Computer Integrated Manufacturing System

CNC

- Computer numerical control (CNC) uses computer-controlled machines to perform a series of operations over and over.
- Drilling, milling, and lathes are often controlled by CNC programming.
- CNC machines are reprogrammed to make different parts.

Advantages of CNC

- Increased Flexibility
- Greater Accuracy
- More Versatility

Rapid Prototyping

- Rapid prototyping utilizes a CAD system and a 3D printer to produce a 3-D model of a product layer-by-layer.

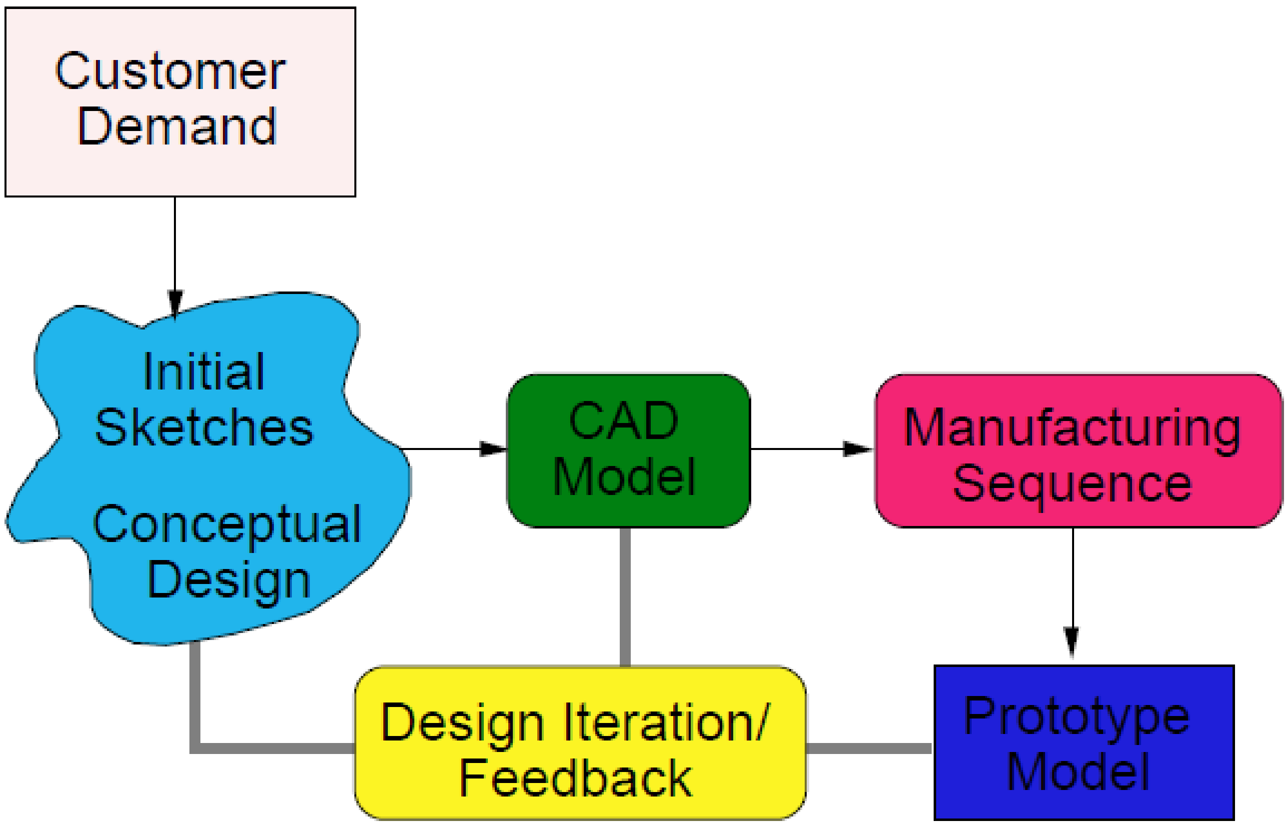
Motivation for Rapid Prototyping

- Shorter lead times from design to prototype
- Ability to incorporate designs from multiple locations
- Potential for one-of-a-kind customization
- Can increase precision and detail of prototype

Motivation for Rapid Prototyping

- Provides initial testing of form and function
- Can be used to create molds for mass-production

Rapid Prototype Process

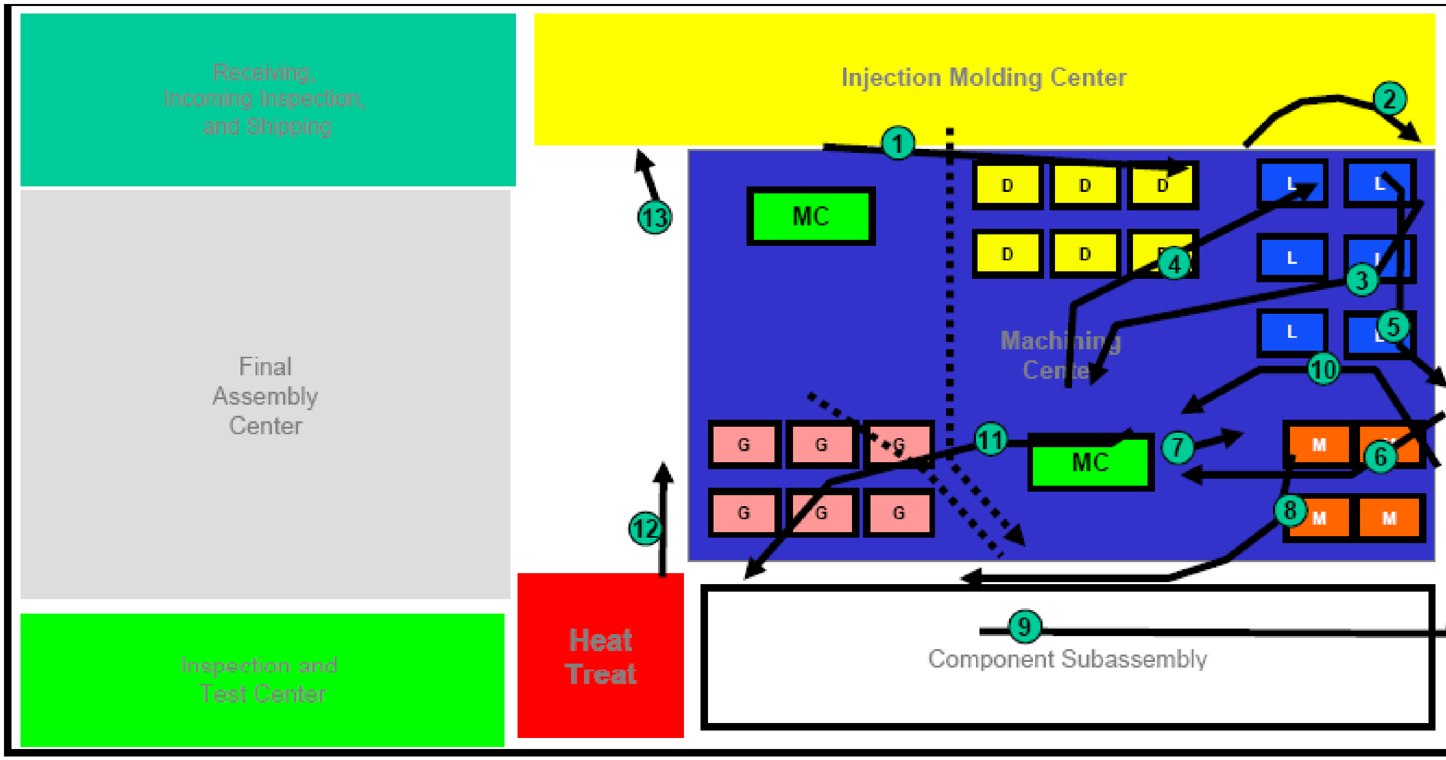


Rapid Manufacturing

The techniques are the same ones used for rapid prototypes, except that the process is repeated to make tens or hundreds of actual products for sale.

Characteristics of a Line Layout

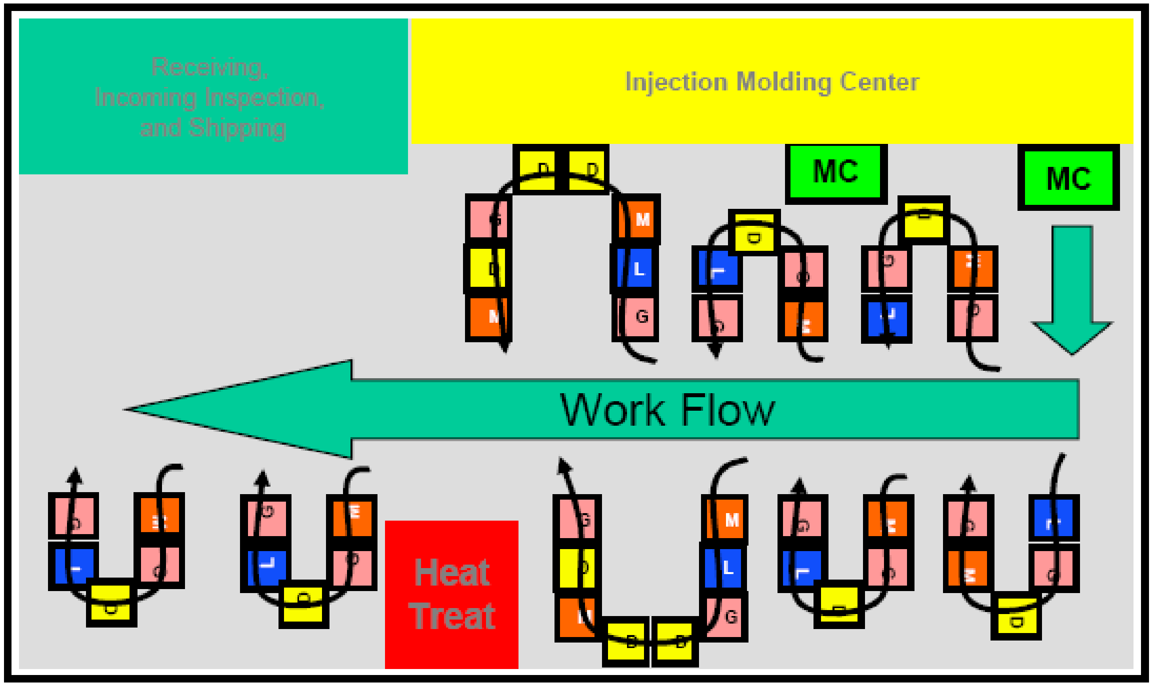
- Volume operation; continuous production
- Capital intensive resources (equipment)
- Faster processing rates
- Lower inventories
- Less time lost to changeovers
- Less flexibility
- Low resources used; low volume products



The material flow could take up to millions of different paths, creating waste of transportation and waiting at virtually every step.

Production Cells

A group of functionally dissimilar production capabilities (different equipment) located in physical proximity which are dedicated to the complete processing of given product.



Rather than route the materials required through the entire plant, materials flow to the head of each work cell, through each process in the cell, then to final assembly. This eliminates most of the transportation and waiting we would see in the traditional approach.

Characteristics of Manufacturing Cells

- Short Lead-Times
- Small Backlogs (In-process Inventory)
- Reduced Material Handling
- Improved Quality
- More Flexible Workforce

ADVANTAGES OF CELLS

- Improved workflow
- Increased operational flexibility
- Reduced material handling
- Improved quality

ADVANTAGES OF CELLS

- Improved equipment utilization
- Facilitates reduced setup times and tooling costs (Identifies families of parts)
- Flexible staffing and improved operator utilization

ADVANTAGES OF CELLS

- Improved human relations
- Workers respond positively when goals are apparent and attainable
- Workers have a greater sense of importance
- Labor productivity increases
- Problems are continually revealed and solved by the “Cell Teams!”

- Improved/Simplified Shop Floor Control
- Simplified paperwork
- Less supervision??
- Accurate equipment and manpower requirement analysis

ADVANTAGES OF CELLS

- Improved/Simplified Shop Floor Control
- Facilitates Better Quality and "Quicker Adjustments"
- Improved information flow

DISADVANTAGES OF CELLS

- Reduced Flexibility
- Imbalance of machine utilization
- Equipment Cost (Duplication)
- Higher Skill/Training
- Relocation Costs
- Tooling/Support
- Cost of Downtime

DISADVANTAGES OF CELLS

- Traditional Methods of Cost Justification Don't Work
- Obsolescence of Technology
- Potential of crippling delays due to machine breakdowns, operator absenteeism,etc.

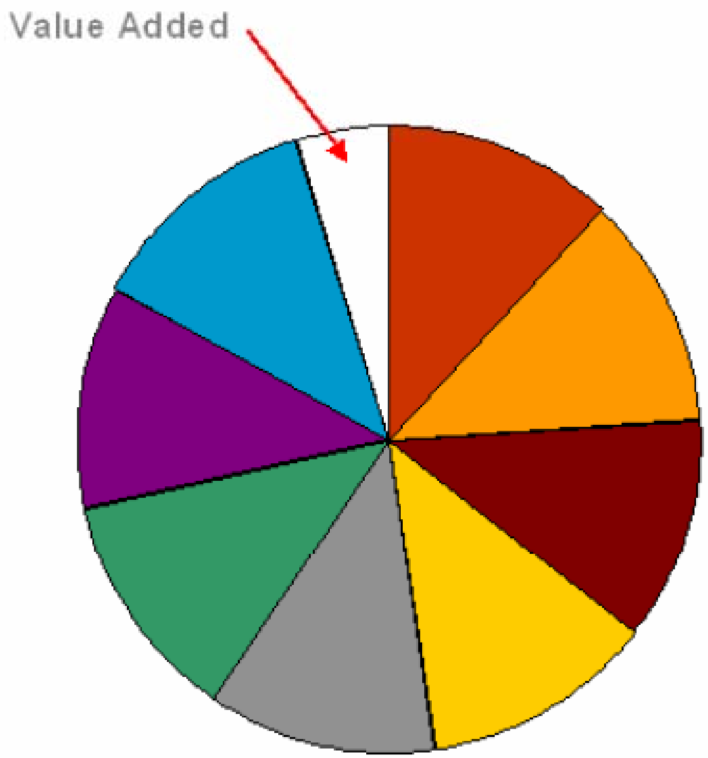
Lean Manufacturing

A systematic approach to reducing how long it takes to complete a defined set of tasks out of the conviction that "Time = Cost".

Lean Manufacturing

- Continuous improvement
- Just-in-time inventory management (JIT)
- Teamwork
- Work cells

The 8 WASTES in a Process



1. **D** efects
2. **O** verproduction
3. **W** aiting
4. **N** on-utilized people
5. **T** ransportation
6. **I** nventory
7. **M** otion
8. **E** xtra processing

Typically 90-95% of **Lead Time** is Non-Value Added **!**

8 Wastes in Manufacturing

- Wait time includes setup, handling, order processing, storage/retrieval, rework, inspection, breakdowns, and unscheduled maintenance.
- In most of manufacturing, value-added time is a small % of total time, and is scattered throughout the process.

Just-in-Time Inventory & Production

- Designed to keep only the immediately needed parts on hand.
- Saves costs because less storage space is needed and there are fewer unused parts.
- New parts are delivered to the factory “Just-In-Time” to be used.

Just-in-Time Inventory & Production

- First implemented in Japan
- Eliminate sources of waste
- Receive supplies Just-In-Time
- Produce parts Just-In-Time
- Produce subassemblies Just-In-Time
- Produce and deliver finished products Just-In-Time to be sold

Advantages of JIT

- Low Inventory Carrying Costs
- Fast Detection of Defects
- Reduced Inspection and Rework of Parts
- High-Quality Parts Produced at Low Cost

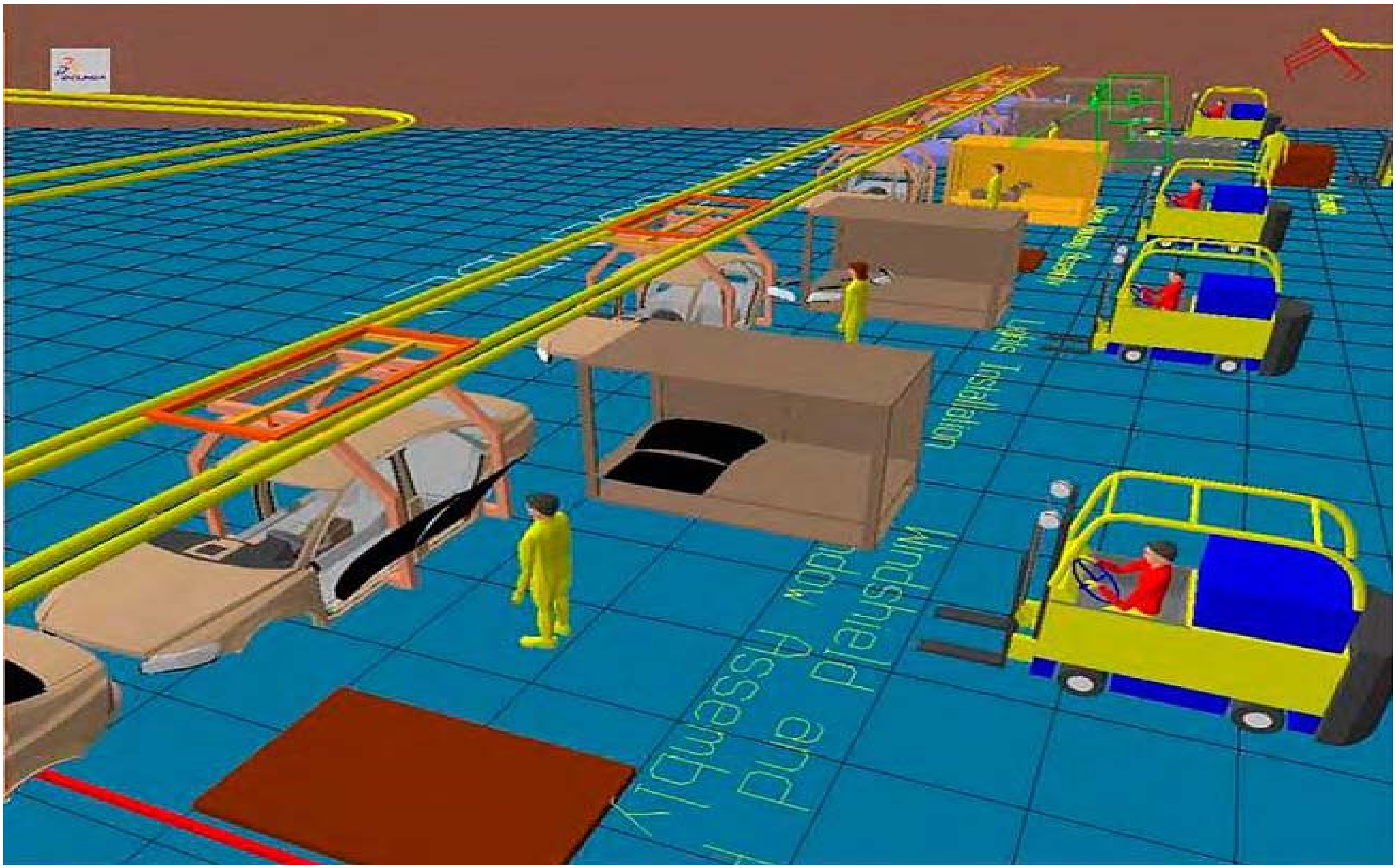
Definition

- *Computer-integrated manufacturing* (CIM) is the manufacturing approach of using computers to control the entire production process
- This integration allows individual processes to exchange info with each other and initiate actions
- Through the computers integration, manufacturing can be faster and less error-prone, although the main advantage is the ability to create automated manufacturing processes
- Typically CIM relies on closed-loop control processes, based on real-time input from sensors
- It is also known as *flexible design and manufacturing*

Definition

- **CIM encompasses the entire range of product development and manufacturing activities with all the functions being carried out with the help of dedicated SW packages**
- **The data required for various functions are passed from one application SW to another in a seamless manner**
  - **For example, the product data is created during design**
  - **This data has to be transferred from the modeling SW to manufacturing SW without any loss of data**
- **CIM use a common DB wherever feasible and commun-tech to integrate design, manufacturing and associated business**
- **CIM reduces the human component of manufacturing and thereby relieves the process of its slow, expensive and error-prone component**

Manufacturing Systems Integration Program



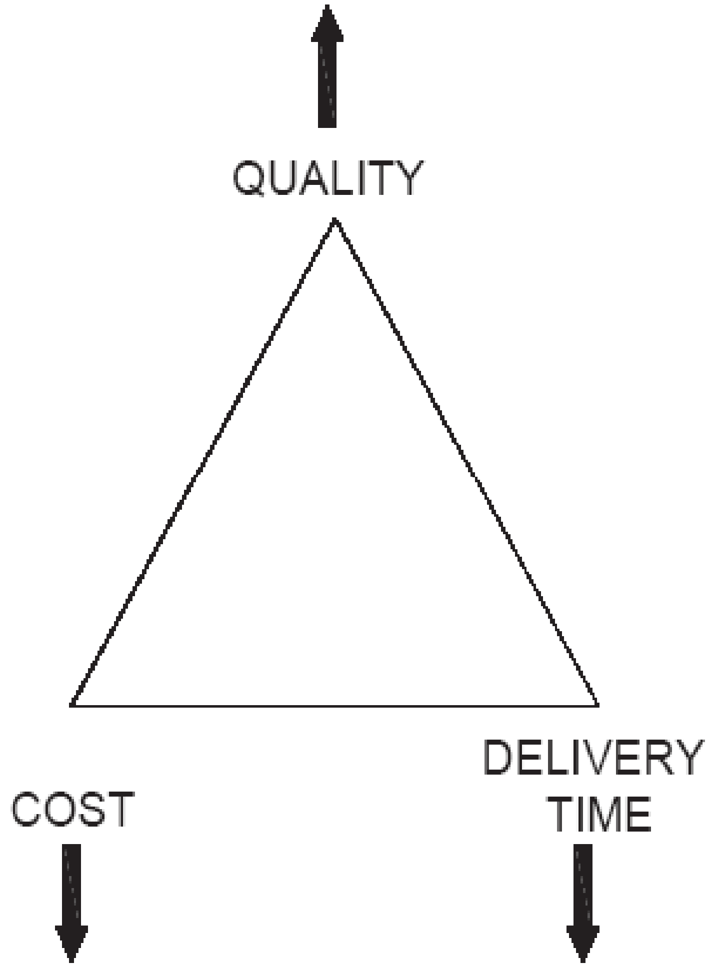
Origin

- The term "CIM" is both a method of manufacturing and the name of a computer-automated system in which individual engineering, production, marketing, and support functions of a manufacturing enterprise are organized
- In a CIM system functional areas such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with factory floor functions such as materials handling and management, providing direct control and monitoring of all the operations.

Origin

- **CIM also encompasses the whole lot of enabling technologies including total quality management, business process reengineering, concurrent engineering, workflow automation, enterprise resource planning and flexible manufacturing**
- **A distinct feature of manufacturing today is *mass customization***
- **This implies that though the products are manufactured in large quantities, products must incorporate customer-specific changes to satisfy the diverse requirements of the customers**
- **This requires extremely high flexibility in the manufacturing system.**

Challenges in Manufacturing



Challenges in Manufacturing

Three Distinguished Components

- As a method of manufacturing, three components distinguish CIM from other manufacturing methodologies:
  - Means for data storage, retrieval, manipulation and presentation
  - Mechanisms for sensing state and modifying processes
  - Algorithms for uniting the data processing component with the sensor/modification component

Definition

- CIM is an example of the implementation of info and common technologies in manufacturing
- CIM implies that there are at least two computers exchanging info, e.g. the controller of an arm robot and a micro-controller of a Computer Numerical Control(CNC) machine
- Some factors involved when considering a CIM implementation are the production volume, the experience of the company or personnel to make the integration, the level of the integration into the product itself and the integration of the production processes
- CIM is most useful where a high level of ICT is used in the company or facility, such as CAD/CAM systems

Definition

- Manufacturing engineers are required to achieve the following objectives to be competitive in a global context
  - Reduction in inventory
  - Lower the cost of the product
  - Reduce waste
  - Improve quality
  - Increase flexibility in manufacturing to achieve immediate and rapid response to:
    - Product & Production changes
    - Process & Equipment change
    - Change of personnel

Benefit from CIM

Integration of technologies brings following *benefits*:

1. Creation of a truly *interactive system* that enables manufacturing functions to communicate easily with other relevant functional units
2. Accurate data transferability among manufacturing plant or subcontracting facilities at implant or diverse locations
3. Faster responses to data-changes for manufacturing flexibility
4. Increased flexibility towards introduction of new products

5 Improved accuracy and quality in the manufacturing process (*continued)*

Benefit from CIM

6. Improved quality of the products.
7. Control of data-flow among various units and maintenance of user-library for system-wide data.
8. Reduction of lead times which generates a competitive advantage.
9. Streamlined manufacturing flow from order to delivery.
10. Easier training and re-training facilities.

Evolution of Computer Integrated Manufacturing

- CIM is considered a natural evolution of the technology of CAD/CAM which by itself evolved by the integration of CAD and CAM
- Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM
- The need to meet the design and manufacturing requirements of aerospace industries after the Second World War necessitated the development these technologies
- The manufacturing technology available during late 40’s and early 50’s could not meet the design and manufacturing challenges arising out of the need to develop sophisticated aircraft and satellite launch vehicles
- This prompted the US Air Force to approach MIT to develop suitable control systems, drives and programming techniques for machine tools using electronic control

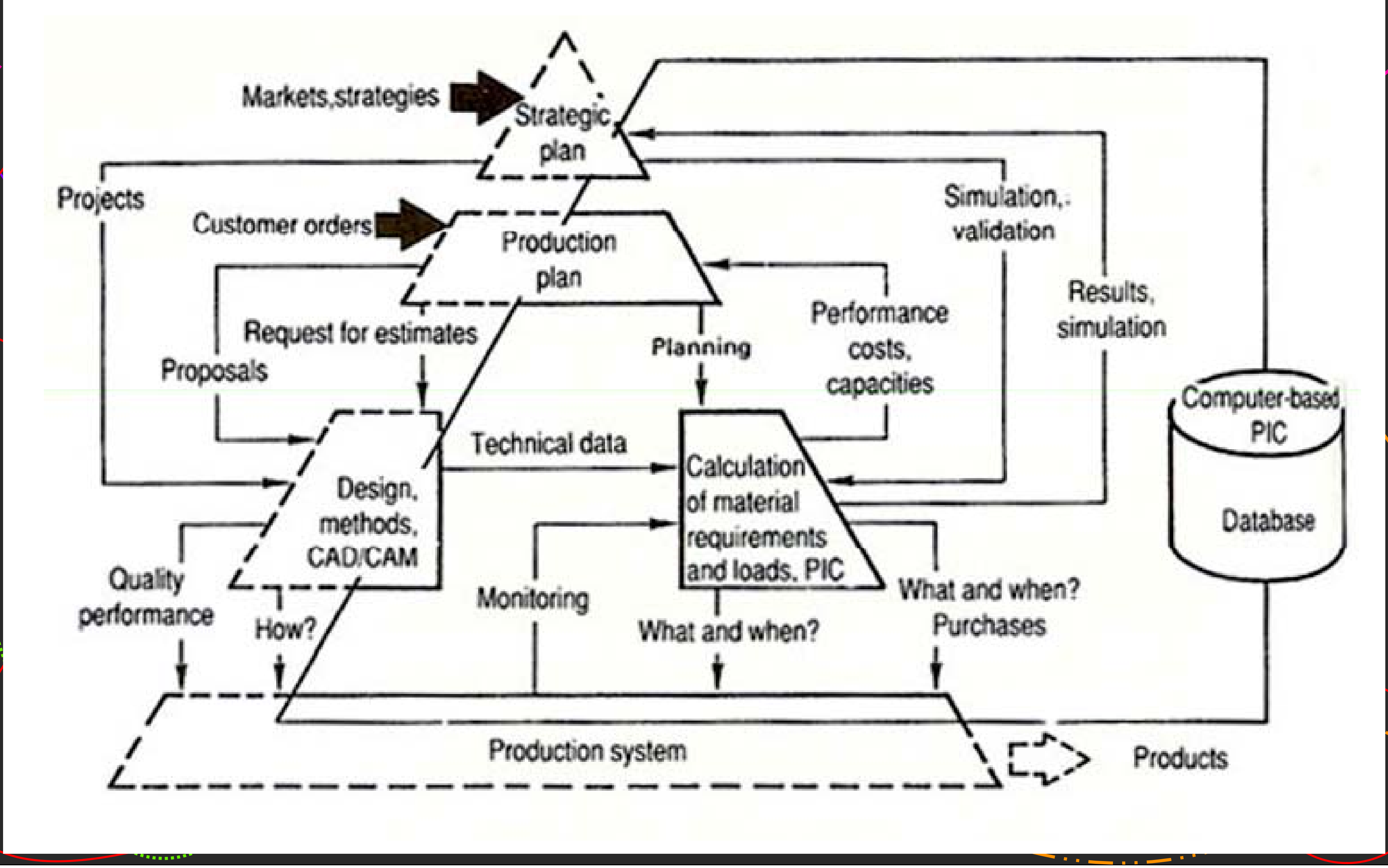
Digital Manufacturing

- The idea of "digital manufacturing" was prominent the 1980s, when computer-integrated manufacturing was developed and promoted by machine tool manufacturers and the Computer and Automated Systems Association and Society of Manufacturing Engineers (CASA/SME).
- "CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency."

Key challenges - *three major challenges*

- **Integration of components from different suppliers**: when different machines, such as CNC, conveyors and robots, are using different communications protocols
- **Data integrity**: The higher the degree of automation, the more critical is the integrity of the data used to control the machine
  - While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the control data signals
- **Process control**: Computers may be used to assist the human operators of manufacturing facility, but there must always be a competent engineer to handle circumstances which could not be foreseen by SW designers

CIM & production control system



Subsystems in computer-integrated manufacturing

- **CIM makes full use of the capabilities of the digital computer to improve manufacturing. Two of them are:**

i. Variable and Programmable automation

ii. Real time optimization

- **A computer-integrated manufacturing system is not the same as a "lights-out" factory,**
  - **which would run completely independent of human intervention, although it is a *big step in that direction***
- **Part of the system involves flexible manufacturing, where the factory can be quickly modified to produce different products, or where the volume of products can be changed quickly with the aid of computers**
- **Some or all of the following subsystems may be found in a CIM operation – see *next slide***

Subsystems in computer-integrated manufacturing

- **Computer-aided techniques:**
  - **CAD (computer-aided design)**
  - **CAE (computer-aided engineering)**
  - **CAM (computer-aided manufacturing)**
  - **CAPP (computer-aided process planning)**
  - **CAQ (computer-aided quality assurance)**
  - **PPC (production planning and control)**
  - **ERP (enterprise resource planning)**
  - **A business system integrated by a common database.**

Subsystems in computer-integrated manufacturing

- *Computer-aided design (CAD)* also known as **computer-aided design and drafting (CADD) is the use of computer technology for the process of design and design-documentation**
- ***CAD* describes the process of drafting with a computer providing the user with input-tools for the purpose of streamlining design processes; drafting, documentation**
- ***CAD* output is often in the form of electronic files for print or machining operations**
- ***CAD*-based SW is in direct correlation with the processes; industry-based SW typically uses vector-based(linear) environments whereas graphic-based SW utilizes raster-based one**

Subsystems in computer-integrated manufacturing

- **Computer-aided engineering (CAE) is the broad usage of computer software to aid in engineering tasks**
- **It includes computer-aided design (CAD), computer-aided analysis (CAA), computer-integrated manufacturing (CIM), computer-aided manufacturing (CAM), material requirements planning (MRP), and computer-aided planning (CAP)**
- **Computer-aided process planning (CAPP) is the use of computer technology to aid in the process planning of a part or product, in manufacturing**
- **CAPP is the link between CAD and CAM in that it provides for the planning of the process to be used in producing a designed part**

Subsystems in computer-integrated manufacturing

- *Computer-aided manufacturing (CAM)* **is the use of computer SW to control machine tools and related machinery in the manufacturing of work pieces**
- **CAM may also refer to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage**
- **Primary purpose is to create a faster production process and components and tooling with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material while simultaneously reducing energy consumption**
- *Computer-aided quality assurance (CAQ)* **is the engineering application of computers and computer controlled machines for the definition and inspection of the quality of products**

Subsystems in computer-integrated manufacturing

- ***Project management software*** **is covering many types of SW including estimation and planning, scheduling, cost control and budget management, resource allocation, collaboration SW, communication, quality management and documentation which are used to deal with the** ***complexity of large projects***
- ***Enterprise resource planning (ERP*****) integrates internal and external management info across an entire organization, embracing finance/accounting, manufacturing, sales and service, customer relationship management**
    - **It automate this activity with an integrated SW application**
- **Its purpose is to facilitate the flow of info between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders**

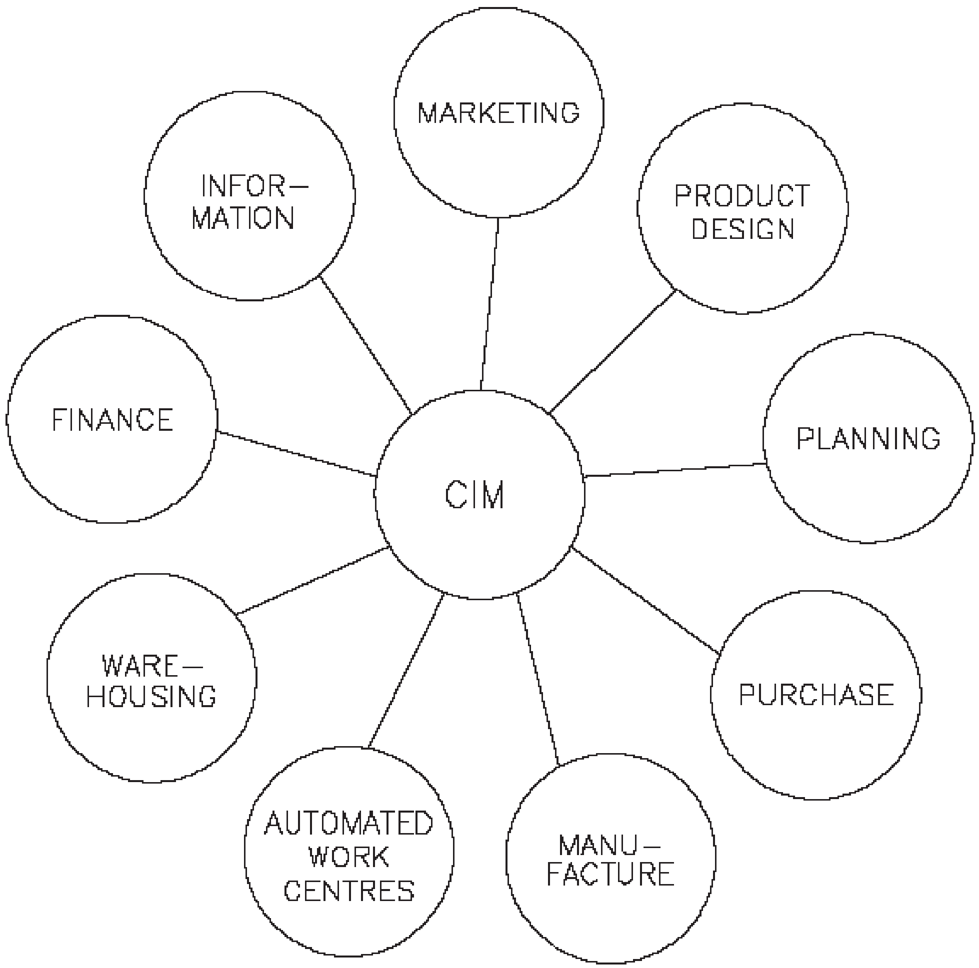
CIM Hardware and Software

- CIM software comprises computer programms to carry out the following functions:
  - Management Information System
  - Sales & Marketing & Finance
  - Database Management
  - Modeling and Design
  - Analysis
  - Simulation
  - Communications
  - Monitoring
  - Production Control
  - Manufacturing Area Control

Nature and Role of the Elements of CIM System

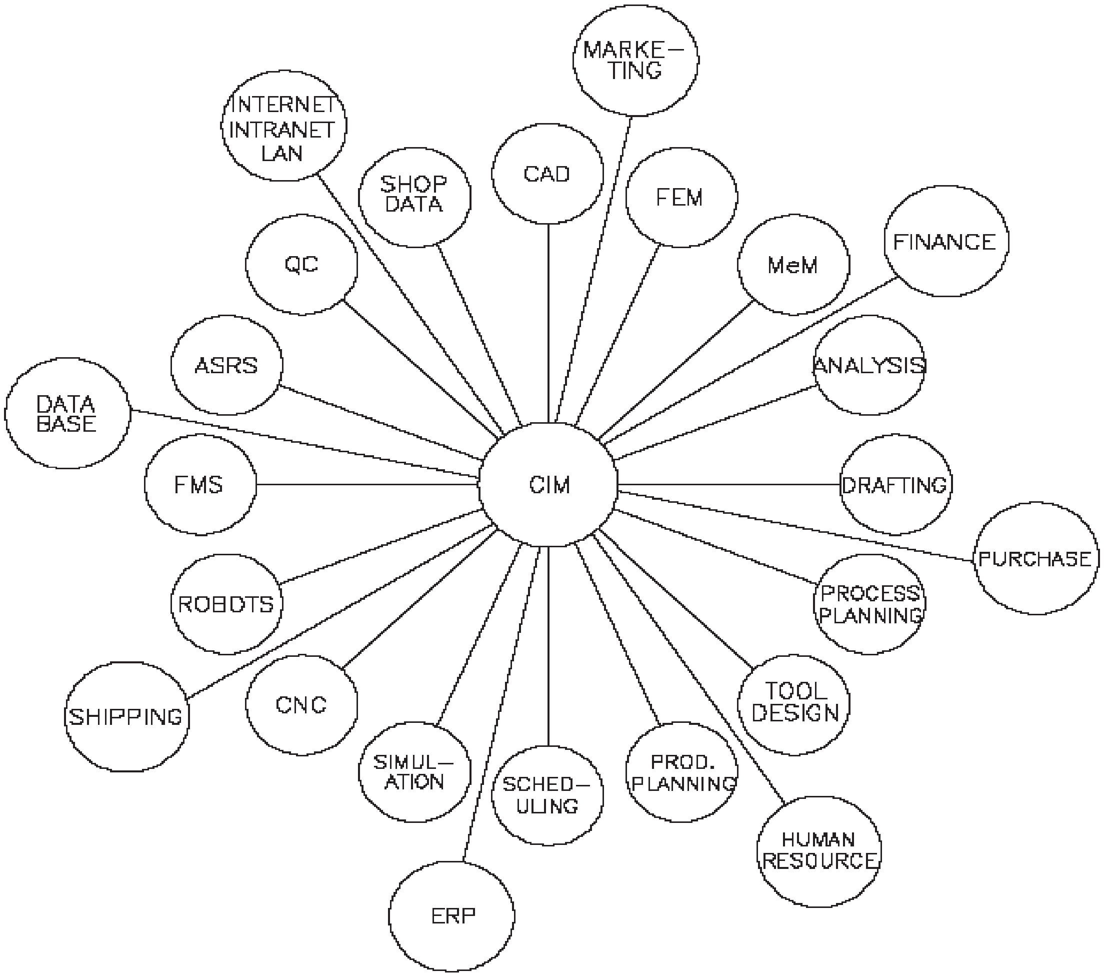
- **Nine major elements of a CIM system are in next slide:**
  - **Marketing**
  - **Product Design**
  - **Planning & Purchase**
  - **Manufacturing Engineering**
  - **Factory Automation Hardware**
  - **Warehousing**
  - **Logistics and Supply Chain Management**
  - **Finance**
  - **Information Management**

Subsystems in computer-integrated manufacturing



Major Elements of a CIM System

Subsystems in computer-integrated manufacturing



Various Activities in CIM

Subsystems in computer-integrated manufacturing

- **Devices and equipment required:**
  - CNC, Computer numerical controlled machine tools
  - DNC, Direct numerical control machine tools
  - PLCs, Programmable logic controllers
  - Robotics
  - Computers
  - Software
  - Controllers
  - Networks
  - Interfacing
  - Monitoring equipment

Subsystems in computer-integrated manufacturing

- **Technologies:**
  - **FMS, (flexible manufacturing system)**
  - **ASRS, automated storage and retrieval system**
  - **AGV, automated guided vehicle**
  - **Robotics**
  - **Automated conveyance systems**
- **Others:**
  - **Lean manufacturing**

CIMOSA

- *CIMOSA* -Computer Integrated Manufacturing Open System Architecture is the enterprise modeling framework, which aims to support the enterprise integration of machines, computers and people
- Its framework is based on the system life cycle concept, and offers a modeling language, methodology and supporting technology to support these goals
  - is a 1990s European proposal for an open system architecture for CIM developed by the AMICE Consortium as a series of ESPRIT projects
- The goal of CIMOSA was "to help companies to manage change and integrate their facilities and operations to face world wide competition”

CIMOSA

- *CIMOSA* provides a solution for business integration with four types of products:
  - The CIMOSA Enterprise Modeling Framework providing a reference architecture for enterprise architecture
  - CIMOSA IIS,
    - a standard for physical and application integration.
  - CIMOSA Systems Life Cycle,
    - is a life cycle model for CIM development and deployment.
  - Inputs to standardization, basics for international standard development.

CIMOSA Architecture

- The main focus of CIMOSA has been to construct:
  - a framework for enterprise modelling, a reference architecture
  - an enterprise modeling language
  - an integrating infrastructure for model enactment supported by
  - a common terminology

CIMOSA Architecture

- **CIMOSA aims at integrating enterprise operations by means of efficient information exchange within the enterprise**
- **CIMOSA models enterprises using four perspectives:**
  - **the *function view* describes the functional structure required to satisfy the objectives of an enterprise and related control structures;**
  - **the *information view* describes the information required by each function;**
  - **the *resource view* describes the resources and their relations to functional and control structures; and**
  - **the *organization view* describes the responsibilities assigned to individuals for functional and control structures**

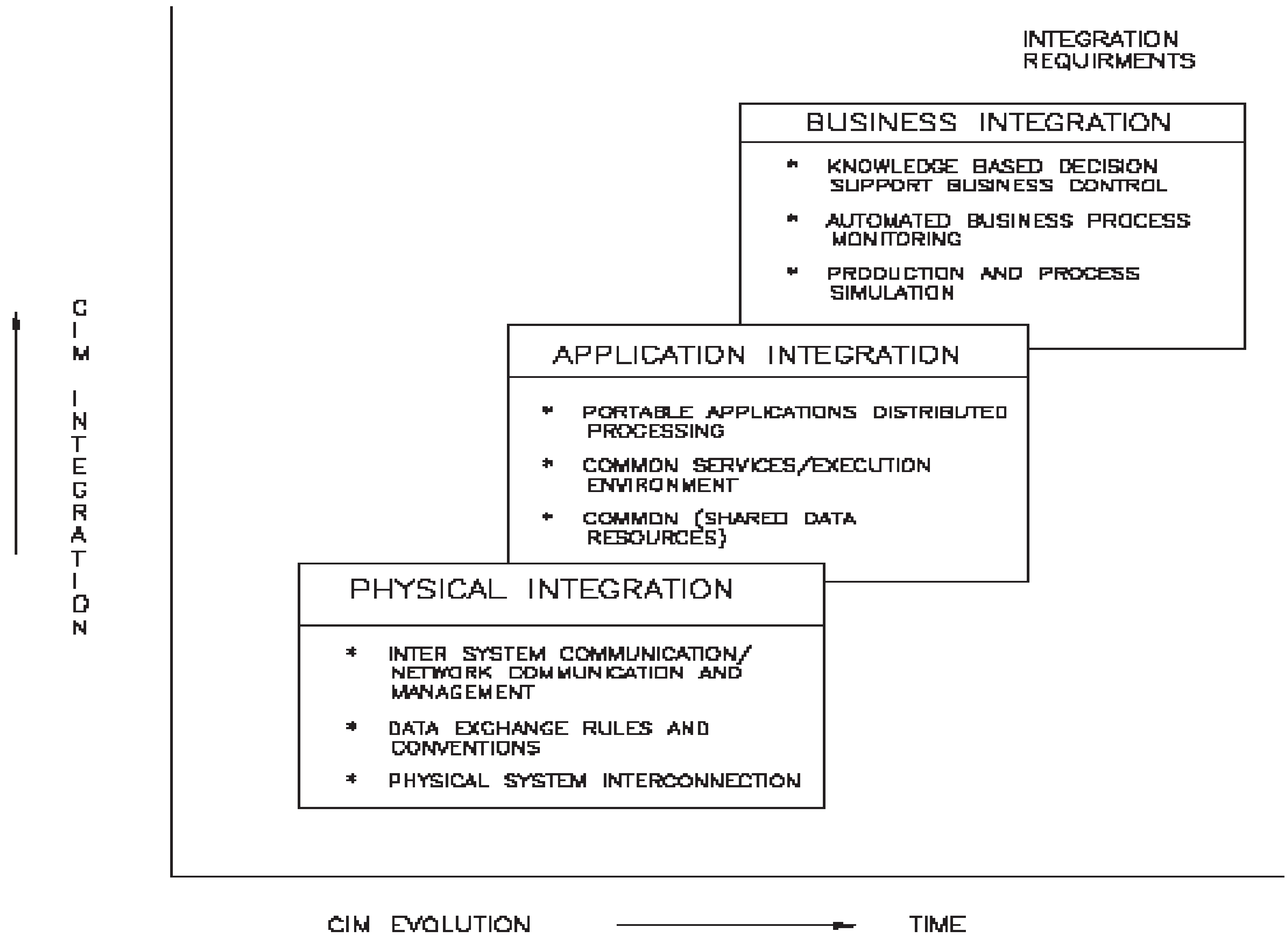
Development of CIM

- **CIM is an integration process leading to the integration of the manufacturing enterprise**
- **Dictated by the needs of the individual enterprise this process usually starts with the need to interchange information between the some of the so called islands of automation**

Development of CIM

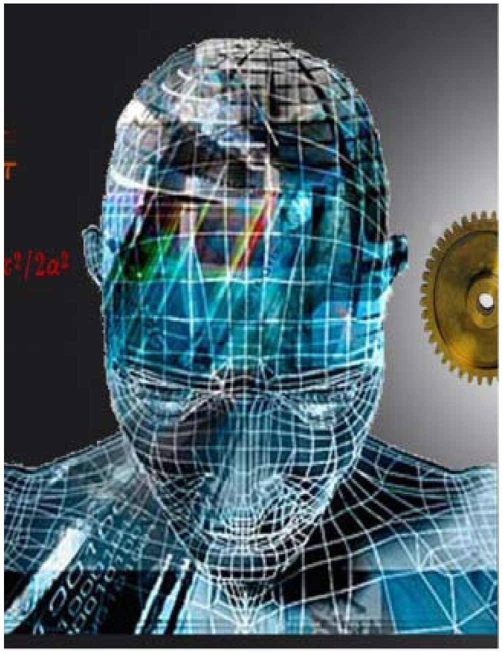
- Flexible manufacturing cells, automatic storage and retrieval systems, CAD/CAM based design etc. are the examples of islands of automation i.e. a sort of computer based automation achieved completely in a limited sphere of activity of an enterprise
- This involves data exchange among computers, NC machines, robots, gantry systems etc.
  - Therefore the integration process has started bottom up
  - The interconnection of physical systems was the first requirement to be recognized and fulfilled.

Development of CIM

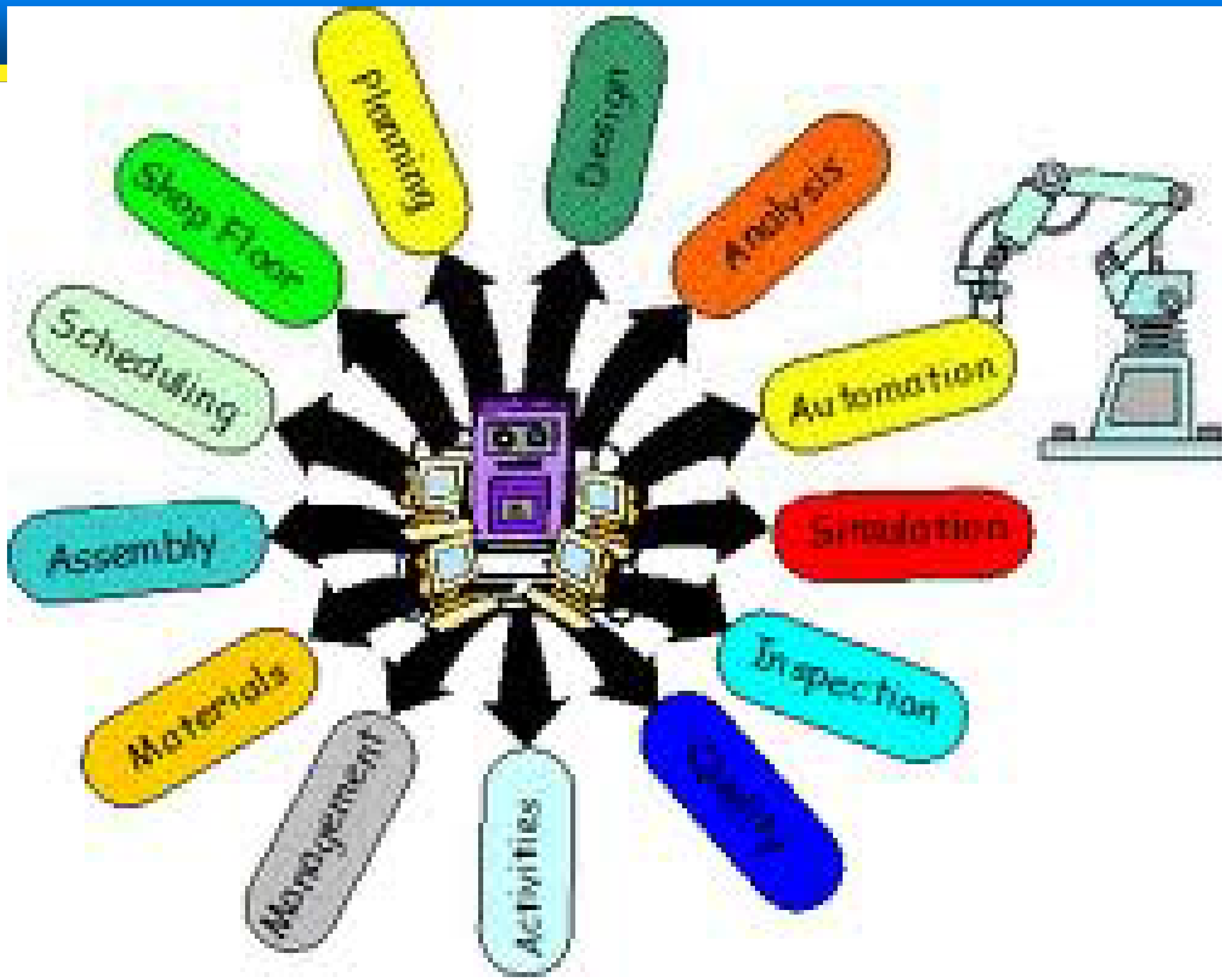


WHAT IS CIM?

Basically Computer Integrated Manufacturing (CIM) is the manufacturing approach of using computers to control the entire production process.



In a CIM system functional areas such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with factory floor functions such as materials handling and management, providing direct control and monitoring of all the operations.


Planning
Design
Analysis
Automation
Simulation
Inspection
Activities
Management
Materials
Assembly
Scheduling
Shop Floor

WHAT ARE THE BENEFITS OF CIM?

- CIM allows individual processes to exchange information with each other and initiate actions.
- Through the integration of computers, manufacturing can be faster and less error-prone, although the main advantage is the ability to create automated manufacturing processes.

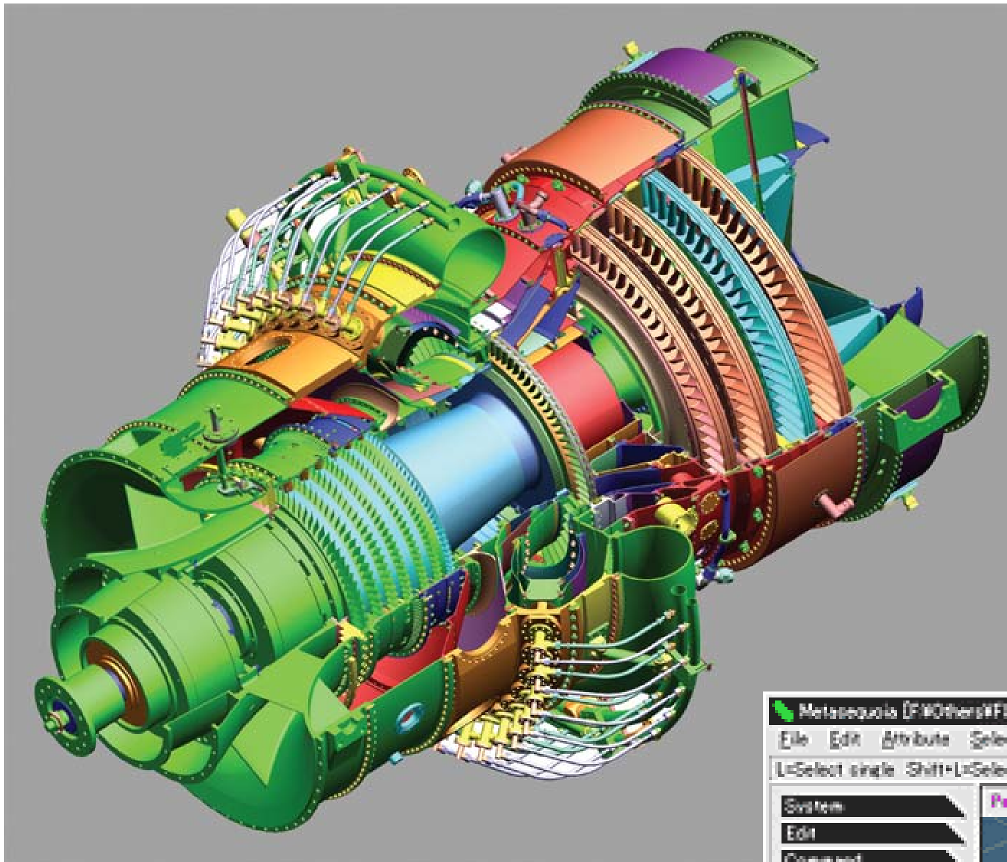
As a method of manufacturing, three components distinguish CIM from other manufacturing methodologies:

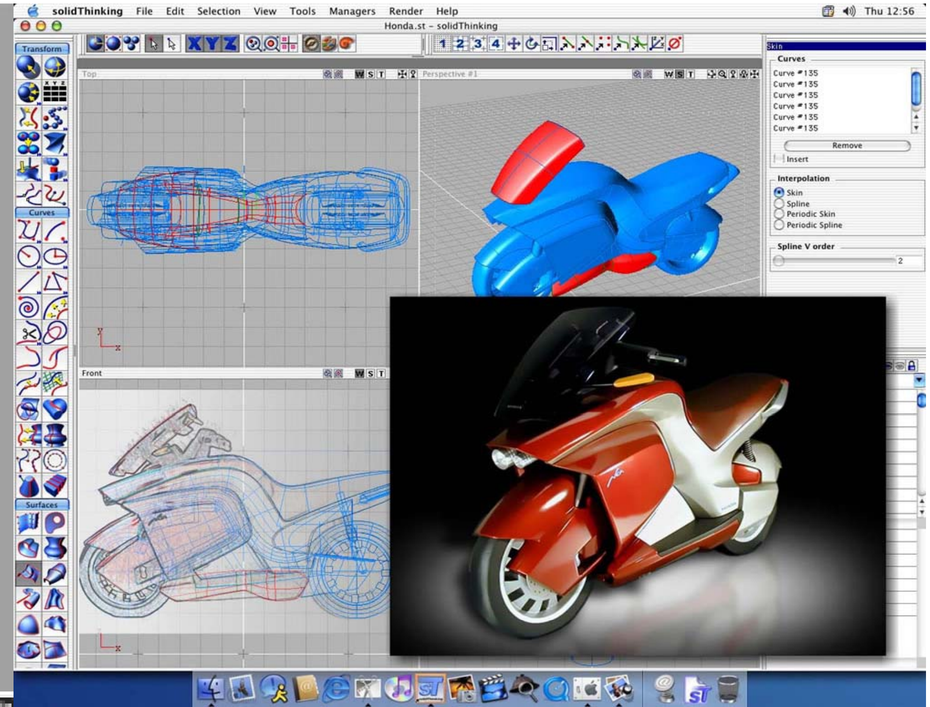
- Means for data storage, retrieval, manipulation and presentation;
- Mechanisms for sensing state and modifying processes;
- Algorithms for uniting the data processing component with the sensor/modification component.

Some factors involved when considering a CIM implementation are;

- The production volume,
- The experience of the company or personnel to make the integration,
- The level of the integration into the product itself and the integration of the production processes.

CIM is most useful where a high level of ICT is used in the company or facility, such as CAD/CAM systems, the availability of process planning and its data.





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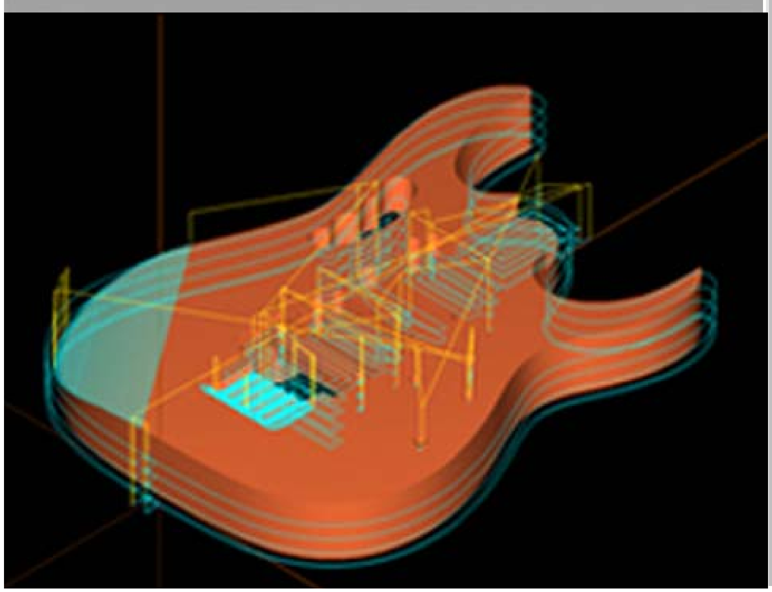

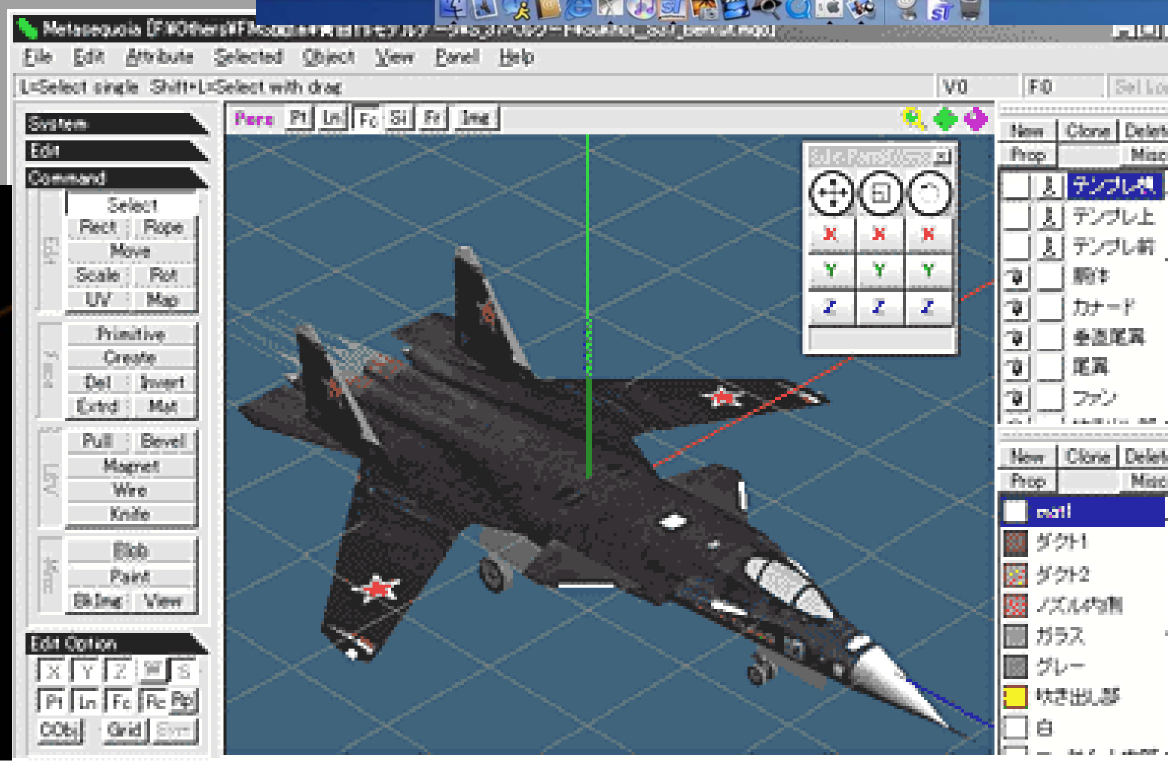

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COMPUTER-INTEGRATED MANUFACTURING TOPICS:

- **Key challenges;**

-Integration of components from different suppliers:

-Data integrity:

-Process control:

- **Subsystems in computer-integrated manufacturing;**

-Computer-aided techniques:

-Devices and equipment required:

-Technologies:

KEY CHALLENGES:

INTEGRATION OF COMPONENTS FROM DIFFERENT SUPPLIERS:

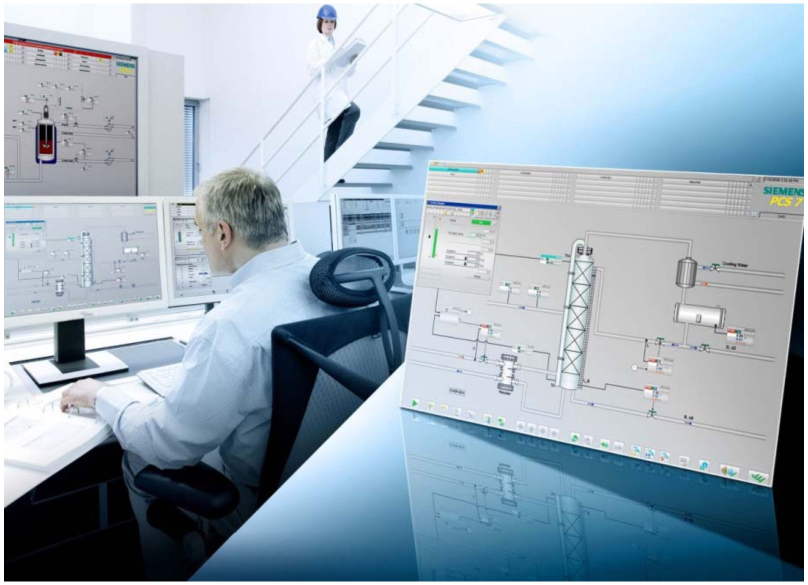
- When different machines, such as CNC, conveyors and robots, are using different communications protocols. In the case of AGVs, even differing lengths of time for charging the batteries may cause problems.

Data integrity:

- The higher the degree of automation, the more critical is the integrity of the data used to control the machines.
- While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the data signals that are used to control the machines.

Process control:

- Computers may be used to assist the human operators of the manufacturing facility, but there must always be a competent engineer on hand to handle circumstances which could not be foreseen by the designers of the control software.



SUBSYSTEMS IN COMPUTER-INTEGRATED MANUFACTURING:

- A computer-integrated manufacturing system is not the same as a *"*lights-out*"* *factory*, which would run completely independent of human intervention, although it is a big step in that direction.
- Part of the system involves flexible manufacturing, where the factory can be quickly modified to produce different products, or where the volume of products can be changed quickly with the aid of computers.

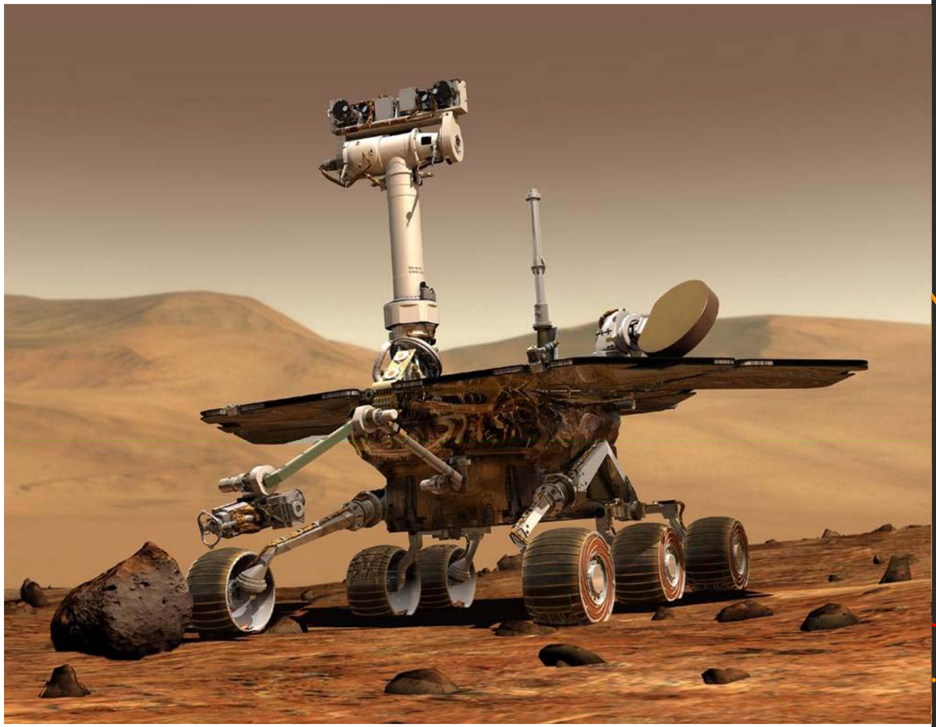
COMPUTER-AIDED TECHNIQUES:

Some or all of the following subsystems may be found in a CIM operation:

- CAD (computer-aided design)
- CAE (computer-aided engineering)
- CAM (computer-aided manufacturing)
- CAPP (computer-aided process planning)
- CAQ (computer-aided quality assurance)
- PPC (production planning and control)
- ERP (enterprise resource planning)
- A business system integrated by a common database.

DEVICES AND EQUIPMENT REQUIRED:

- CNC, Computer numerical controlled machine tools
- DNC, Direct numerical control machine tools
- PLCs, Programmable logic controllers
- Robotics
- Computers
- Software
- Controllers
- Networks
- Interfacing
- Monitoring equipment



TECHNOLOGIES:

- FMS, (flexible manufacturing system)
- ASRS, (automated storage and retrieval system)
- AGV, (automated guided vehicle)
- Robotics
- Automated conveyance systems