CAD/CAM/CAE
Computer Aided Design/Computer Aided Manufacturing/Computer Aided Manufacturing

Part-1
Introduction to CAD/CAM

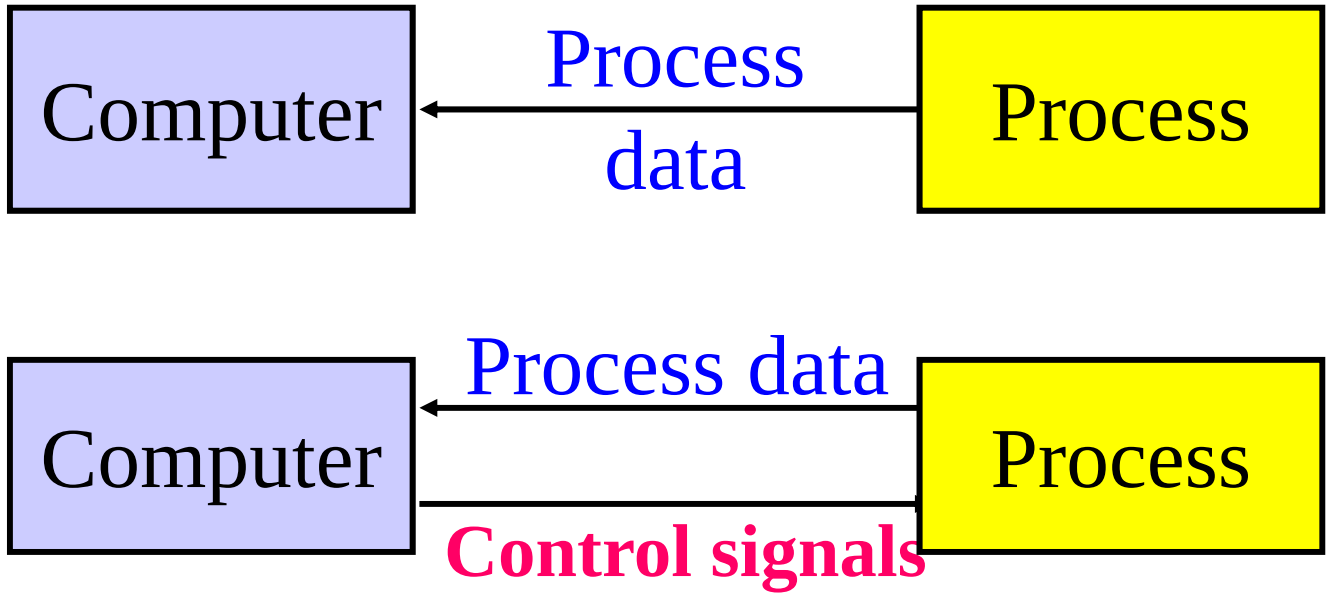
CAD/CAM

- CAD/CAM = Computer Aided Design and Computer Aided Manufacturing. It is the technology concerned with the use of computers to perform design and manufacturing functions.

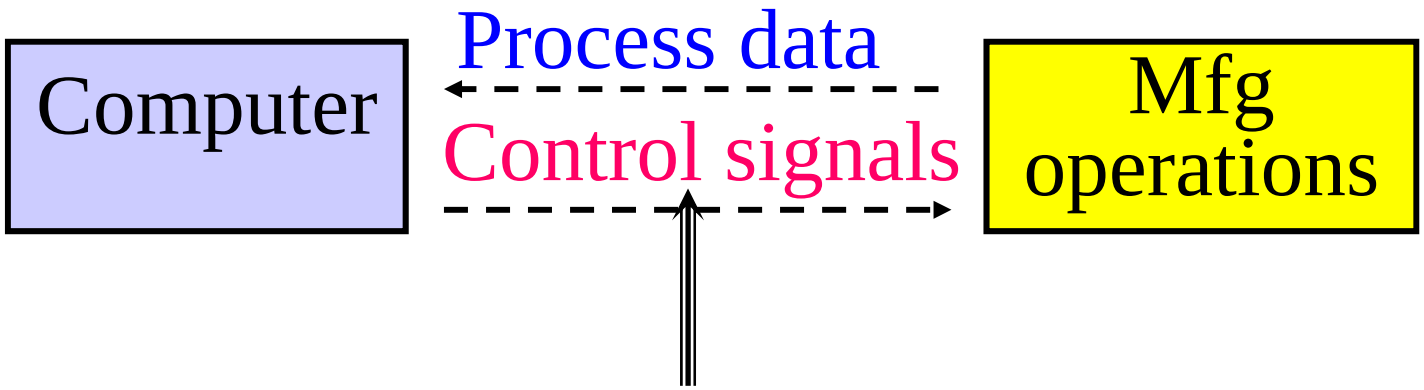
- **CAD** can be defined as the use of computer systems to perform certain functions in the design process.
- **CAM** is the use of computer systems to plan, manage and control the operations of manufacturing plant through either direct or indirect computer interface with the plant's production resources.

From CAM definition, the application of CAM falls into two broad categories:

1. Computer monitoring and control .



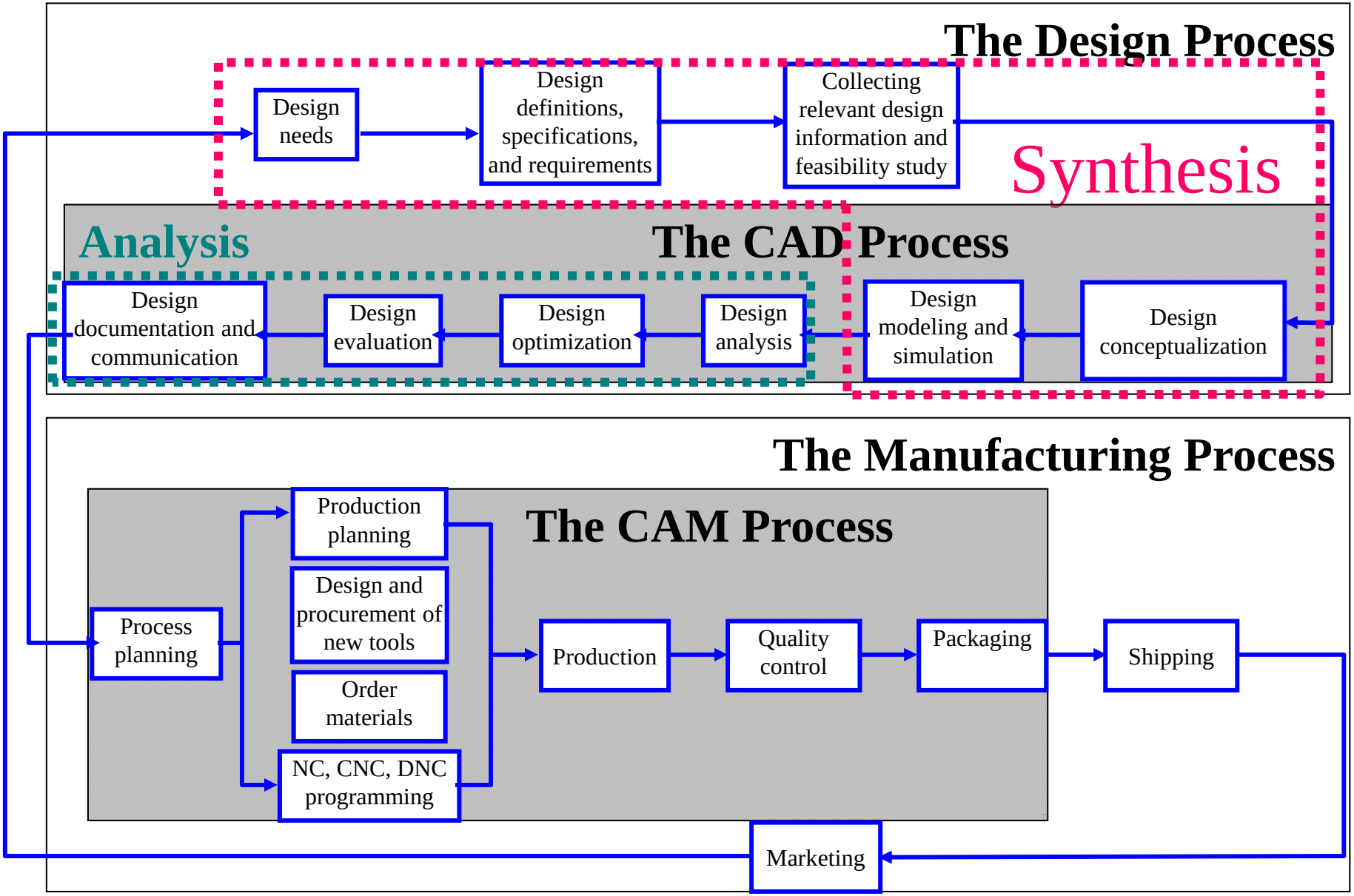
2. Manufacturing support application .



The Product Cycle and CAD/CAM

In order to establish the scope and definition of CAD/CAM in an engineering environment and identify existing and future related tools, a study of a typical product cycle is necessary. The following Figure shows a flowchart of such a cycle.

Typical Product Life Cycle

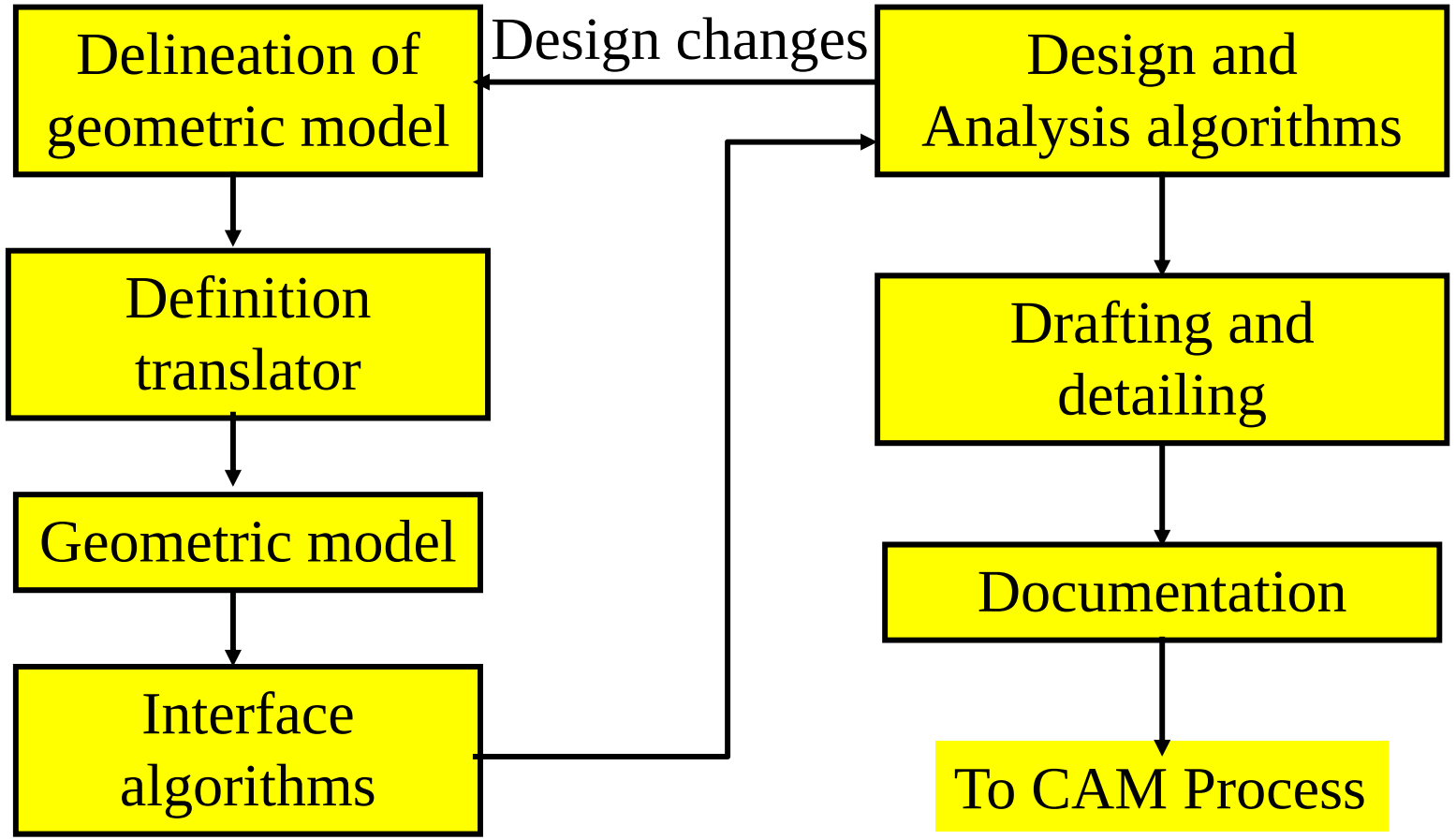


- The product begins with a need which is identified based on customers' and markets' demands.
- The product goes through two main processes from the idea conceptualization to the finished product:
  1. **The design process.**
  2. **The manufacturing process.**

The main sub-processes that constitute the design process are:

1. Synthesis.
2. Analysis.

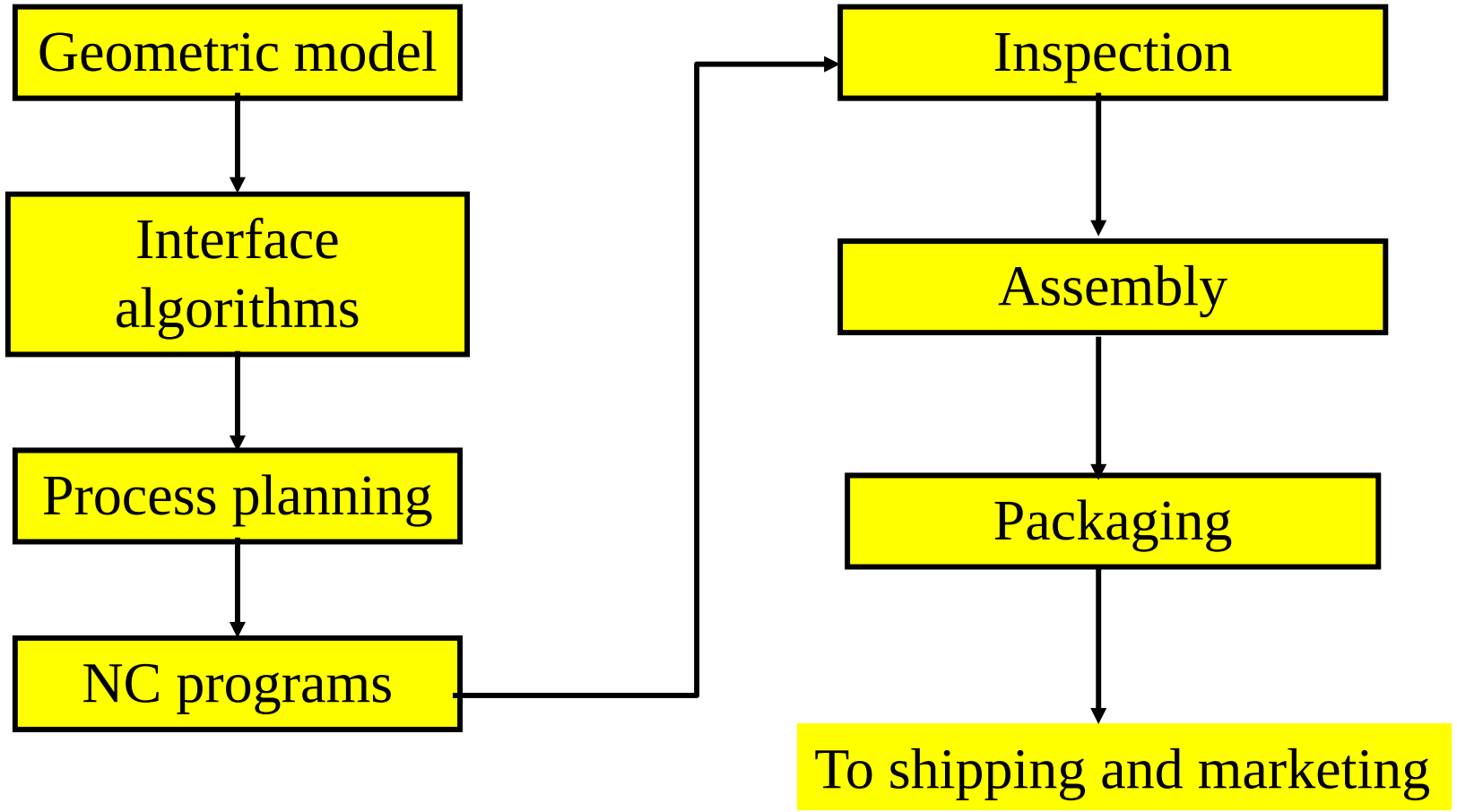
Implementation of a Typical CAD Process on a CAD/CAM system



CAD Tools Required to Support the Design Process

Design phase	Required CAD tools
Design conceptualization	Geometric modeling techniques; Graphics aids; manipulations; and visualization
Design modeling and simulation	Same as above; animation; assemblies; special modeling packages.
Design analysis	Analysis packages; customized programs and packages.
Design optimization	Customized applications; structural optimization.
Design evaluation	Dimensioning; tolerances; BOM; NC.
Design communication and documentation	Drafting and detailing…

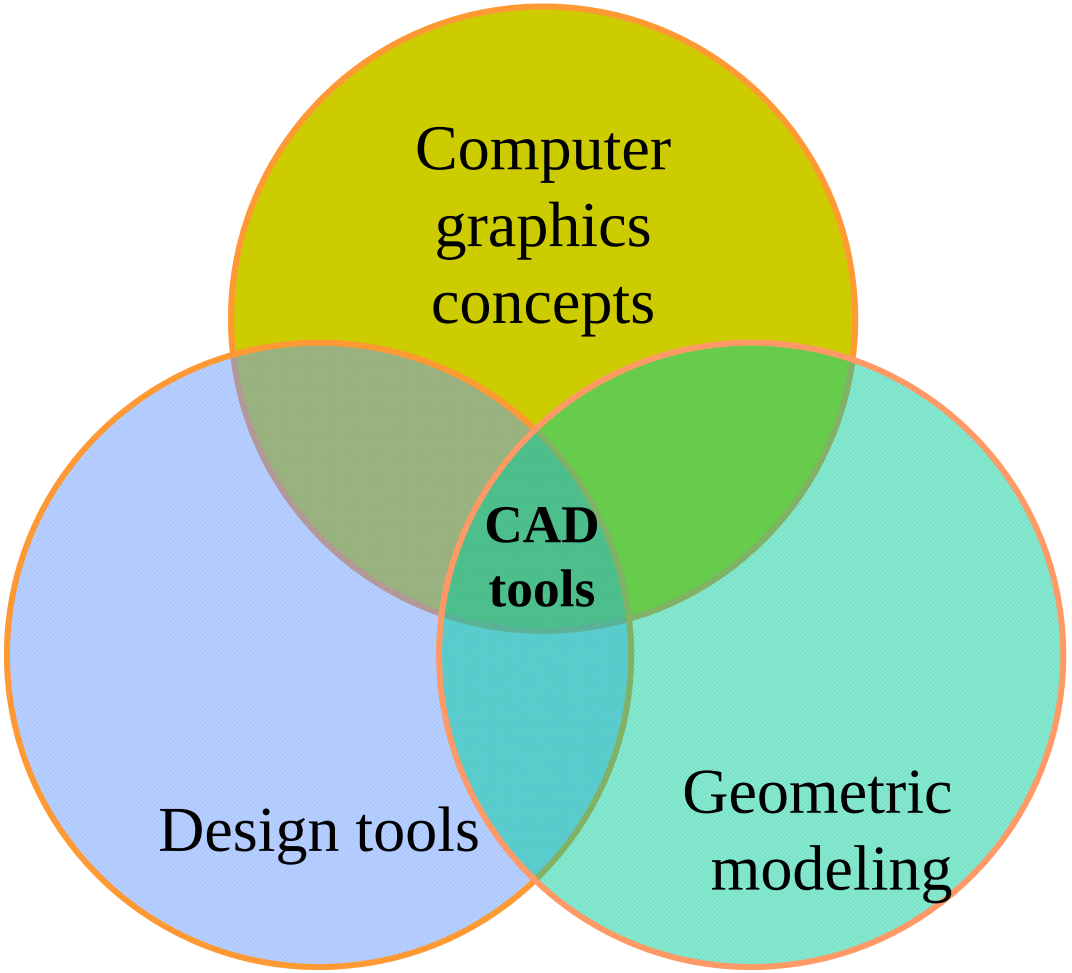
Implementation of a Typical CAM Process on a CAD/CAM system



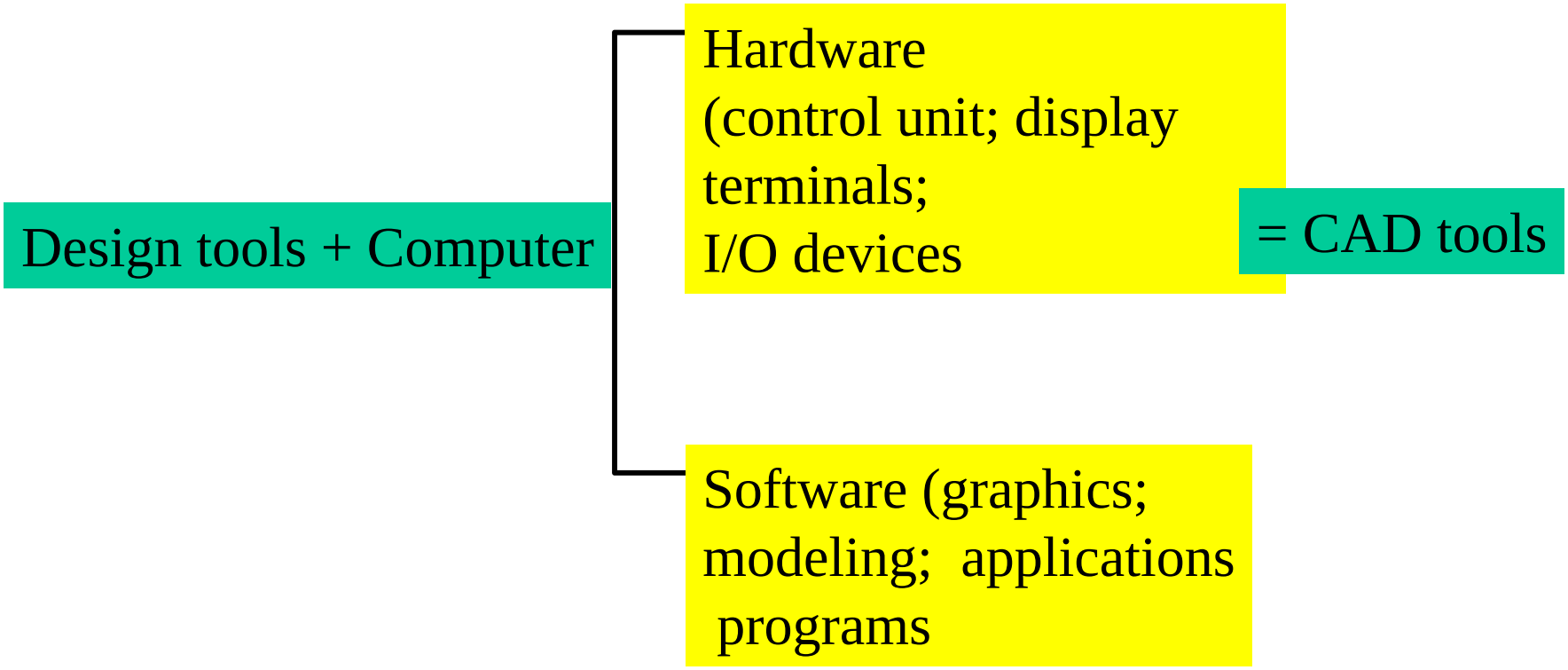
CAM Tools Required to Support the Design Process

Manufacturing phase	**Required CAM tools**
Process planning	CAPP techniques; cost analysis; material and tooling specification.
Part programming	NC programming
Inspection	CAQ; and Inspection software
Assembly	Robotics simulation and programming

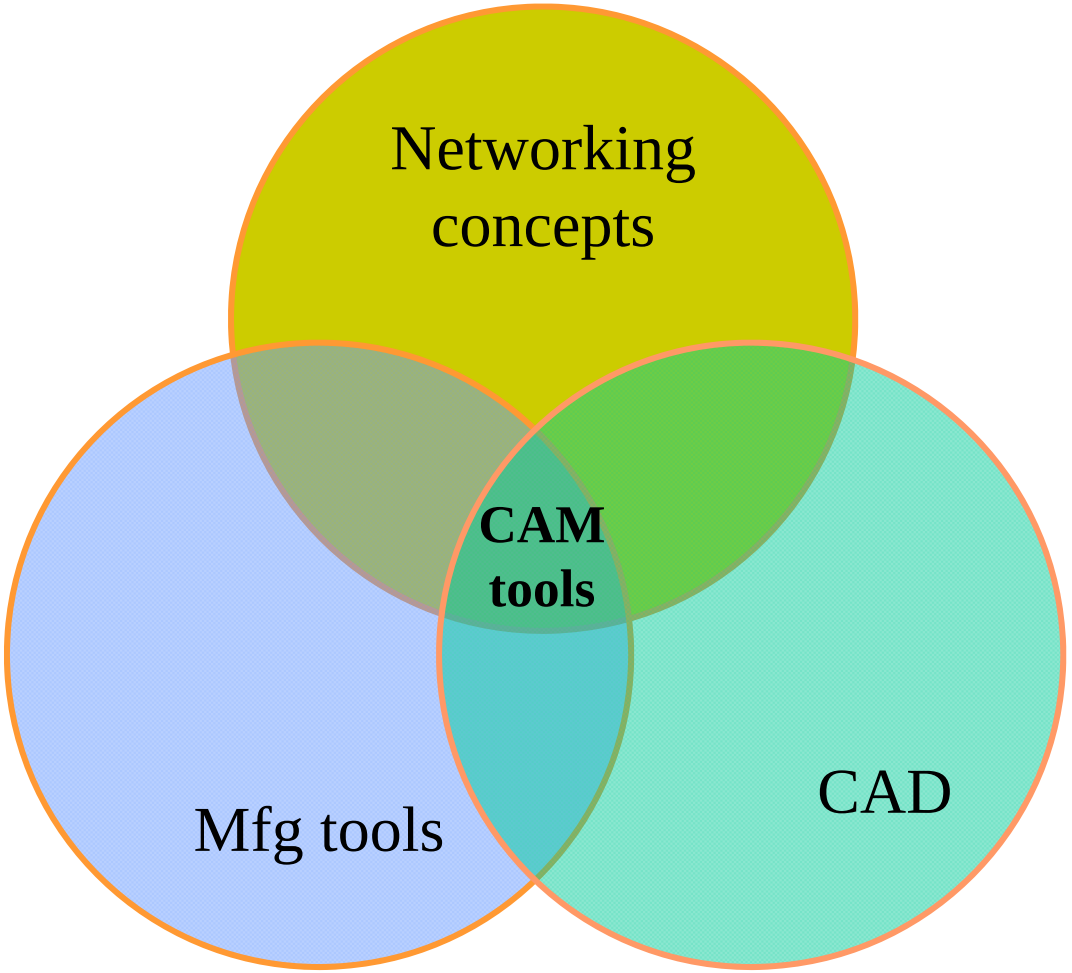
Definitions of CAD Tools Based on Their Constituents



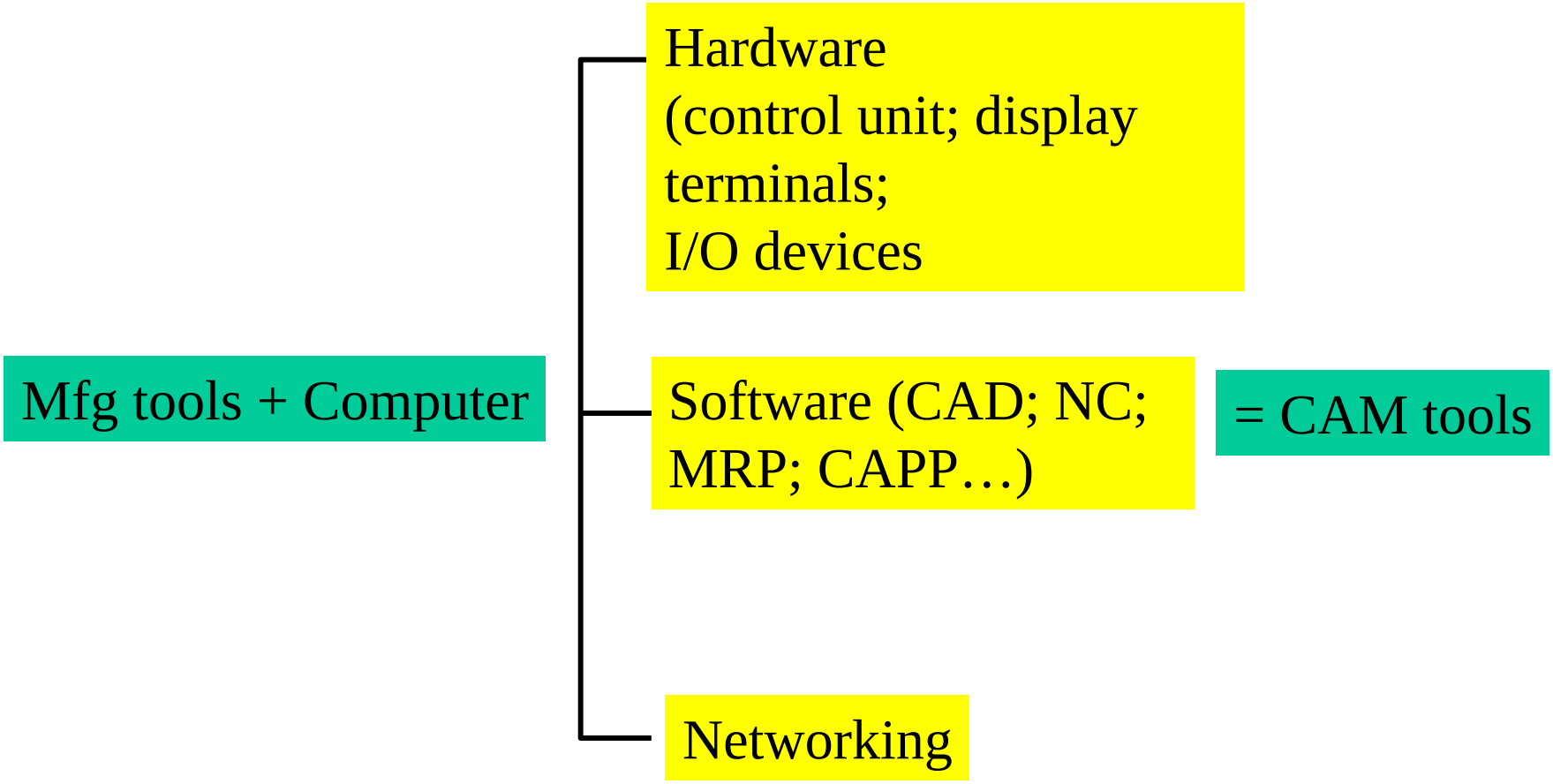
Definition of CAD Tools Based on Their Implementation in a Design Environment



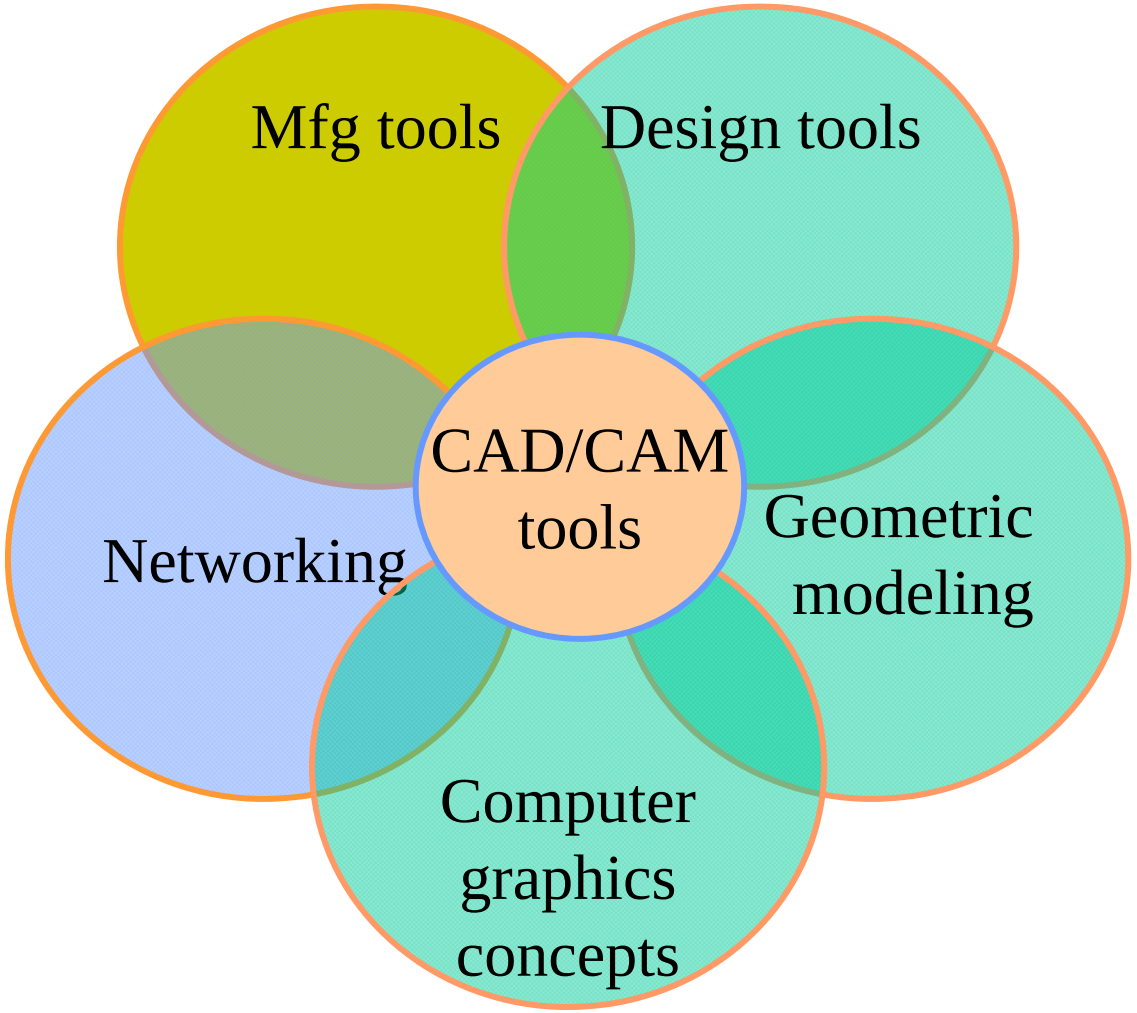
Definitions of CAM Tools Based on Their Constituents



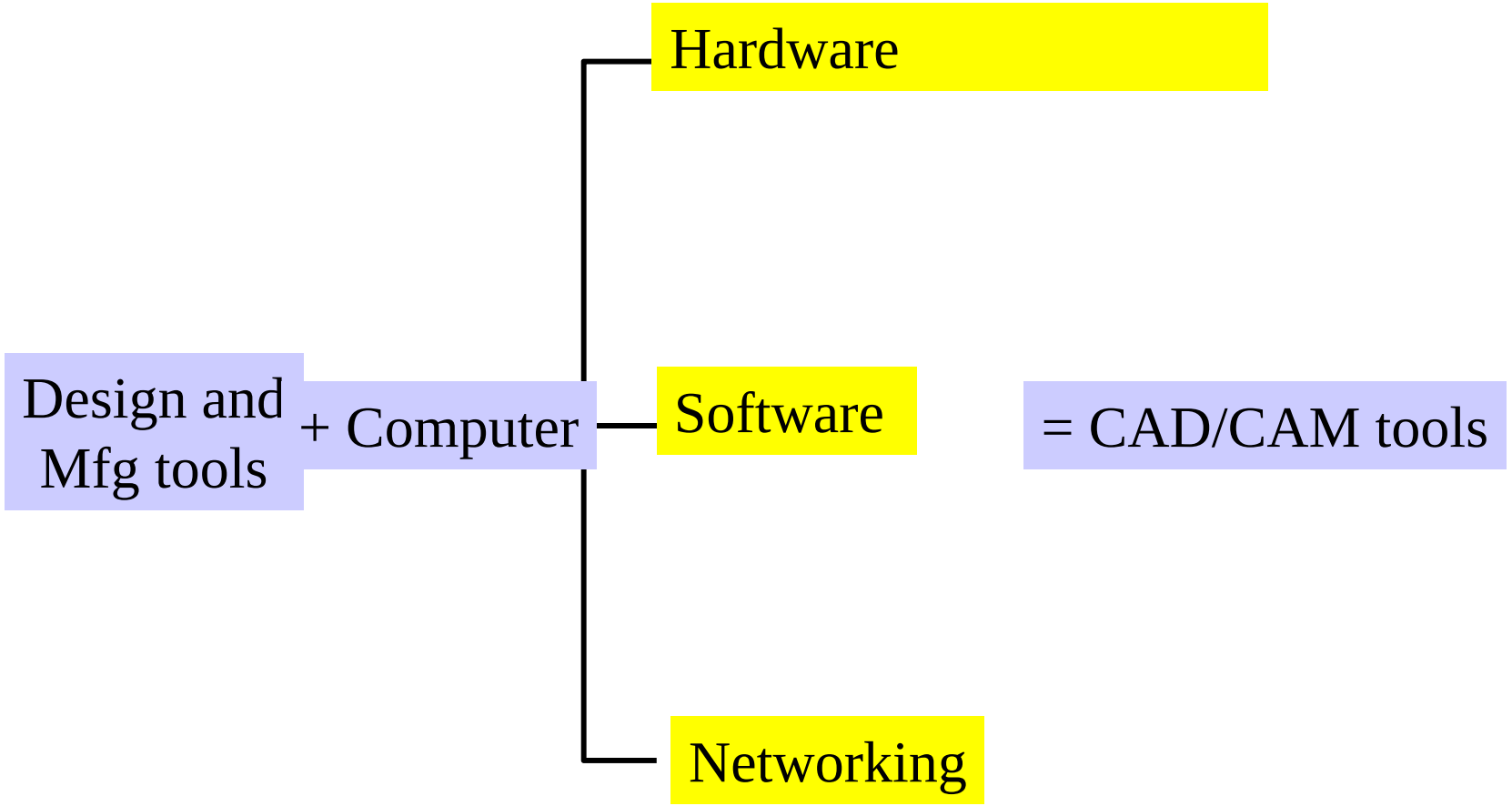
Definition of CAM Tools Based on Their Implementation in a Manufacturing Environment



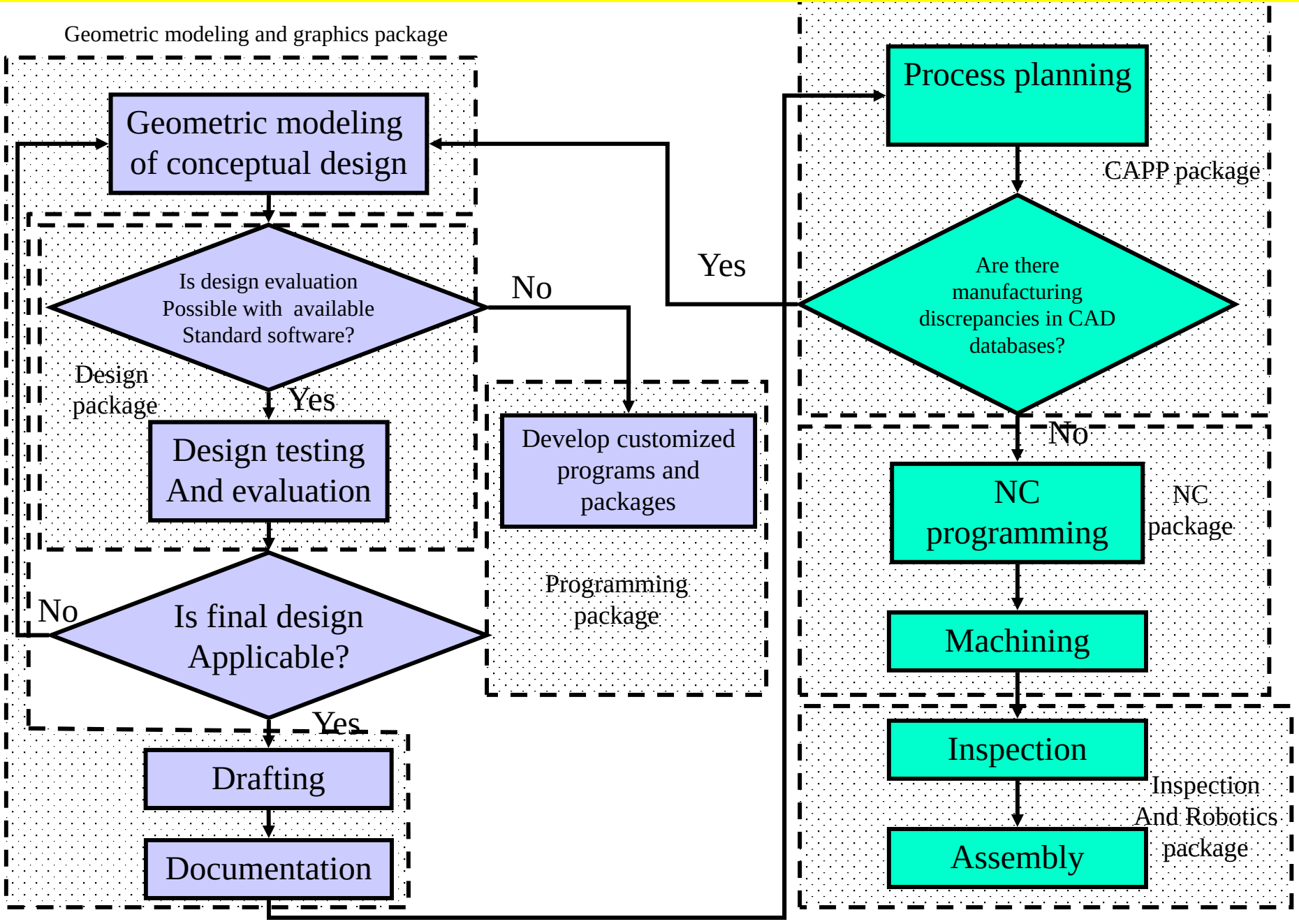
Definitions of CAD/CAM Tools Based on Their Constituents



Definition of CAD/CAM Tools Based on Their Implementation in an Engineering Environment



Typical Utilization of CAD/CAM Systems in an Industrial Environmen

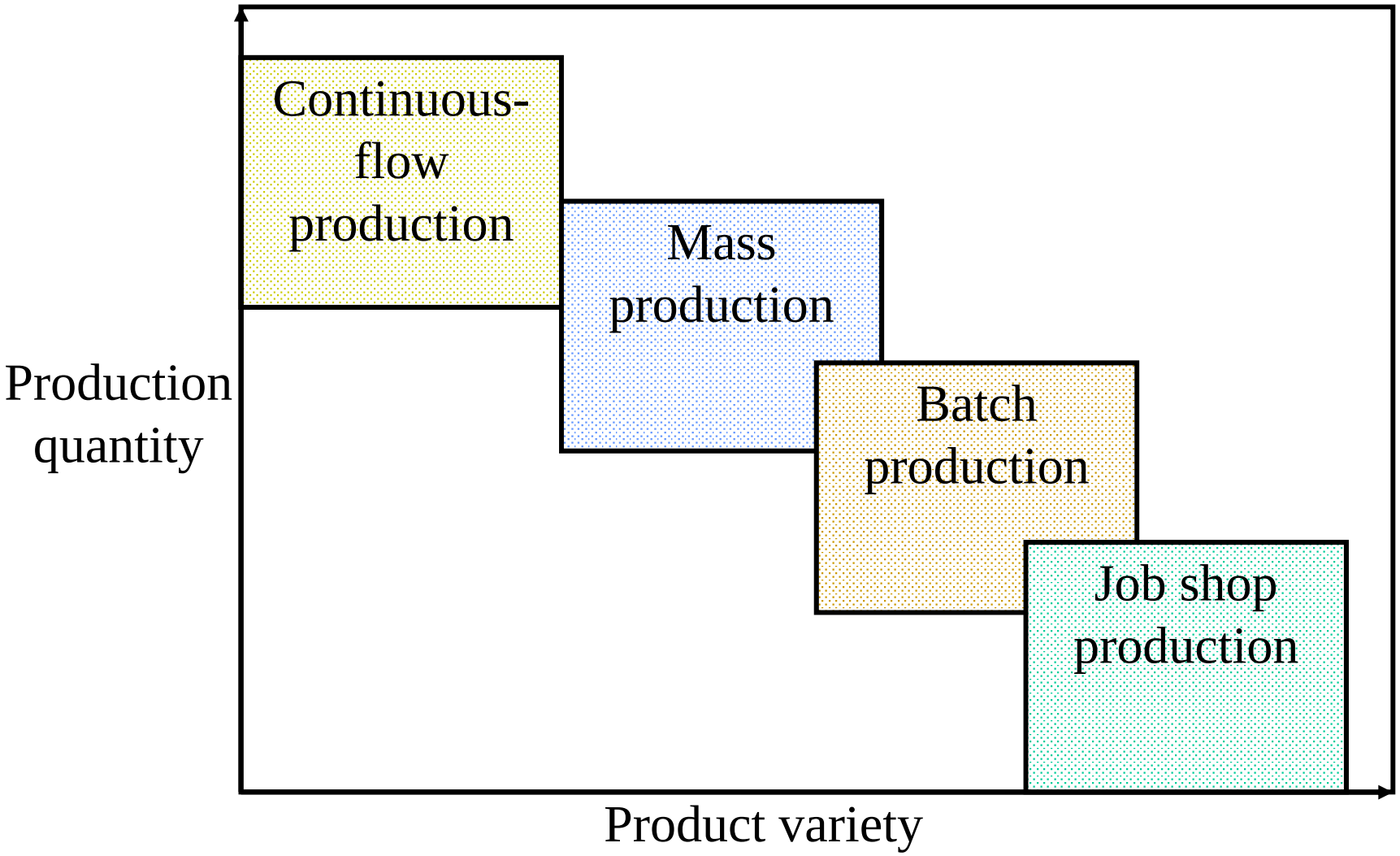


Automation and CAD/CAM

Automation can be defined as the technology concerned with the application of complex mechanical, electronic, and computer-based systems in the operation and control of manufacturing systems.

TTypes of Manufacturing Systems

1. **Continuous-flow processes**. Continuous dedicated production of large amount of bulk product. Continuous manufacturing is represented by chemicals, plastics, petroleum, and food industries.
2. **Mass production of discrete products**. Dedicated production of large quantities of one product (with perhaps limited model variations). Examples include automobiles, appliances and engine blocks.
3. **Batch production.** Production of medium lot sizes of the same product. The lot may be produced once or repeated periodically. Examples: books, clothing and certain industrial machinery.
4. **Job-shop production**. Production of low quantities, often one of a kind, of specialized products. The products are often customized and technologically complex. Examples: prototypes, aircraft, machine tools and other equipment.


Continuous-flow production
Mass production
Batch production
Job shop production
Production quantity
Product variety

Category	Automation achievements
Continuous-flow process	•Flow process from beginning to end •Sensors technology available to measure important process variables •Use of sophisticated control and optimization strategies •Fully computer automated lines
Mass production of discrete products	•Automated transfer machines •Dial indexing machines •Partially and fully automated assembly lines •Industrial robots for spot welding, part handling, machine loading, spray painting, etc. •Automated material handling systems •Computer production monitoring
Batch production	•Numerical control (NC), direct numerical control (DNC), computer numerical control (CNC). •Adaptive control machining •Robots for arc welding, parts handling, etc. •CIM systems.
Job shop production	•Numerical control, computer numerical control

Computer Technology in Automation

Most of the automated production systems implemented today make use of computers. CAD/CAM in addition to its particular emphasis on the use of computer technology, is also distinguished by the fact that it includes not only the manufacturing operations but also the design and planning functions that precede manufacturing.

To emphasize the differences in scope between automation and CAD/CAM, consider the following mathematical model:

$$TT_{lc} = BQT_1 + BT_2 + T_3$$

TT_{cl} = total time during the product life cycle

B = The number of batches produced throughout the product life cycle.

Q = The number of units produced in each batch.

T_1 = The time required to produce one unit of product.

T_2 = The time associated with planning and setting up for each batch of production.

T_3 = The time required for designing the product and for all the other activities that are accomplished once for each different product .

T_{lc} = The average time spent on each unit of product during its life cycle $= T_1 + \frac{T_2}{Q} + \frac{T_3}{BQ}$

T_1 The most important term in mass production and batch production

T_2 & T_3 become very important in job shop manufacturing.

Automation technology is concerned with reducing T_1 & T_2 the with emphasis on the unit production time T_1

CAD/CAM concerned with reducing all three terms, but is perhaps focused on T_2 & T_3 terms. The emphasis in CAD/CAM includes the design and planning function of the product life cycle.

Advantages of CAD/CAM systems

- Greater flexibility.
- Reduced lead times.
- Reduced inventories.
- Increased Productivity.
- Improved customer service.
- Improved quality.
- Improved communications with suppliers.
- Better product design.
- Greater manufacturing control.
- Supported integration.
- Reduced costs.
- Increased utilization.
- Reduction of machine tools.
- Less floor space.