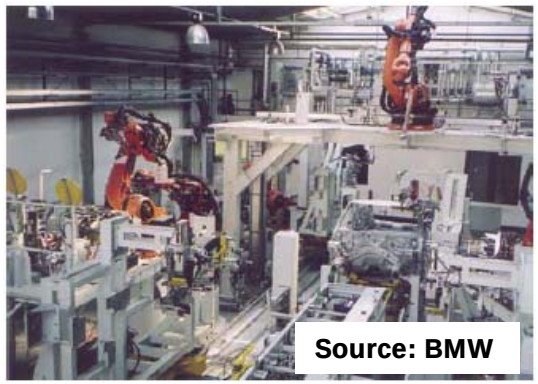
CAM Software

- 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

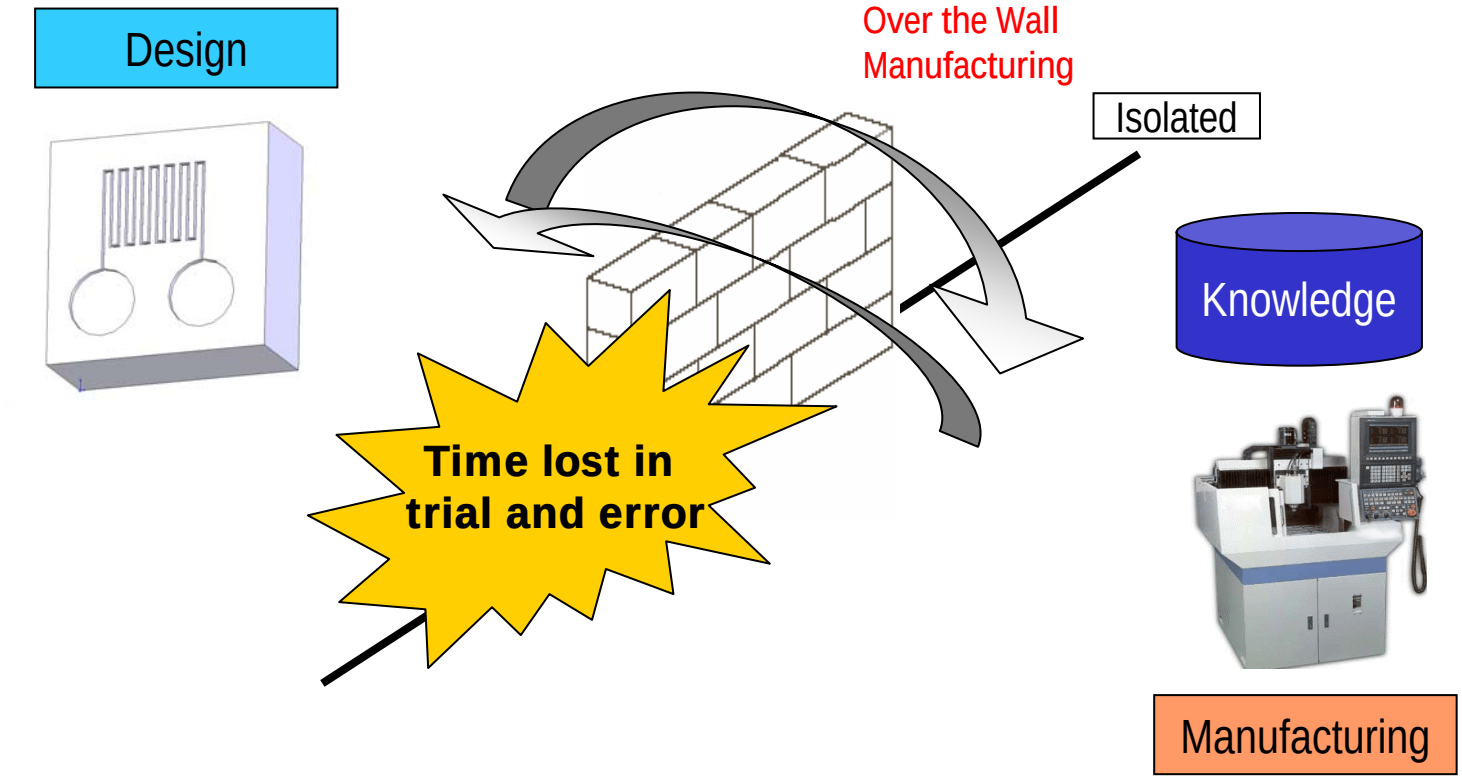
    - Computer-Aided Manufacturing, Chang et al., 1998
  - Process plan; operation sheet; route sheet
  - Computer-Aided Process Planning (CAPP)

- Inspection software
  - Coordinate Measuring Machine (CMM)



Problems in Traditional Production

- Some barriers Between design and manufacturing process

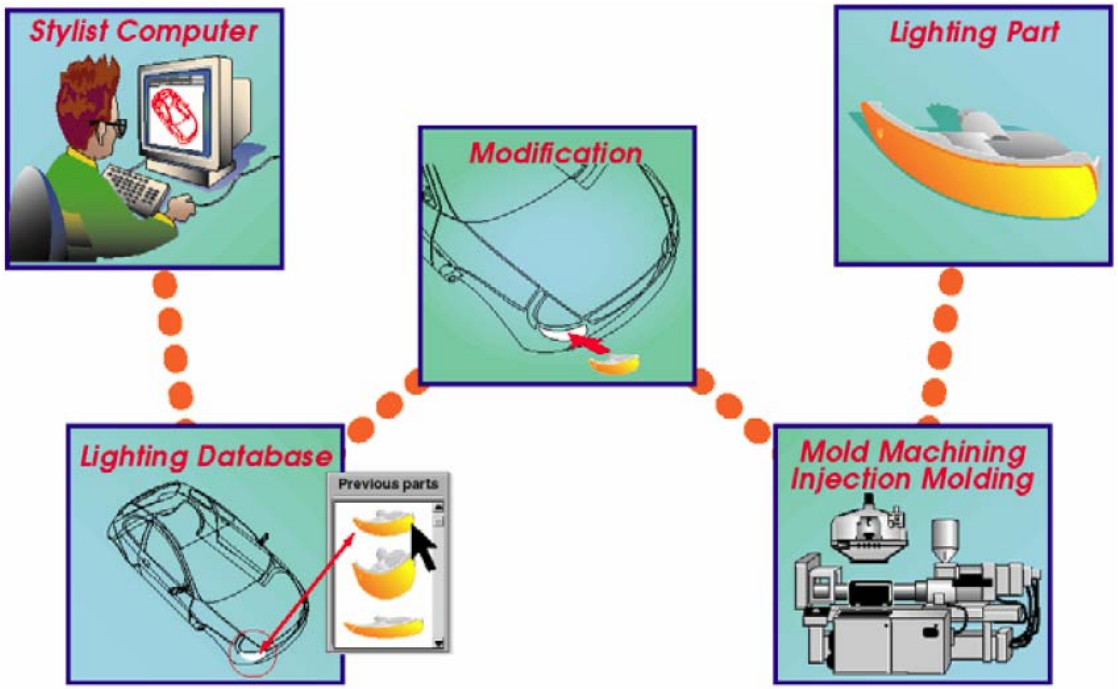


< Diagram of tradition design and manufacturing process >

CAD/CAM Integration

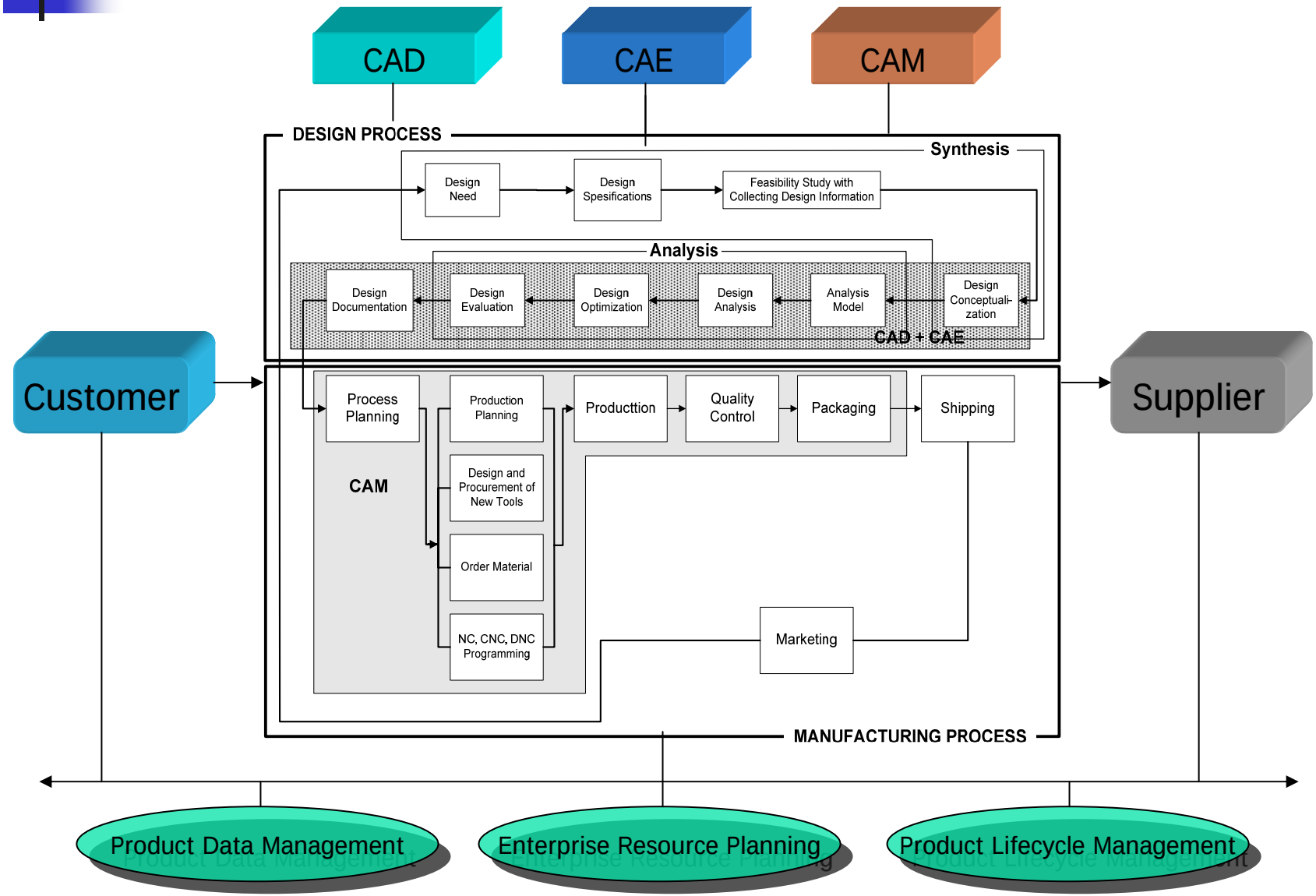
- Goal of integration
  - To facilitate coordination of work and information flow across organizational boundaries

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

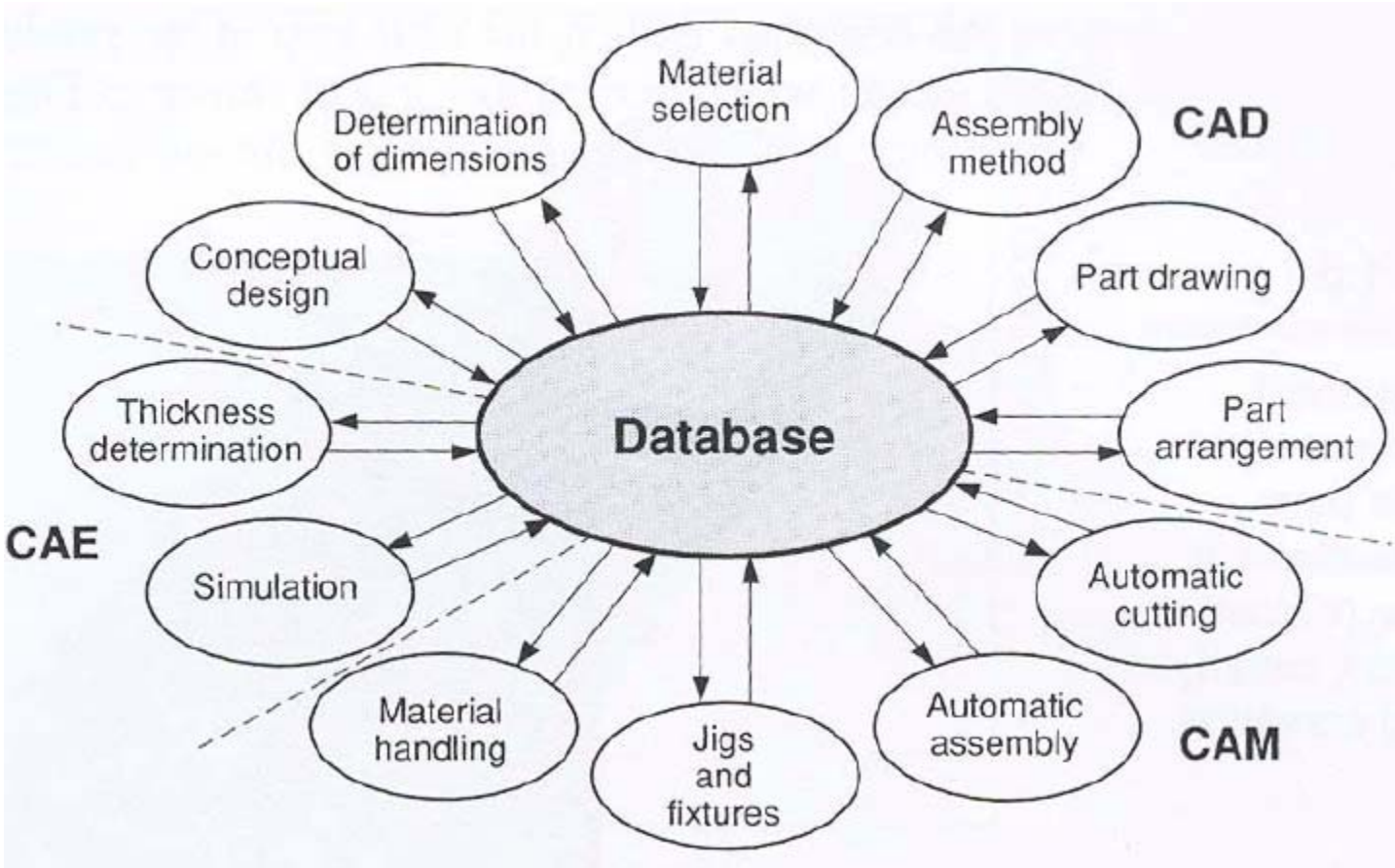


< Example concept of CAD/CAM integration >

Integration in Product Cycle Level



Integration in Database Level

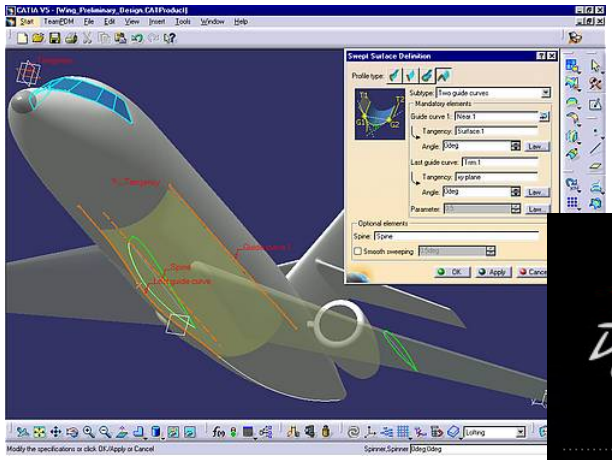


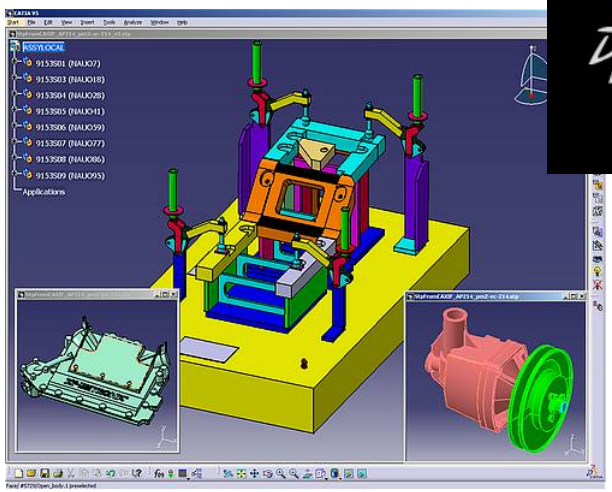
Integration in Commercial Package Level

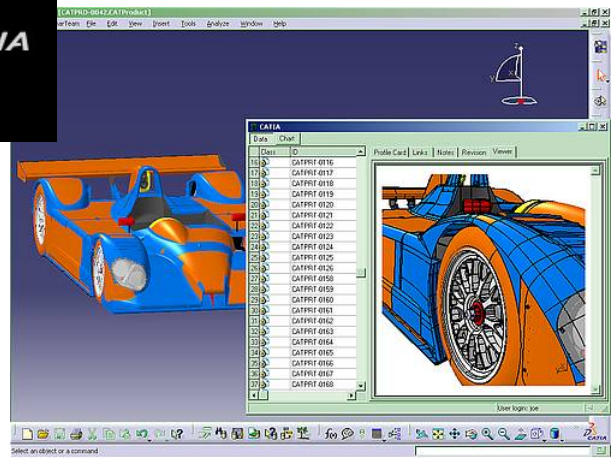
- Integrated CAD/CAE/CAM/PDM/...
- All in one package
  - Dassult systems: CATIA, DELMIA, INOVIA...
    SolidWorks, CosmosWorks...
  - PTC: Pro/Engineering, Windchill...
  - UGS: Unigraphics, Teamcenter, Technomatix...

Trends of Commercial Solutions

- Dassault systems: CATIA







CATIA

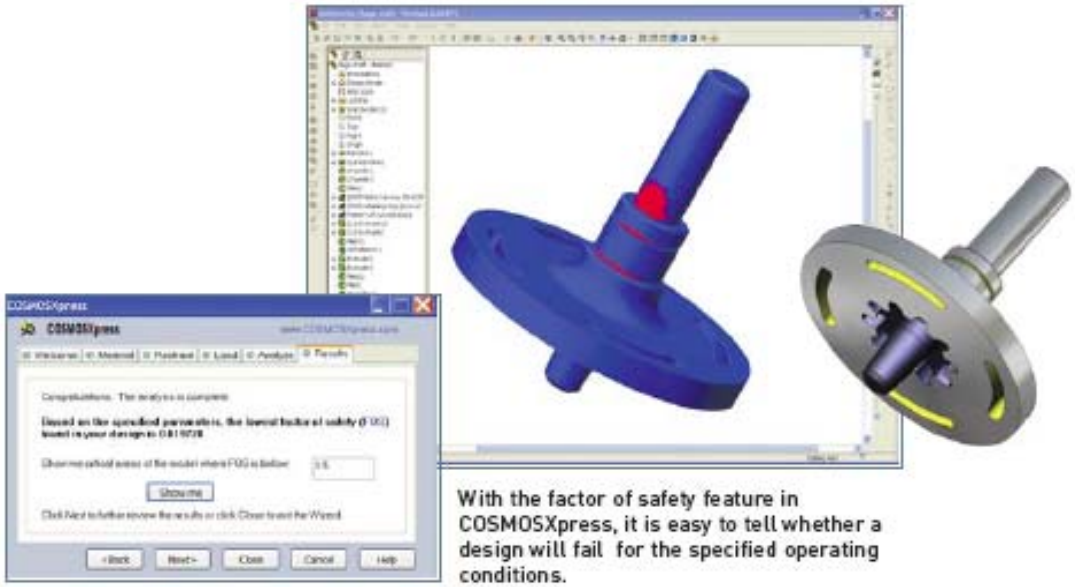
ENOVIA

DELMIA

SIMULIA

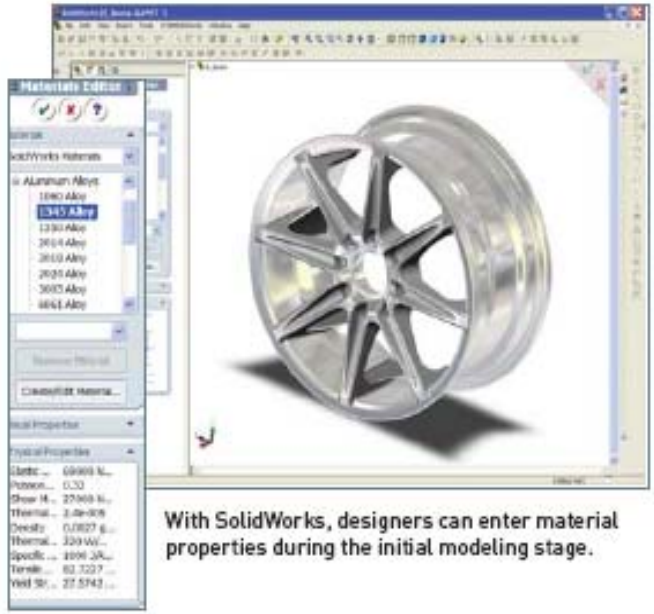
Trends of Commercial Solutions (cont.)

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



With the factor of safety feature in COSMOSXpress, it is easy to tell whether a design will fail for the specified operating conditions.

< COSMOSXpress >



With SolidWorks, designers can enter material properties during the initial modeling stage.

< 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
- ...

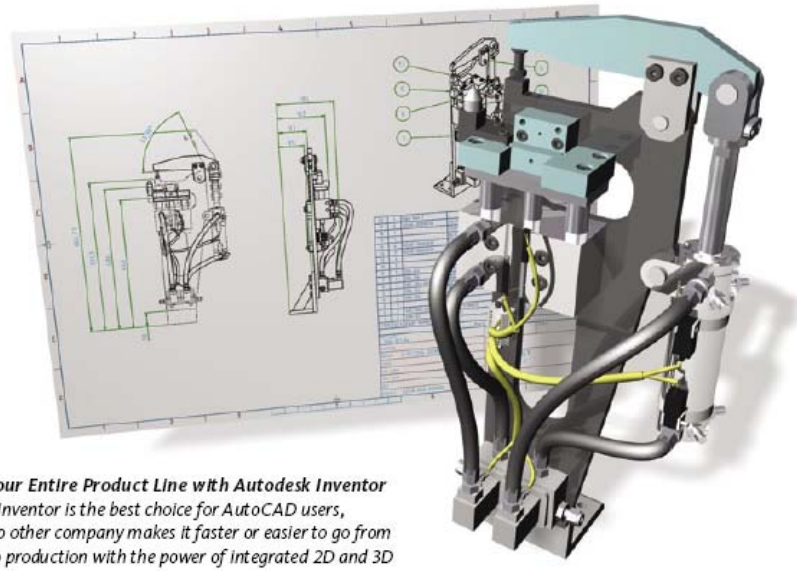
Trends of Commercial Solutions (cont.)

- UGS: NX (Unigraphics)
  - All in NX

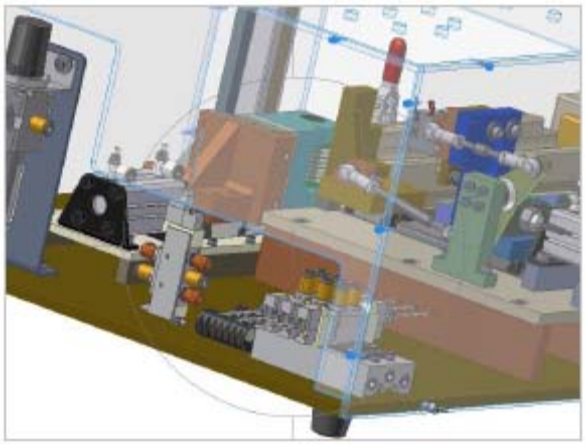
< Main concept >

Trends of Commercial Solutions (cont.)

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



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.



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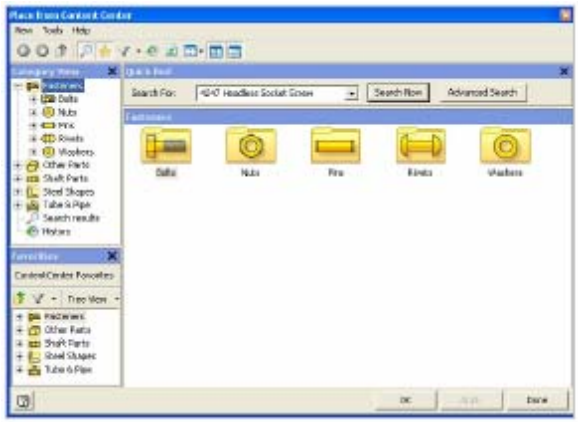
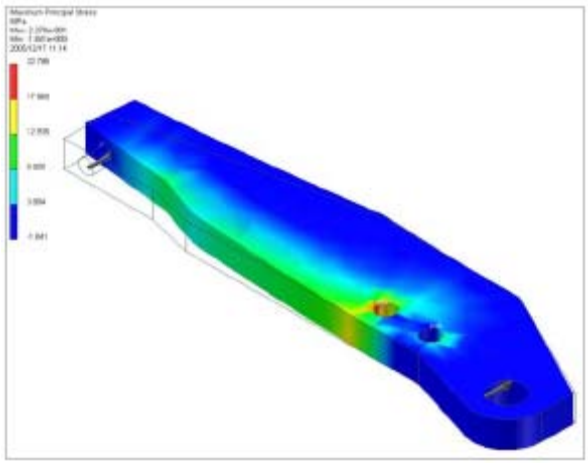


< Virtual prototyping >

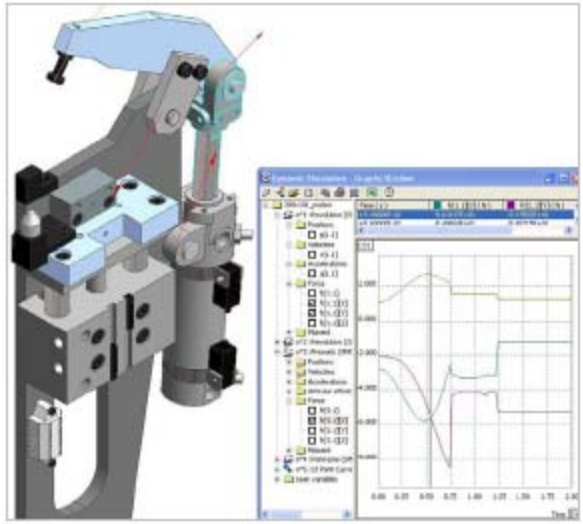
< Bill of Material (BOM) >

Trends of Commercial Solutions (cont.)

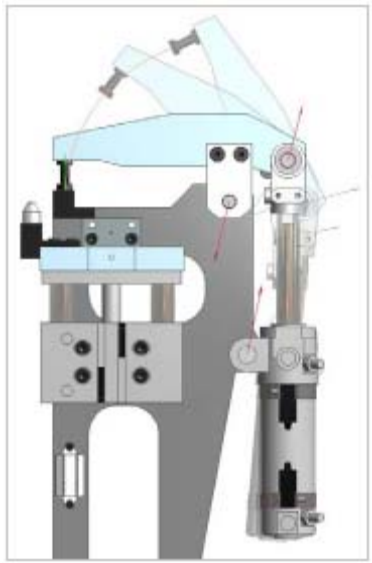
- Embedded CAE ANSYS & Solid Dynamics
  - Stress analysis (ANSYS)
  - Dynamic Simulation (Solid Dynamics)
  - 3D visualization (Solid Dynamics)



< Stress analysis >



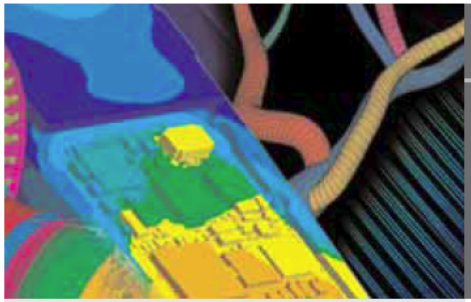
< Dynamic Simulation >



< 3D visualization >

Trends of Commercial Solutions (cont.)

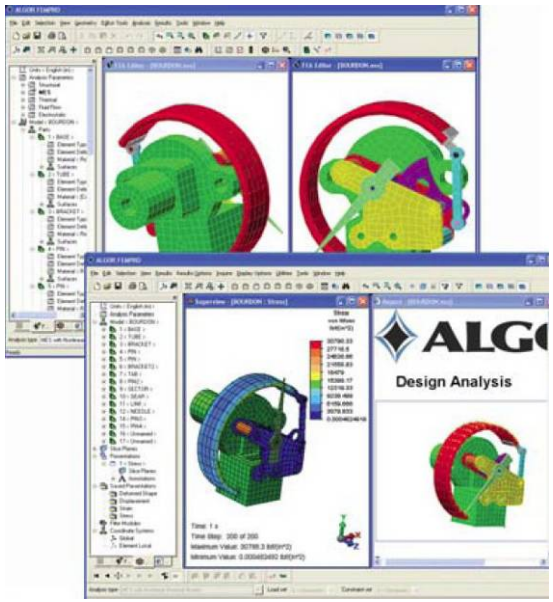
- ANSYS
  - Multi-physics Analysis software
  - CAD supporting in pre-processing



	Complete Simulation Solutions									Meshing Solutions		
	Multiphysics™	Mechanical™	Structural™	Professional™	DesignSpace®	Emag™	CFX®	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	✓	✓	✓	✓	✓	✓			✓	✓

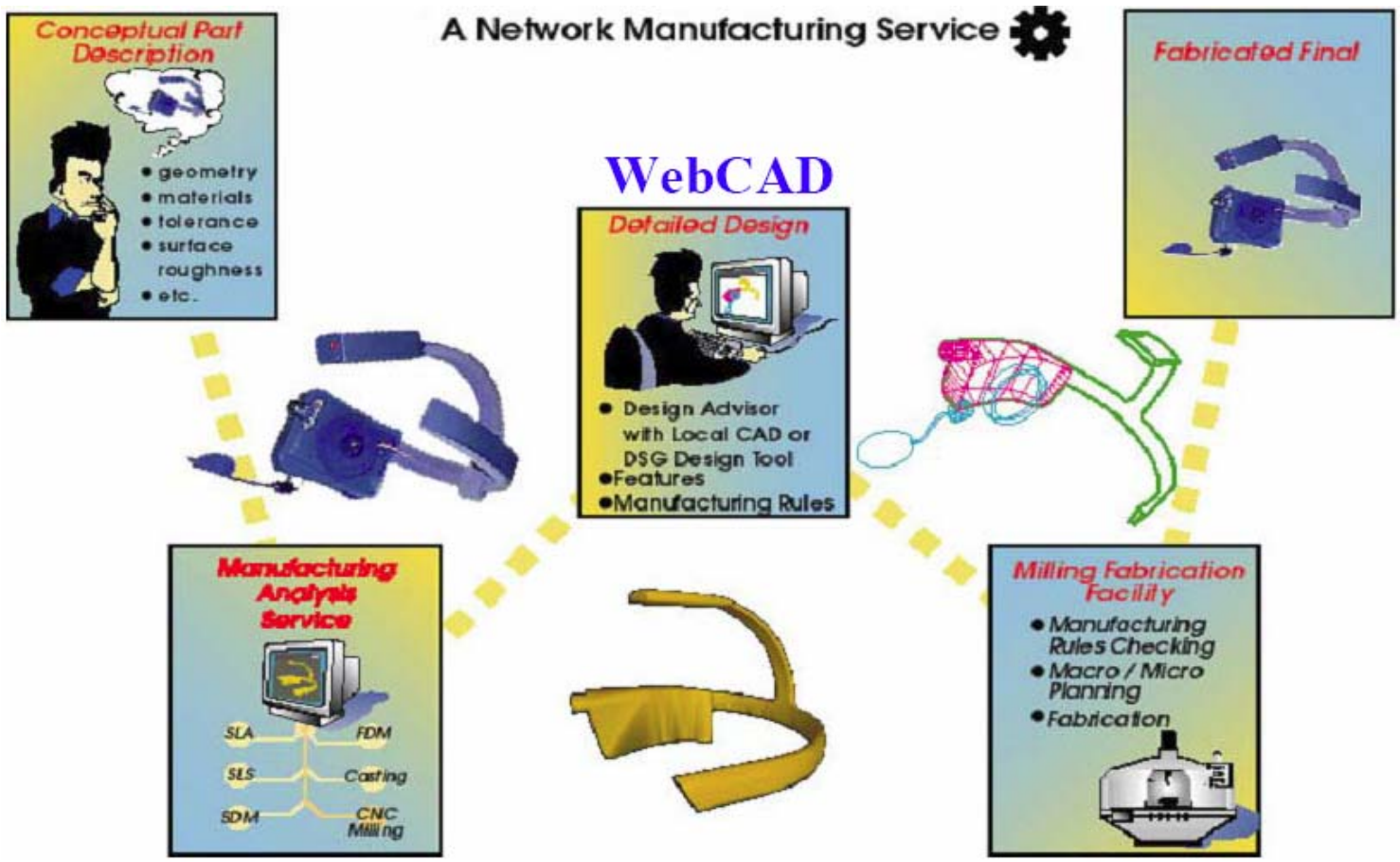
Coupling Modes in Integration

- 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

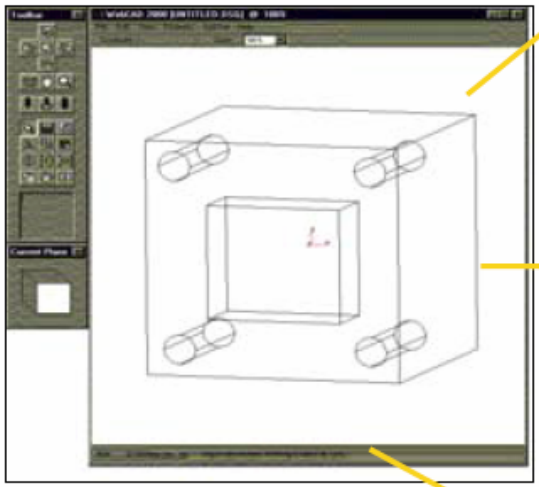
- CyberCut paradigm

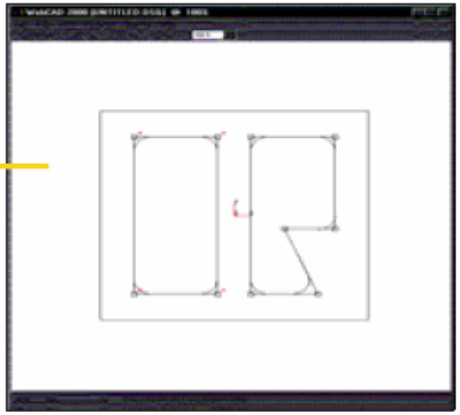


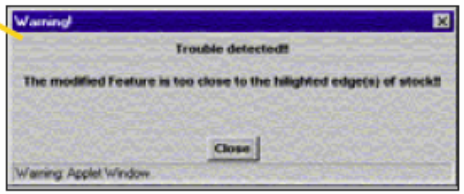
Example Solutions of Stiff mode (cont.)

- CyberCut – Feature 1. WebCAD

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







DFM paradigm

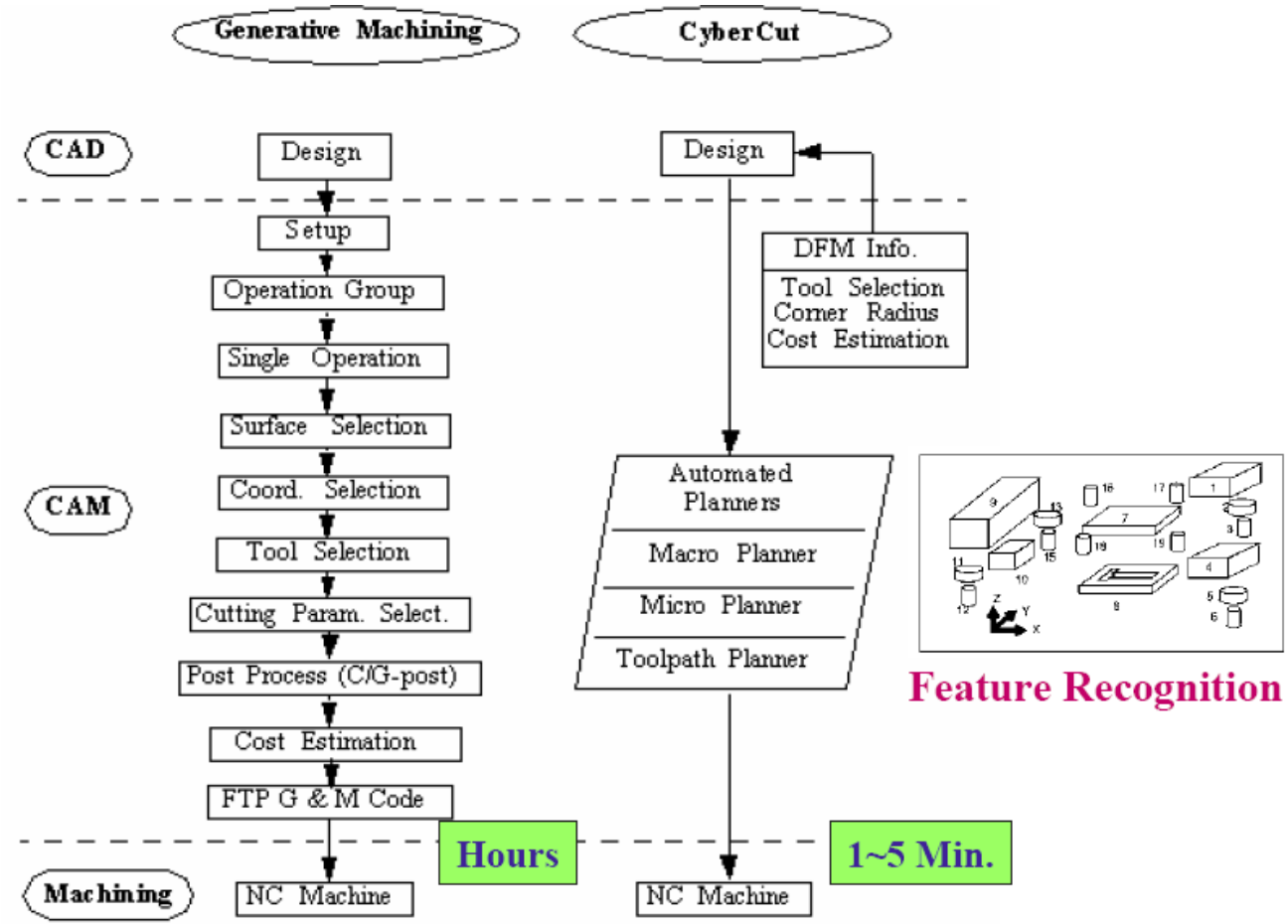
1. Tool diameter & Depth

2.WYSIWYG:
Corner radius

3.Design Rule Checker

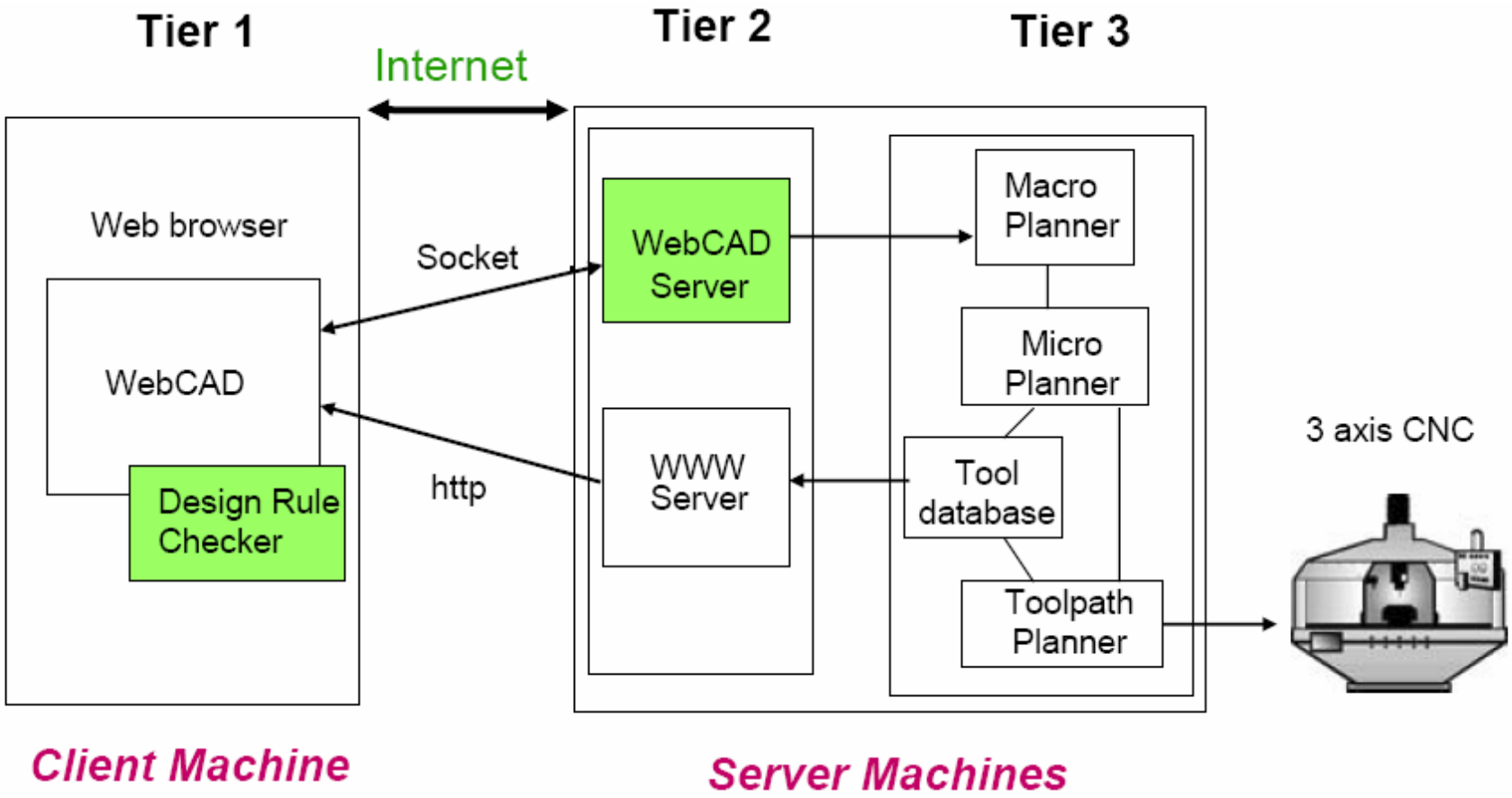
Example Solutions of Stiff mode (cont.)

- CyberCut – Feature 2. Automated Process Planning



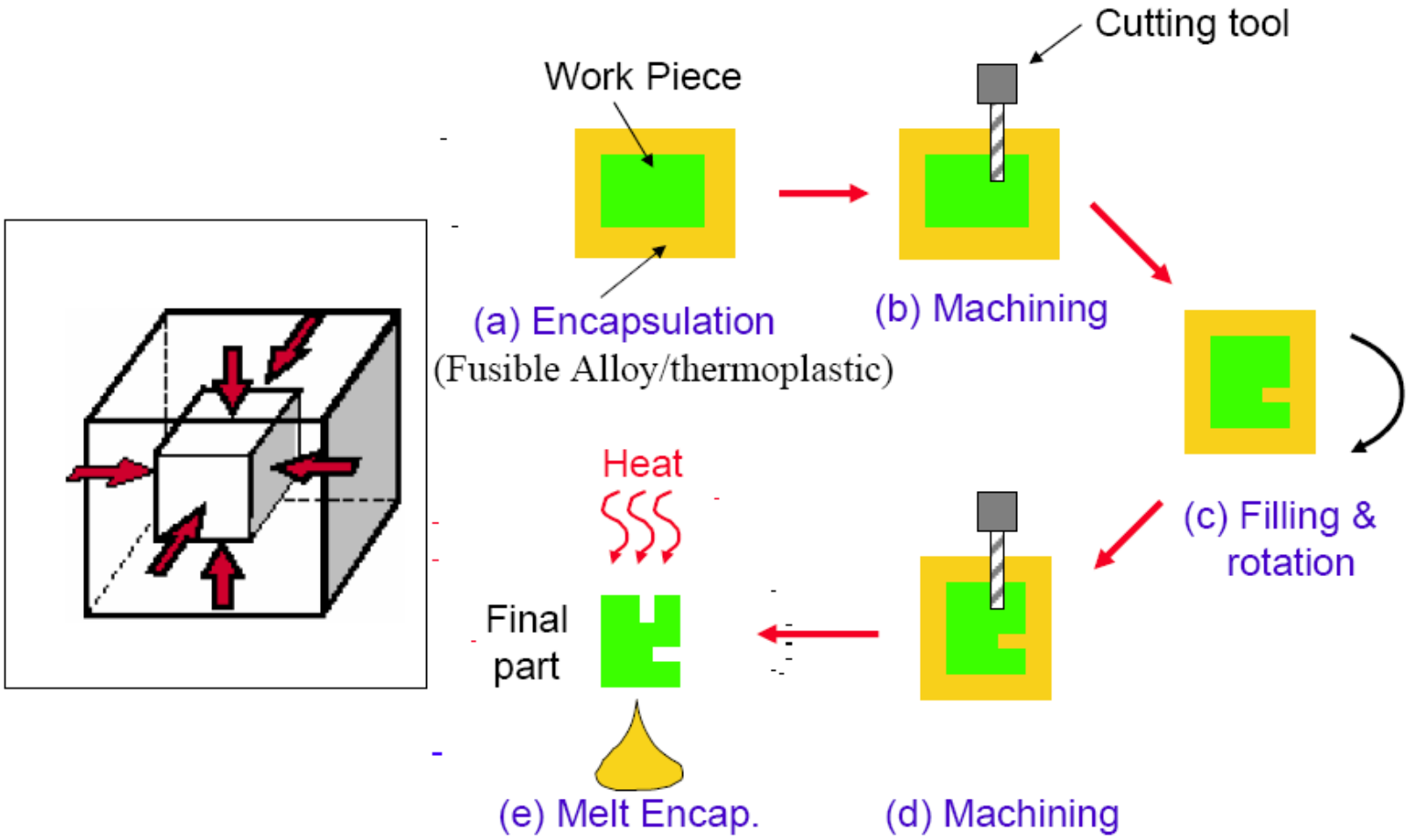
Example Solutions of Stiff mode (cont.)

- CyberCut – Network communication



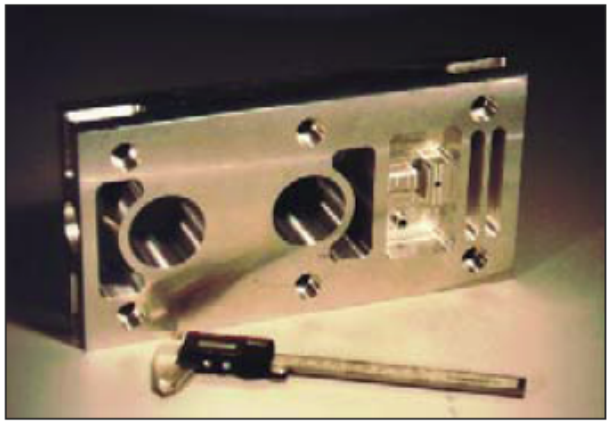
Example Solutions of Stiff mode (cont.)

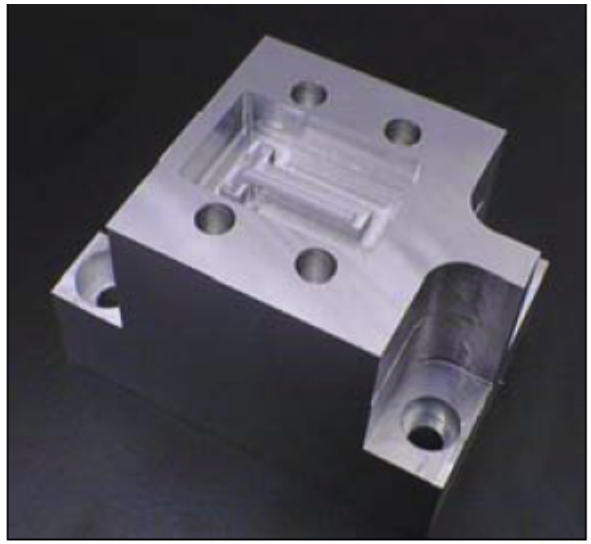
- CyberCut – Feature 3. Universal fixture

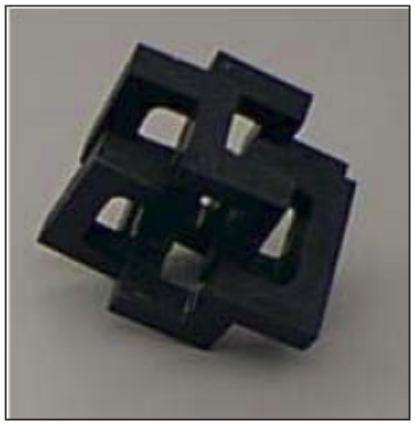


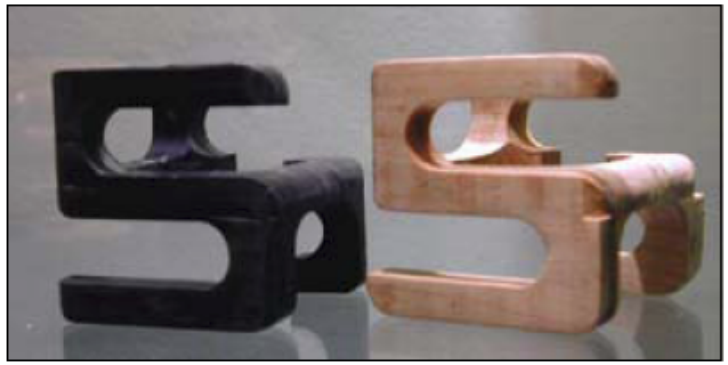
Example Solutions of Stiff mode (cont.)

- CyberCut – Fabricated parts



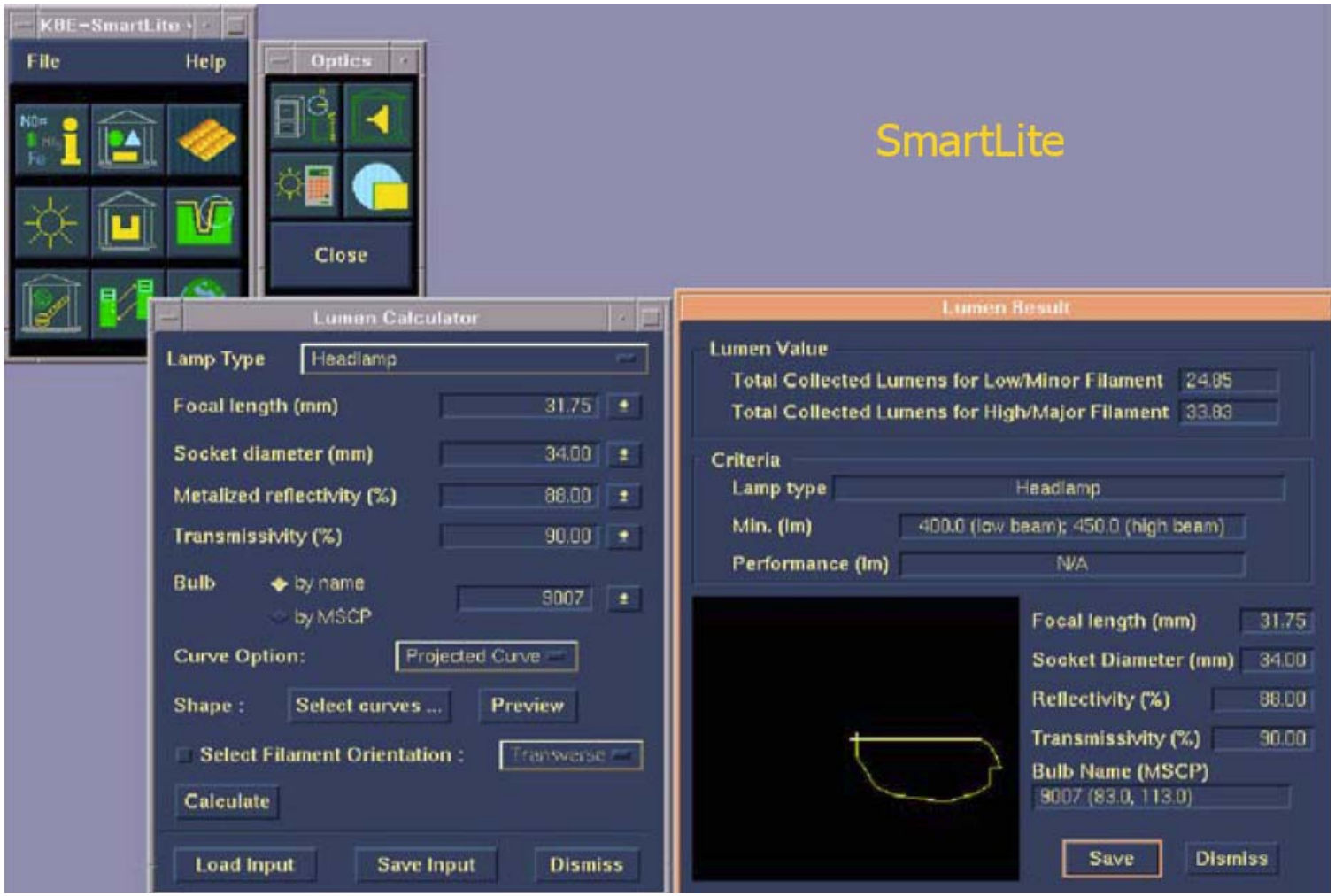






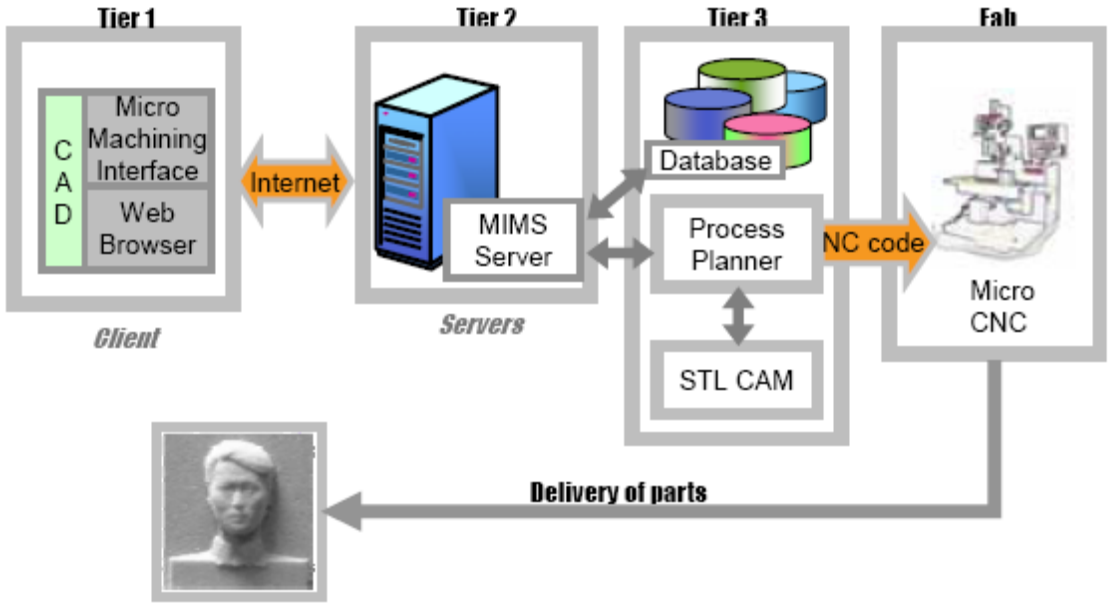
Example Solutions of Strong mode (cont.)

- SmartLite: I-DEAS based tools

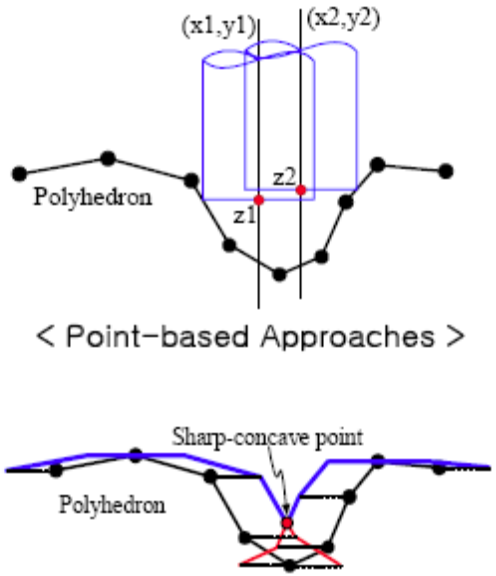


Web-based CAD/CAM Integration

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



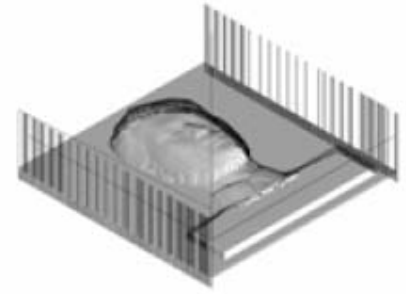
< Communication architecture >



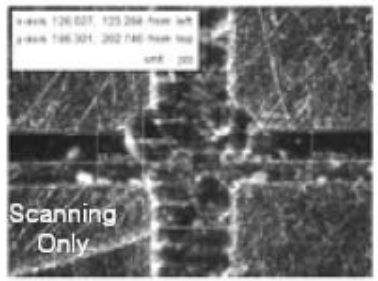
< Curve-based approaches >

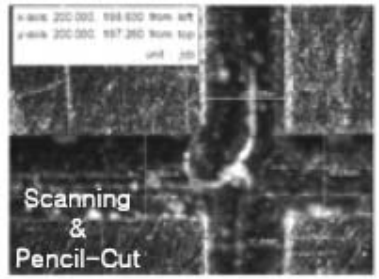
Web-based CAD/CAM Integration (cont.)

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

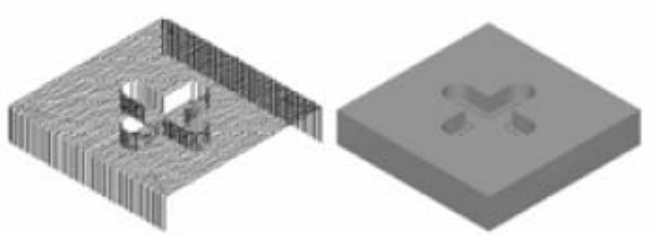


< G&M codes on NC code viewer >



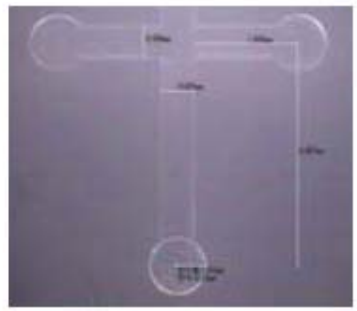


< Micro channel >



< Two types of toolpath >

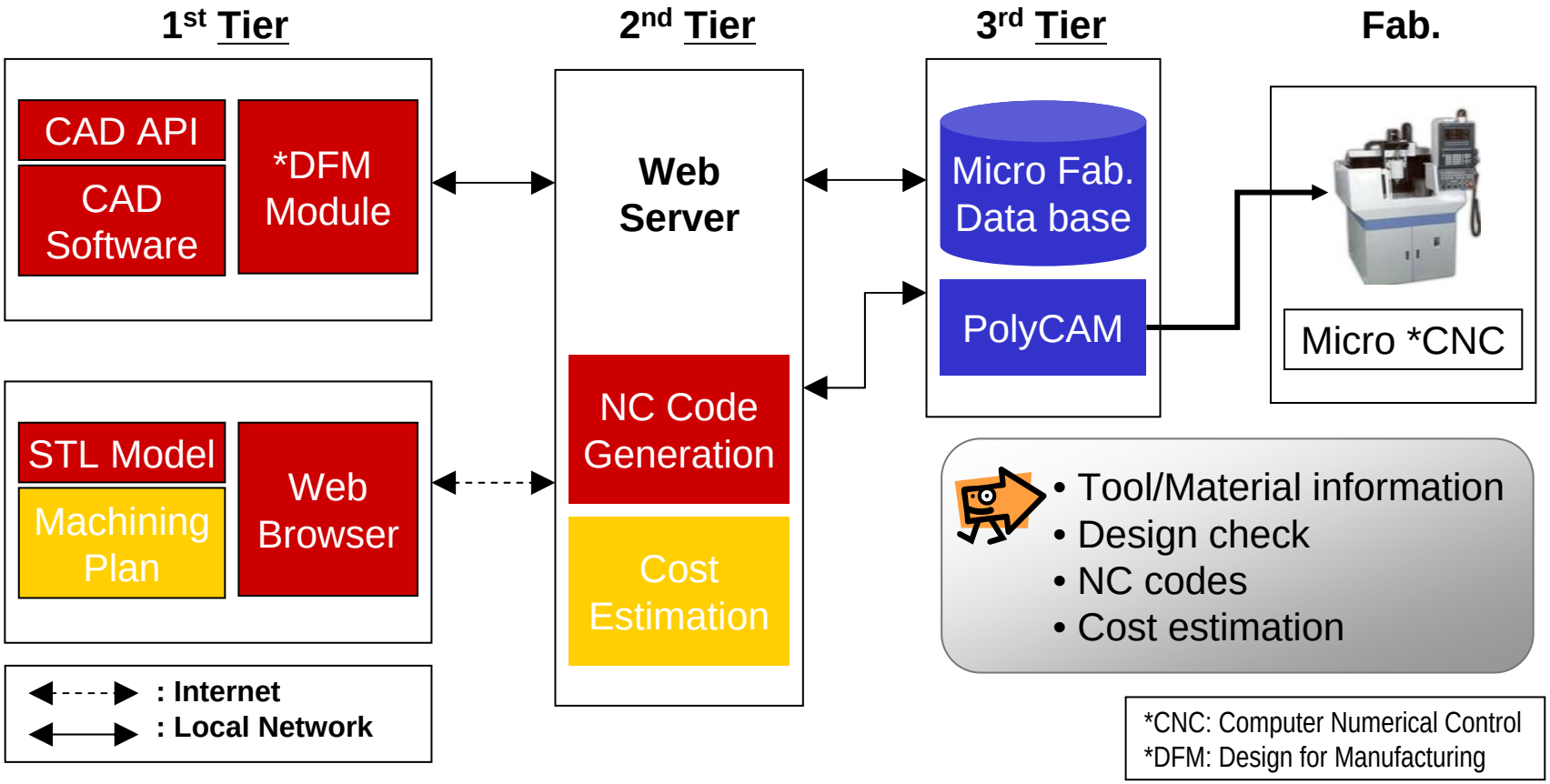
< 3D scanned head >



< Micro fluidic channel >

Web-based CAD/CAM Integration (cont.)

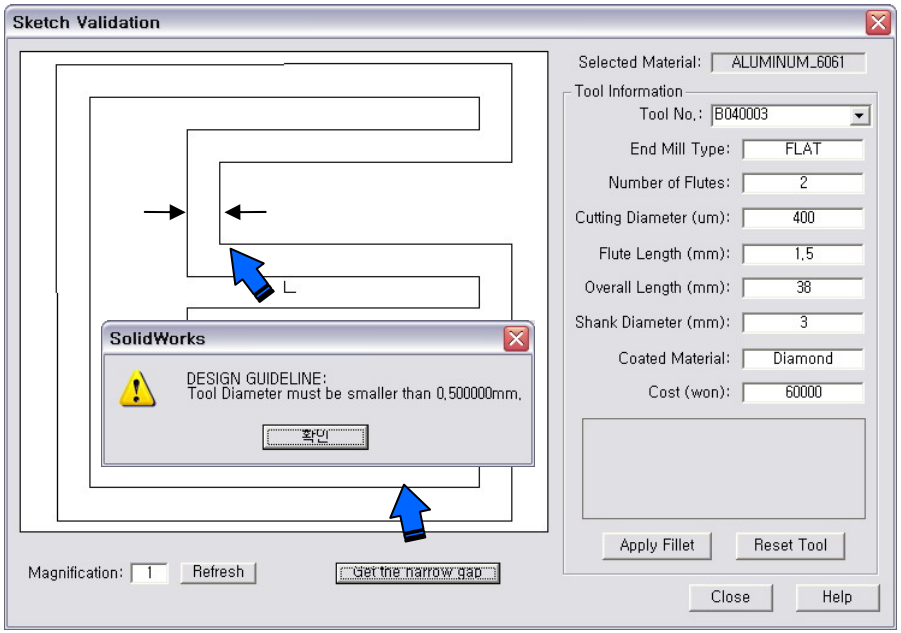
- SmartFab
  - Micro machining using SolidWorks



< 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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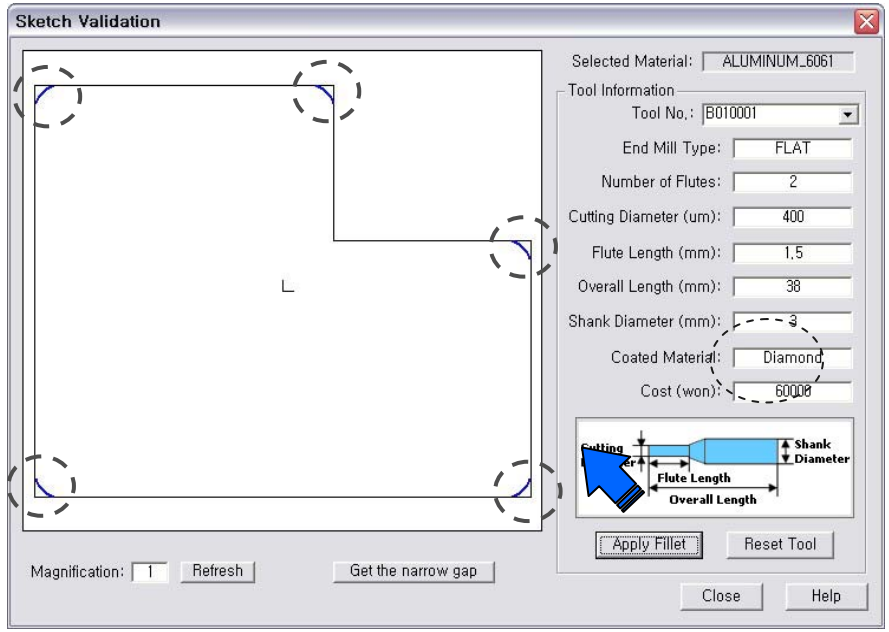
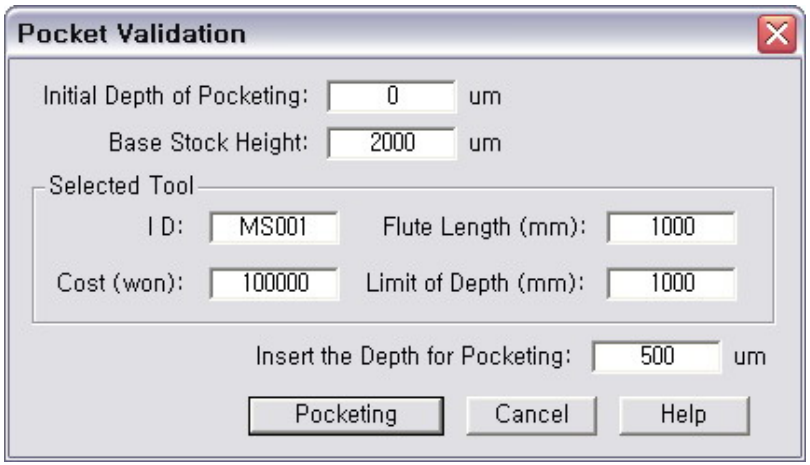
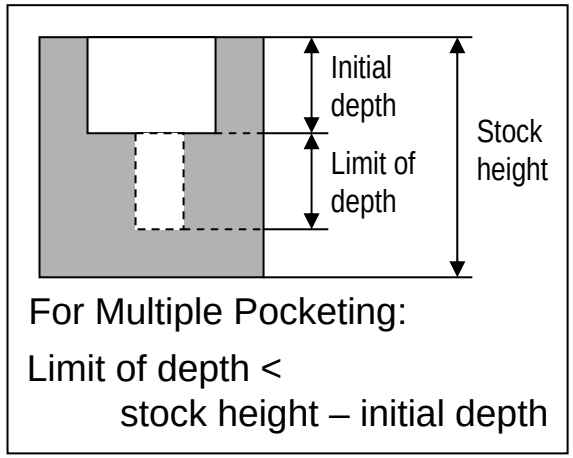


< Check for fillet >

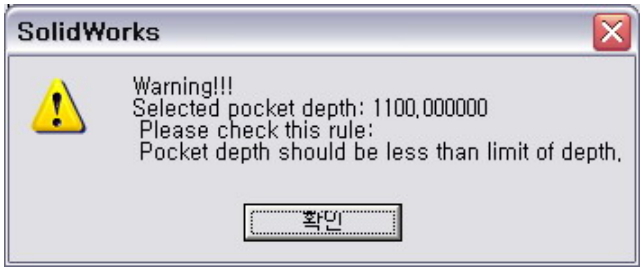
Web-based CAD/CAM Integration (cont.)

- SmartFab – Pocket validation

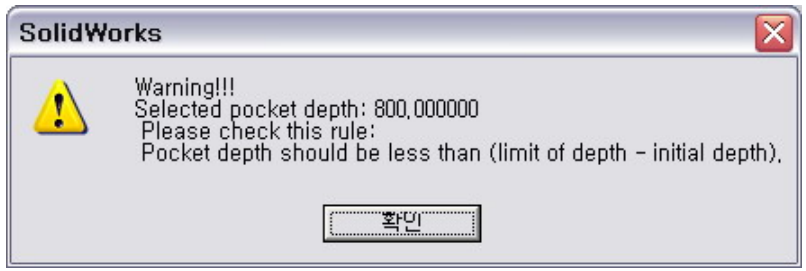




< DFM in pocketing >



Case I. Depth limit



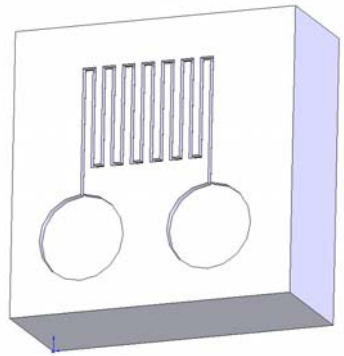
Case II. Depth limit and initial depth

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

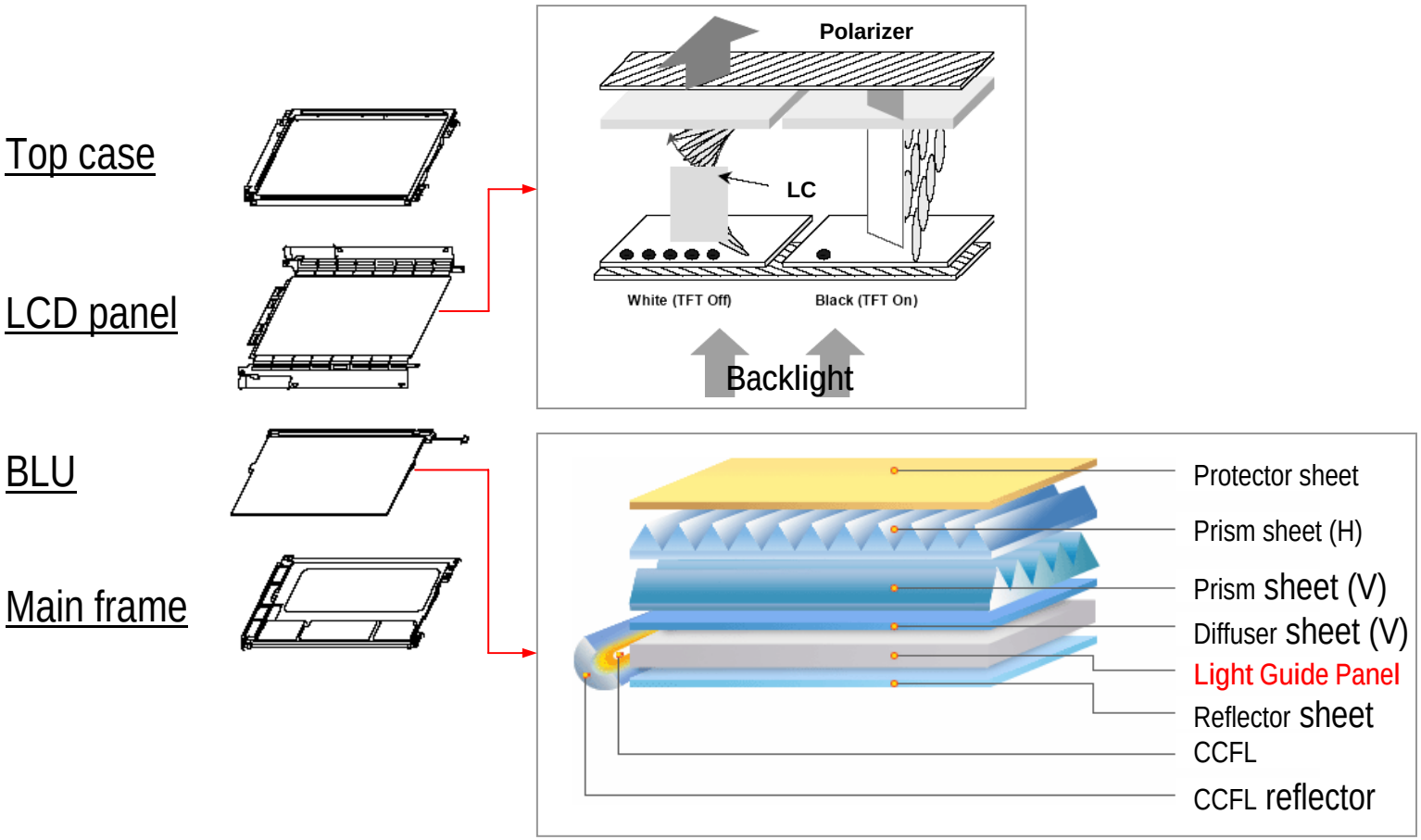
Tm: Machining time (0.41 hr)
W: Operator's wage (2500/hr)

Ct = y*(Tm/T) **(11275 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.)

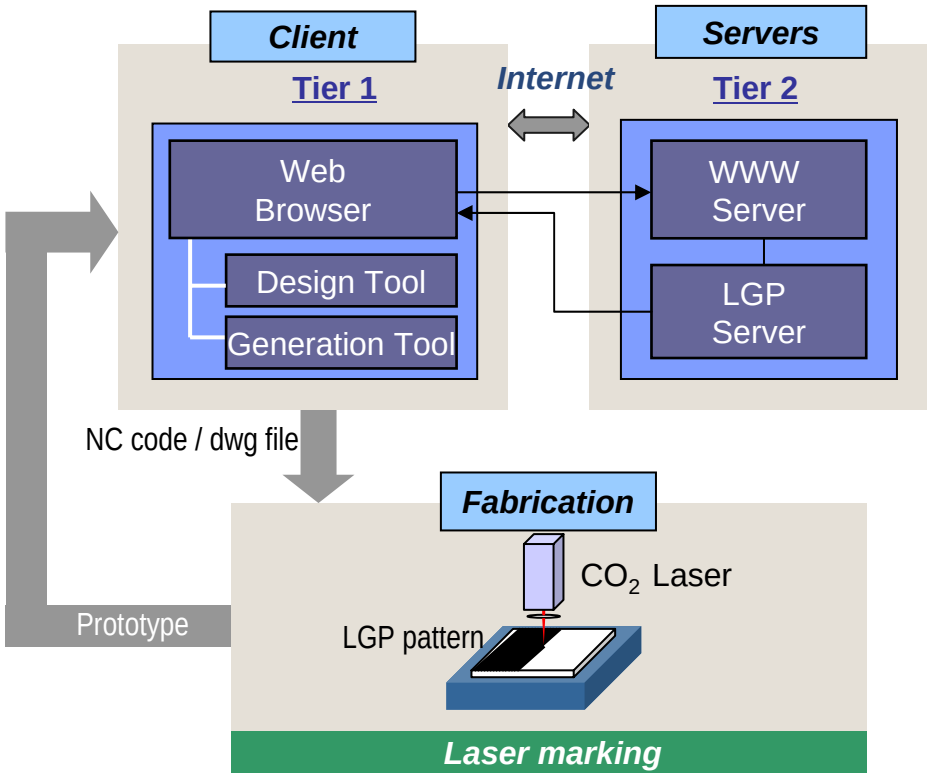
- TFT LCD-LGP (Light Guide Panel) prototyping



< Schematic Structure of LCD Unit >

Web-based CAD/CAM Integration (cont.)

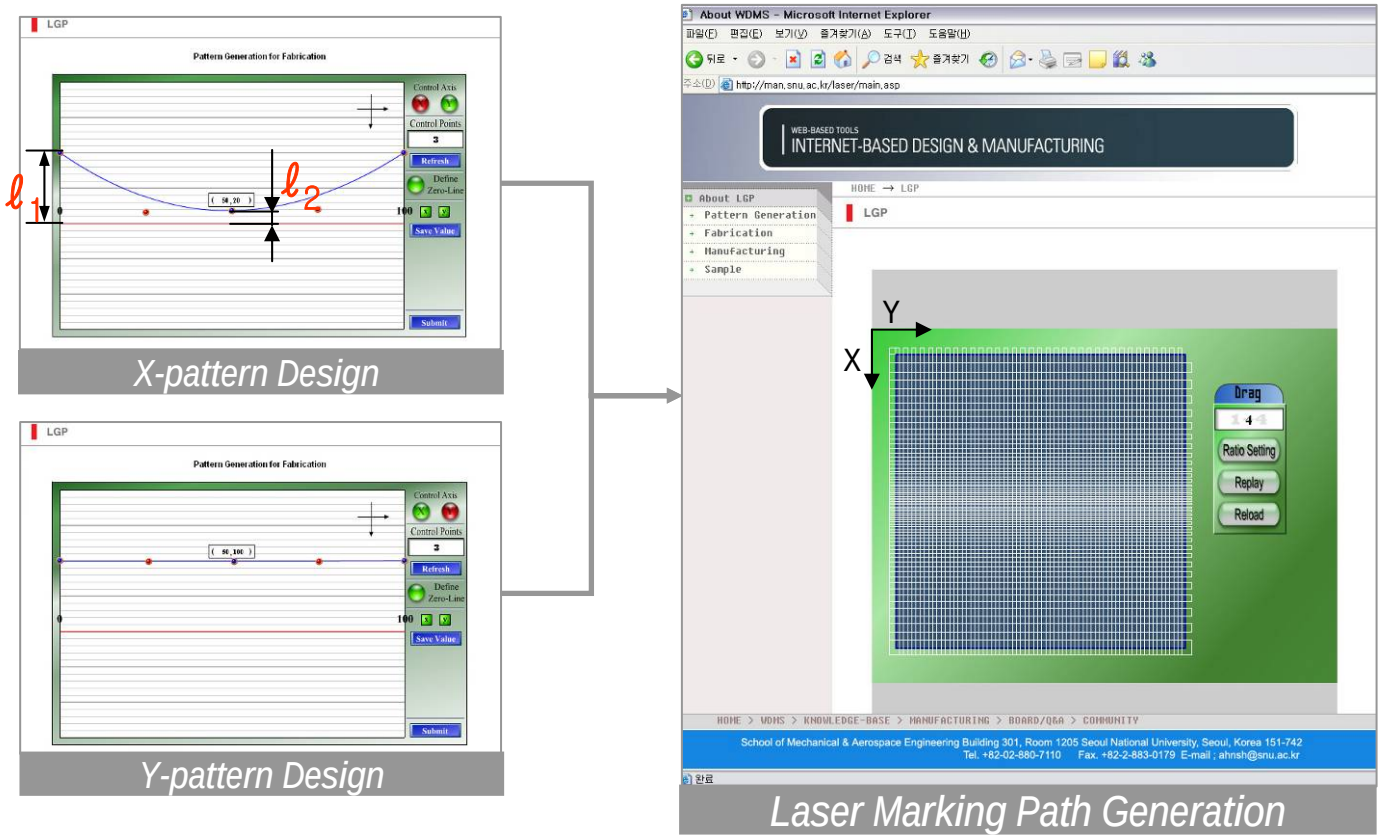
- TFT LCD-LGP (Light Guide Panel) prototyping
  - Patter design & NC code generation tool
  - Provide NC code or DWG file



< 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.)