

Additive Manufacturing

presented by

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Additive Manufacturing → earlier known as 'Rapid Prototyping'

Definition of a Prototype

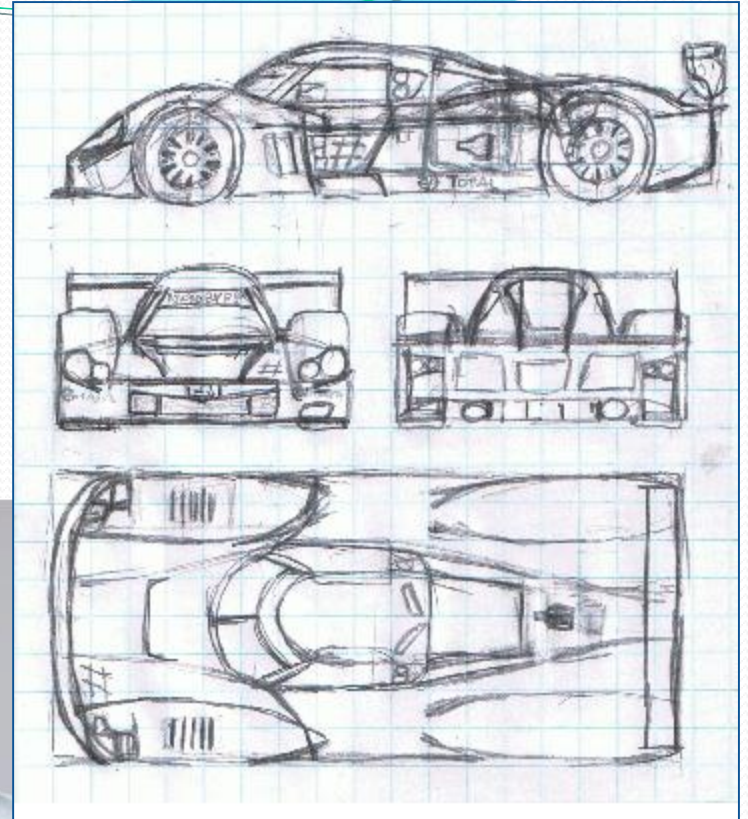
- A '**prototype**' is the first or original example of something that will be copied or further developed.
- So prototype is the basis for later improved models
- It is a model of preliminary version.

e.g. Prototype of car, motorcycle, toy etc.

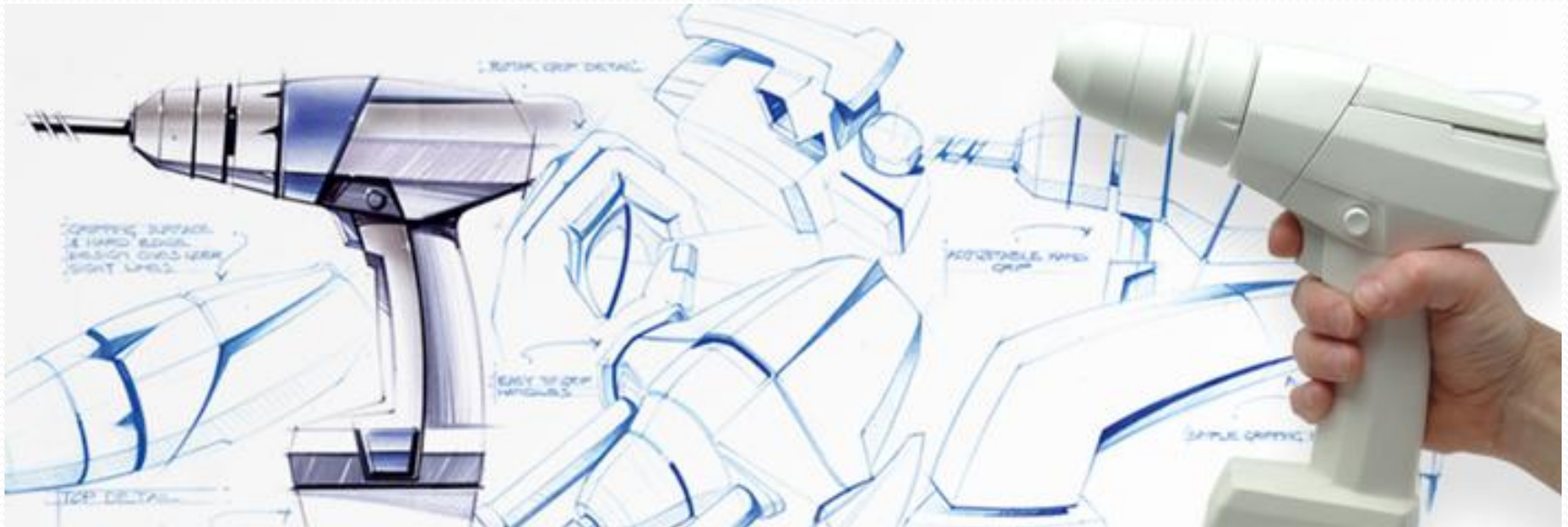


Prototype of a toy
(printed on a 3D printer
with multiple materials)

Prototype of a car



Prototype of a Handheld Drill Gun

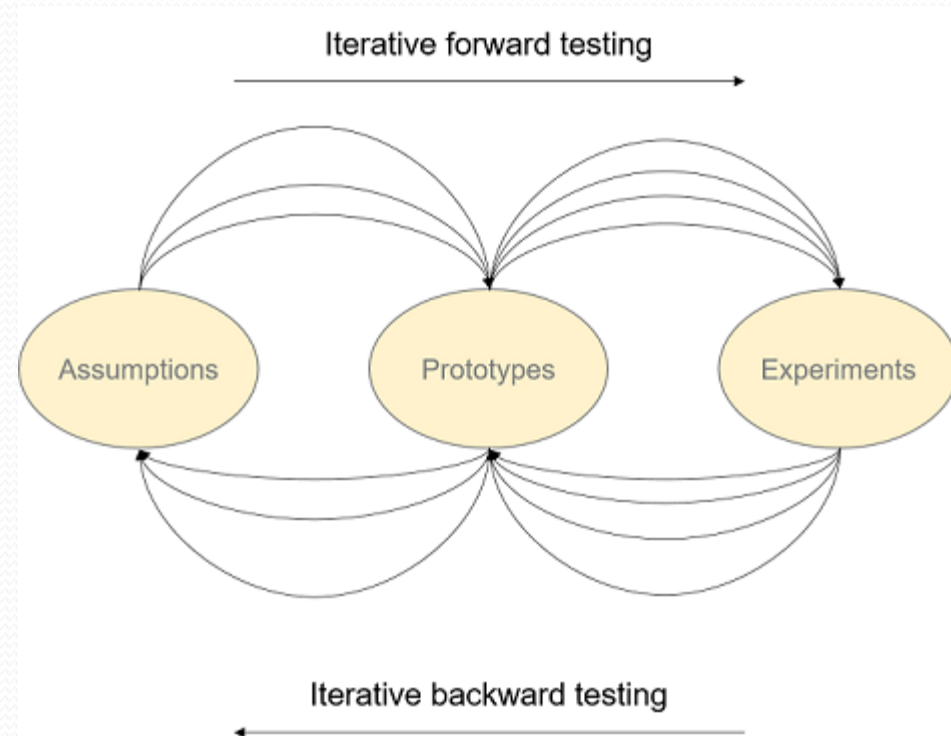


More general and broader definition of Prototype

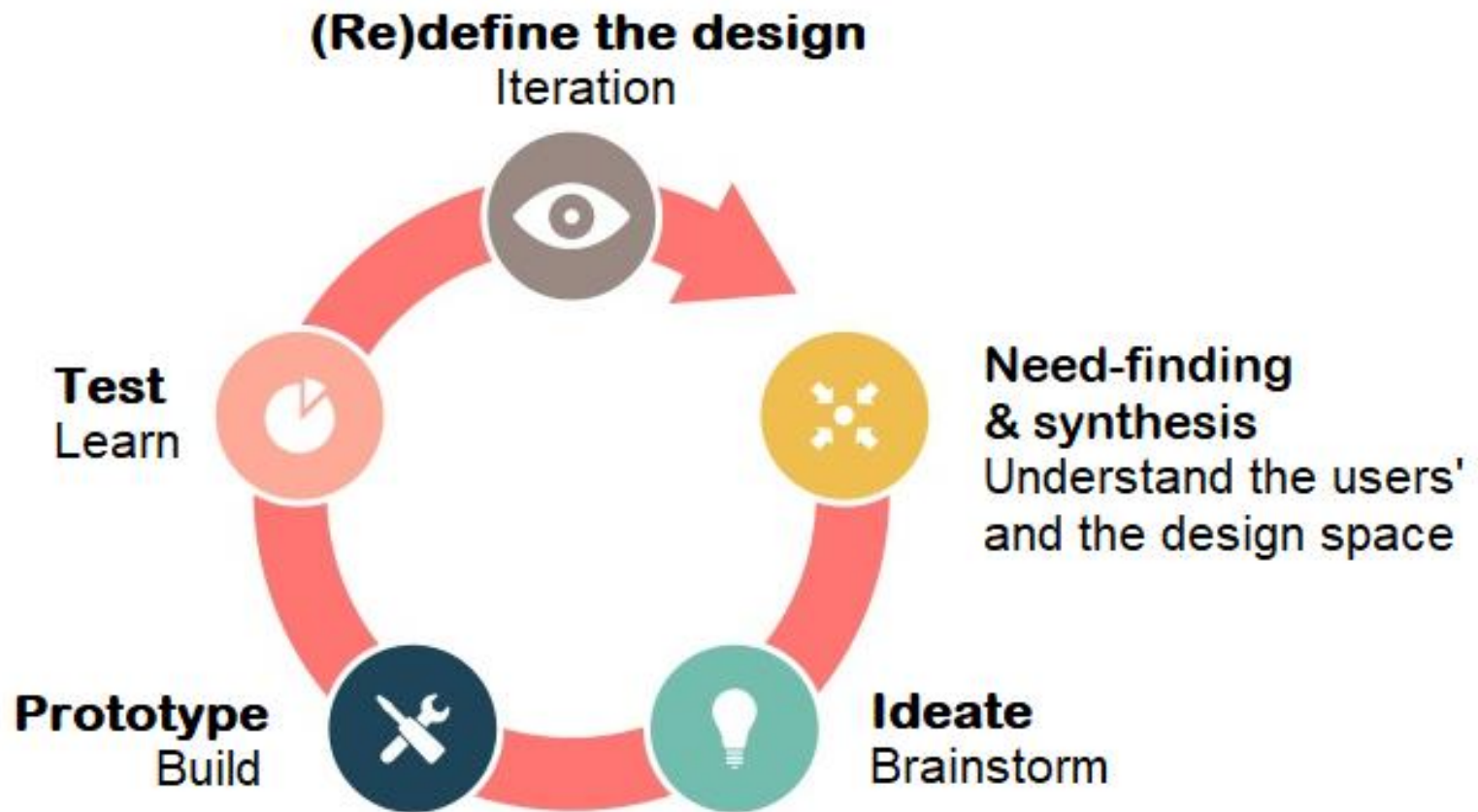
- An approximation of a product (or system) **or** its components in some form for a definite purpose during some stage of its implementation.
- It covers all kind of prototypes used in the product development process; including objects like mathematical models, pencil sketches, foam models, and functional physical model of the product.
- ‘Prototyping’ is the process of realizing these prototypes.

Role of the Prototypes

- Experimentation and learning
- Testing and proofing
- Communication and interaction
- Synthesis and integration
- Scheduling and markers



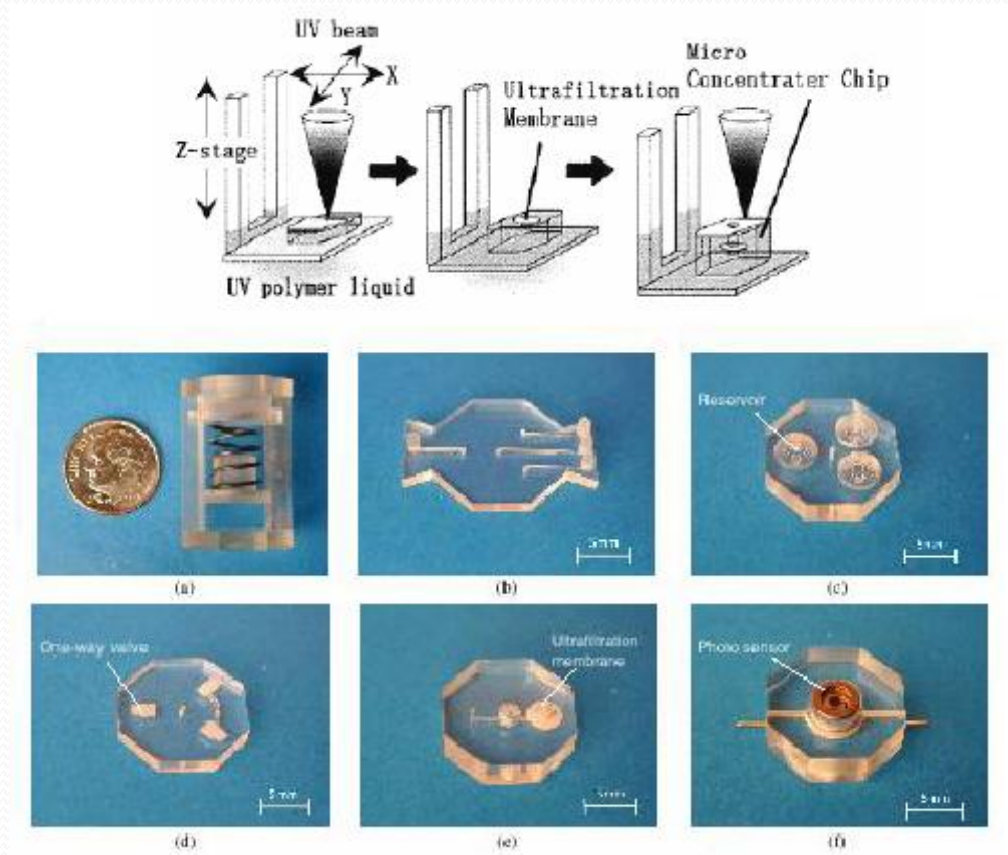
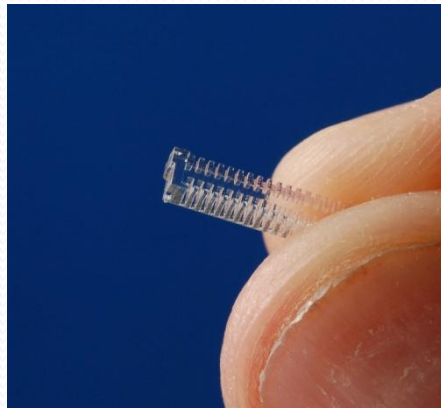
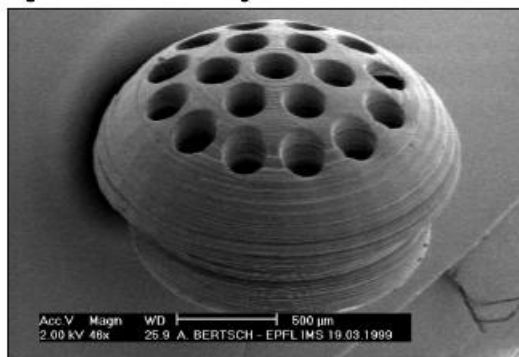
Design thinking process



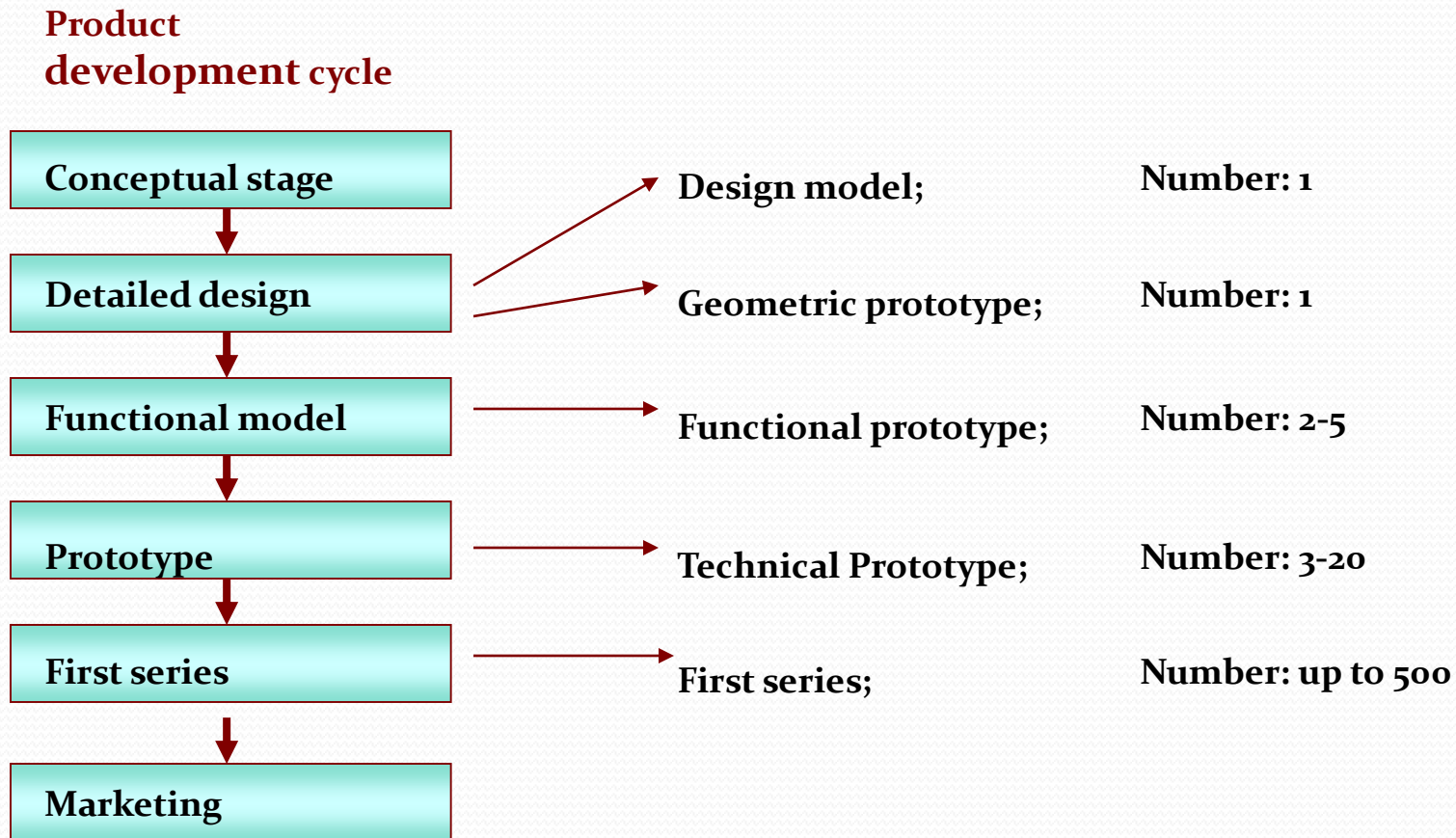
A scale model of an airplane in a wind tunnel for testing



Small Prototypes → Application – MEMS Packaging and Microdevices



Type of prototypes at different stages of product development



25 % of the product development time may go for fabricating the prototypes

Three Aspects of Prototypes

- Implementation of the Prototype; from the entire product (or system) to its sub-assemblies or components
- The form of the prototype; from a virtual prototype to a physical prototype.
- The degree of Approximation of the prototype; from a very rough estimation to a very accurate replication of the product.

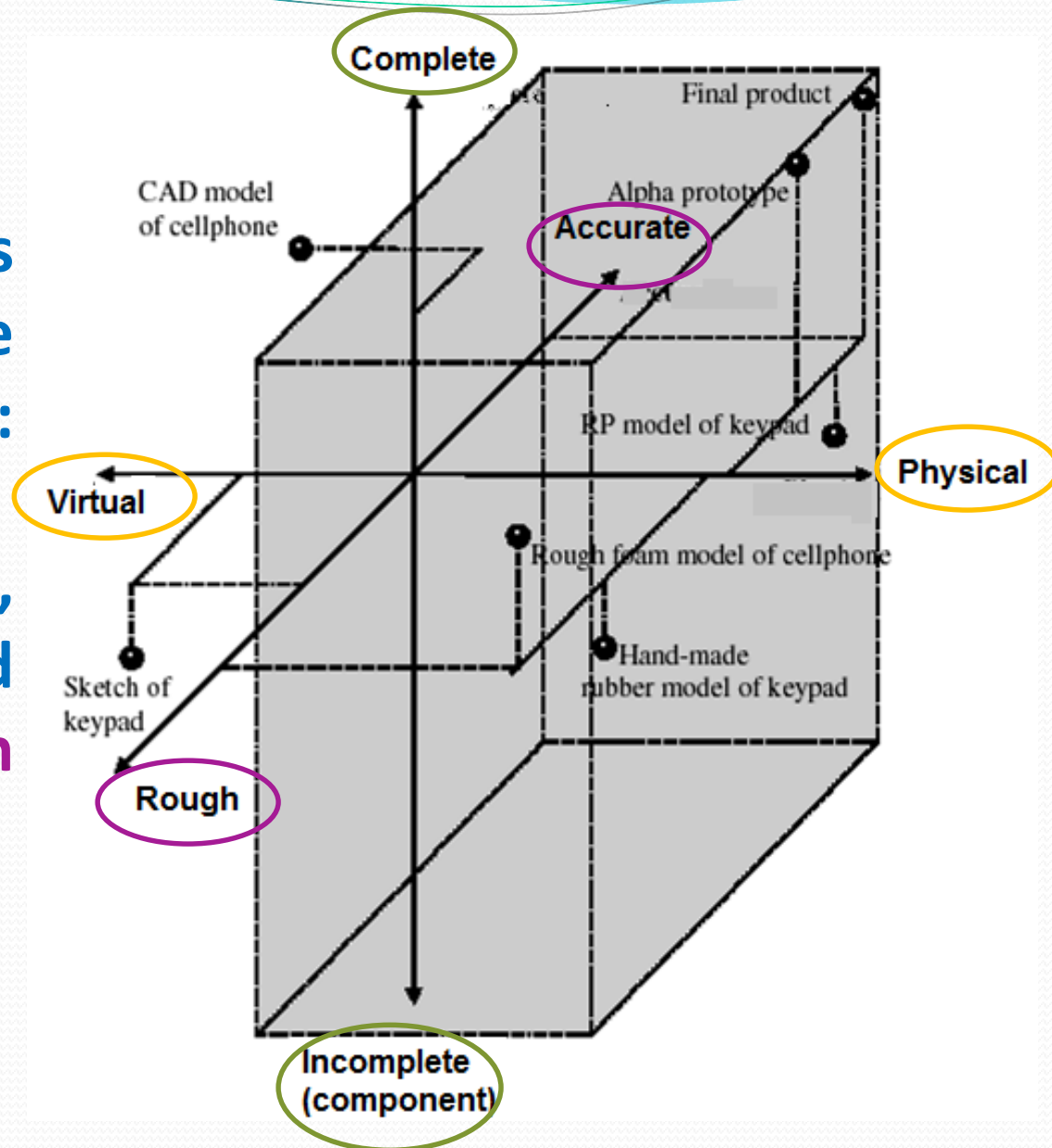
CAD model of a cell phone, Sketch of a keypad, Rough foam model of a cell phone, Handheld rubber model of key pad – **In which category does each one fall ???**



From crude prototype to production: Progression of the flow saddle making.

Types of prototypes described along the 3 aspects:

- Implementation,
- Form, and
- Approximation



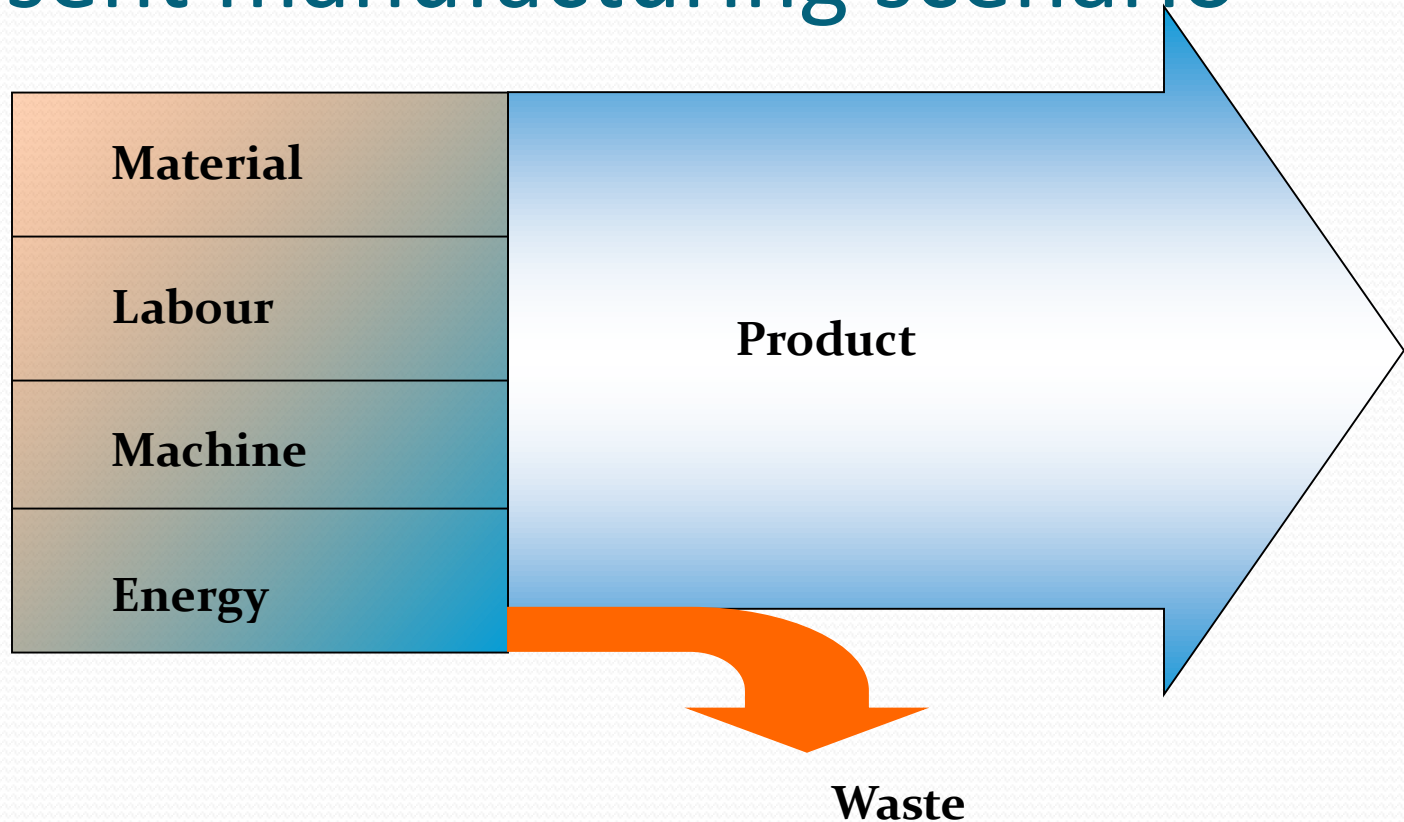
Additive Manufacturing Books

- Rapid Prototyping – Principles & Applications in Manufacturing : Chua Chee Kai, Leong Kah Fai, [John Wiley & Sons]
- Rapid Prototyping: Laser-based and Other Technologies - by Patri K. Venuvinod and Weiyin Ma [Kluwer Academic Publishers]
- Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing - Brent Stucker, David Rosen, Ian Gibson [Springer]

Importance of Additive Manufacturing in Present Manufacturing Scenario

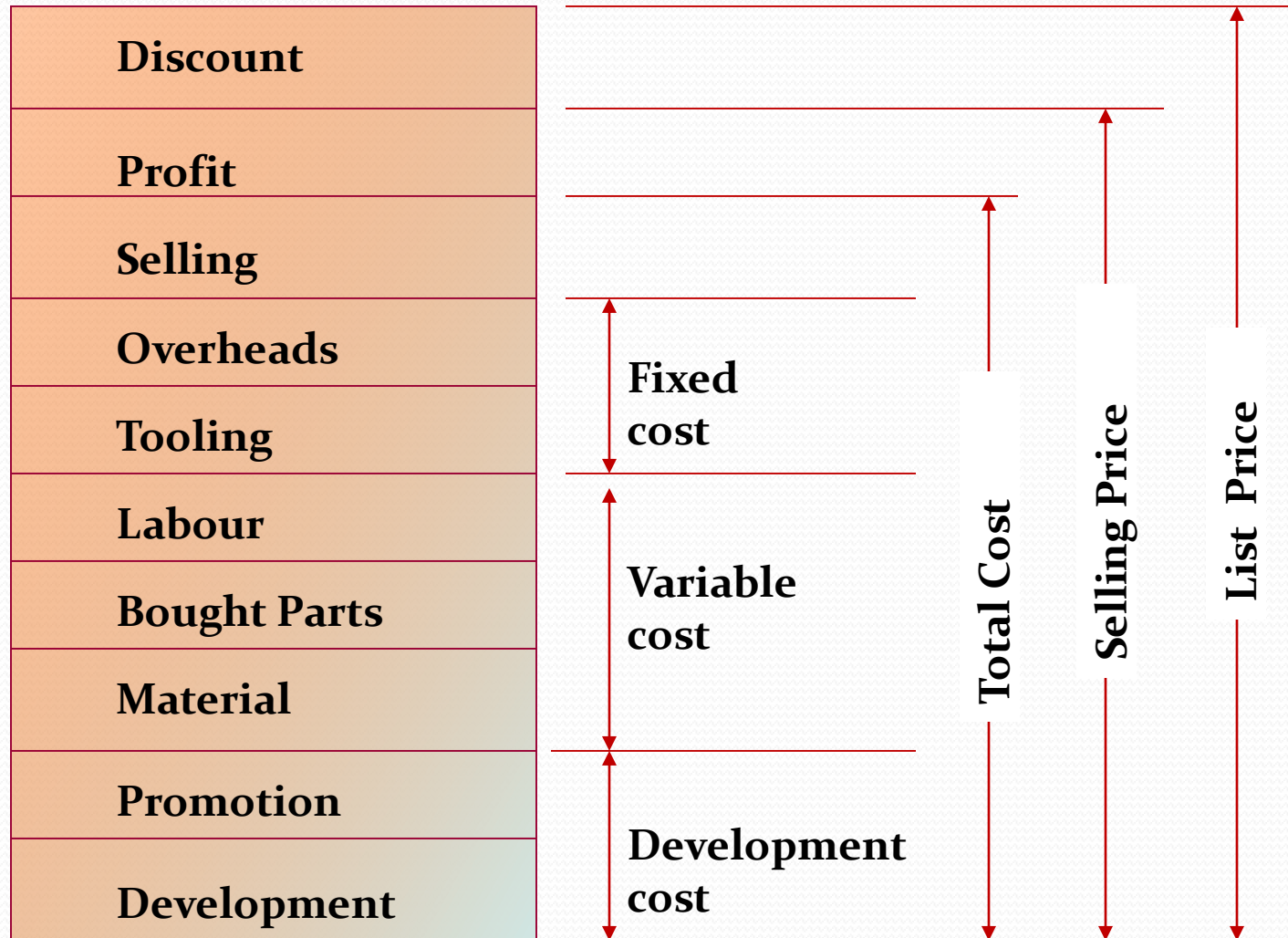


Importance of Additive Manufacturing in present manufacturing scenario



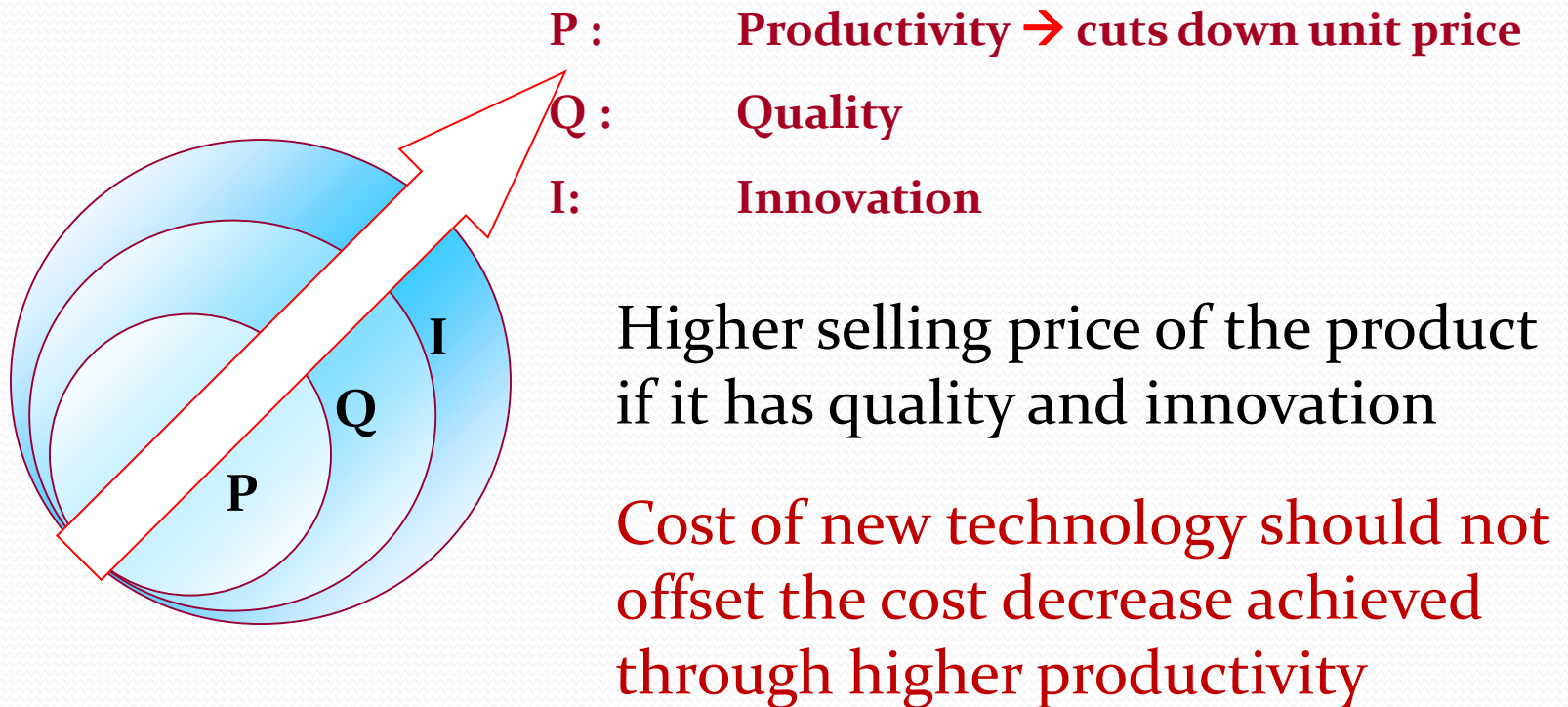
Value of product > Combined values of individual inputs

Cost Structure for Product Realisation



Changing competitive strategies

- Business based on single product: conceived, designed, tooled and manufactured in-house



Different Manufacturing Processes

Forming Processes

Removal Processes

Joining Processes

Original state
of material



Solid



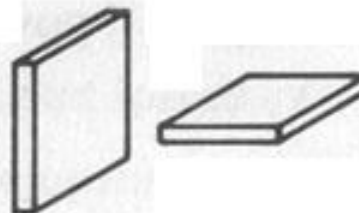
Liquid



Powder



Excess material removed



Weld



Activities Involved In Traditional Manufacturing

- Specific manufacturing Process
- Relative movement between Tool & Work
- Loading-Unloading of Job & Tool Change
- Inspection of Components
- Transportation of Components & Tool from Location to Location

- Assembly & Fabrication
- Testing and quality control of Product
- Packaging
- Material & Inventory Control
- Process Planning & Engineering Design
- Management & Marketing

Mechanization in Manufacturing → Historically

Pre-industrial
Revolution



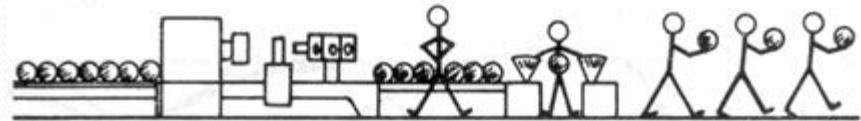
First Industrial
Revolution



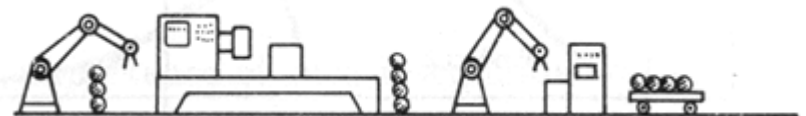
Semi- Automatic
Production Machines



Automatic Machines &
Transfer Line




Flexible Automation &
Computer Integration



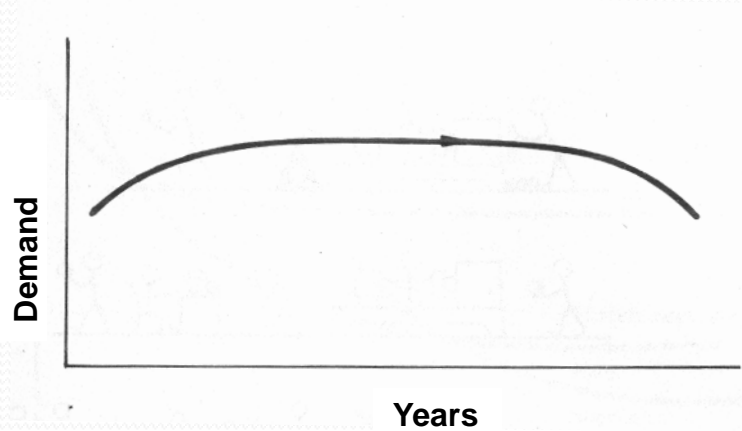
Historical Development of Technologies

→ from Mechanization to AM

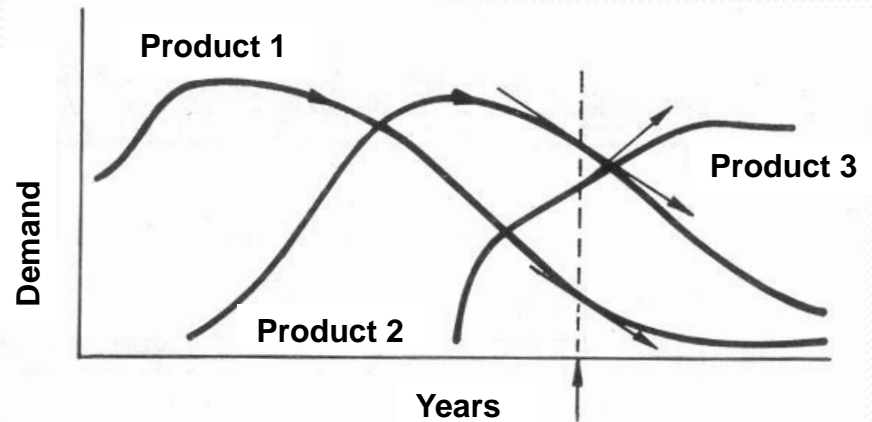


Year of invention (AD)	Technology
1770	Mechanization
1946	First computer
1952	First NC machine tool
1960	First commercial laser
1961	First commercial robot
1963	First interactive graphic system (early version of CAD)
1988	First commercial rapid prototyping machine

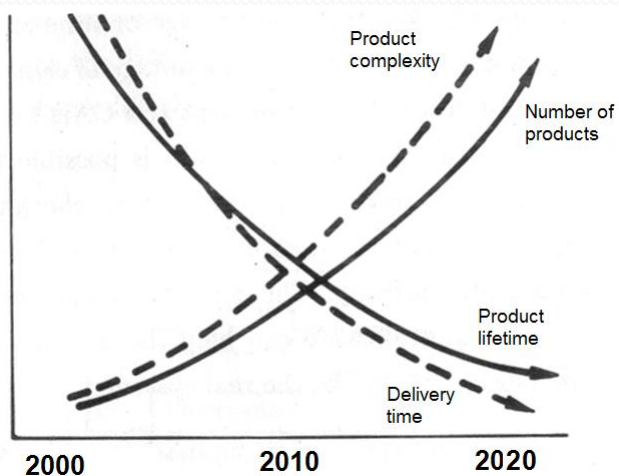
Old Market Pattern



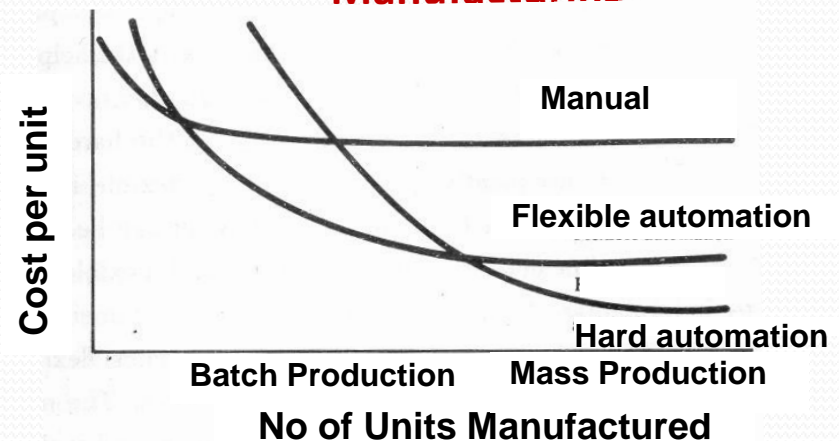
New Market Pattern



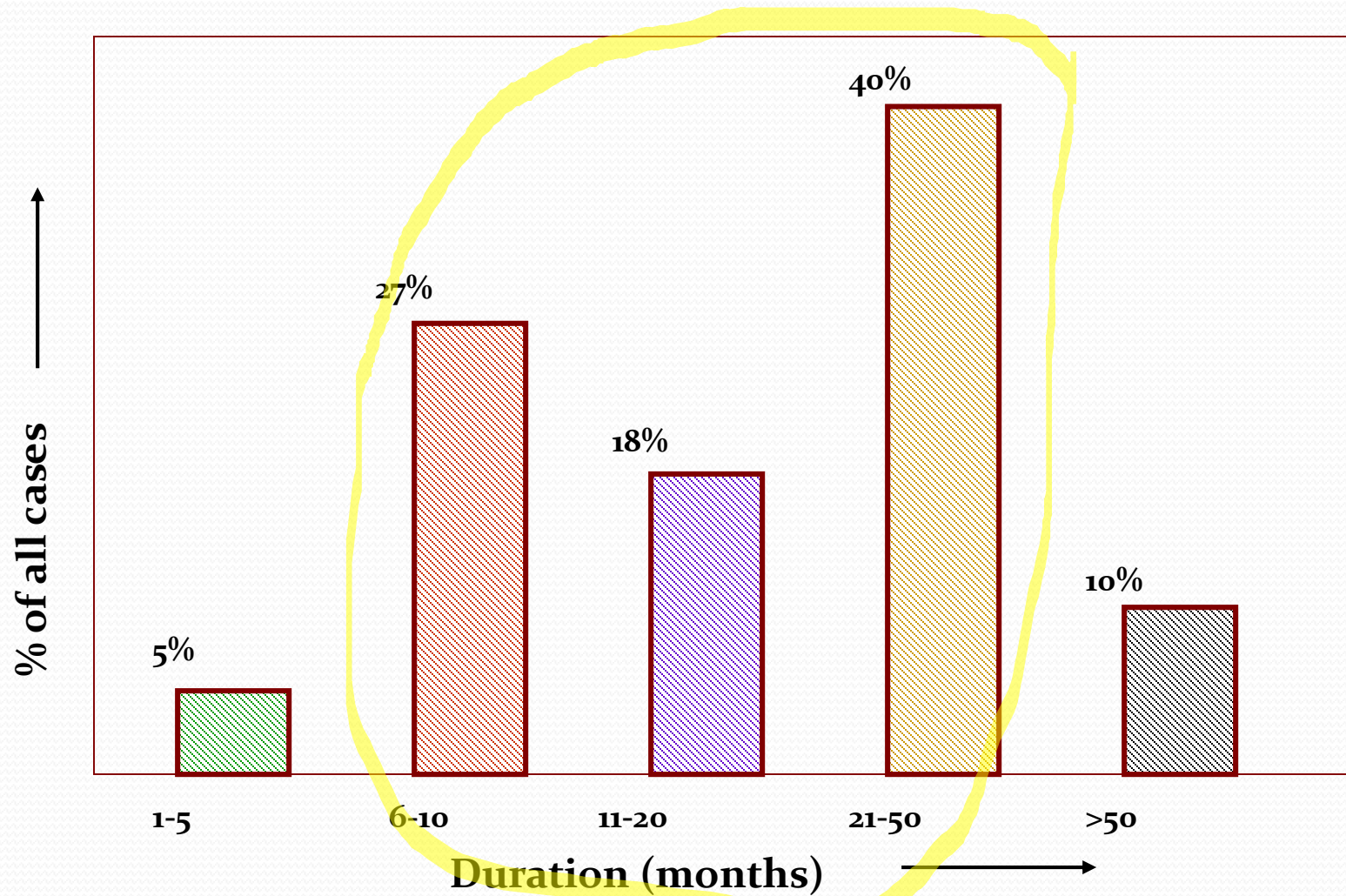
Changes in the Market Requirement



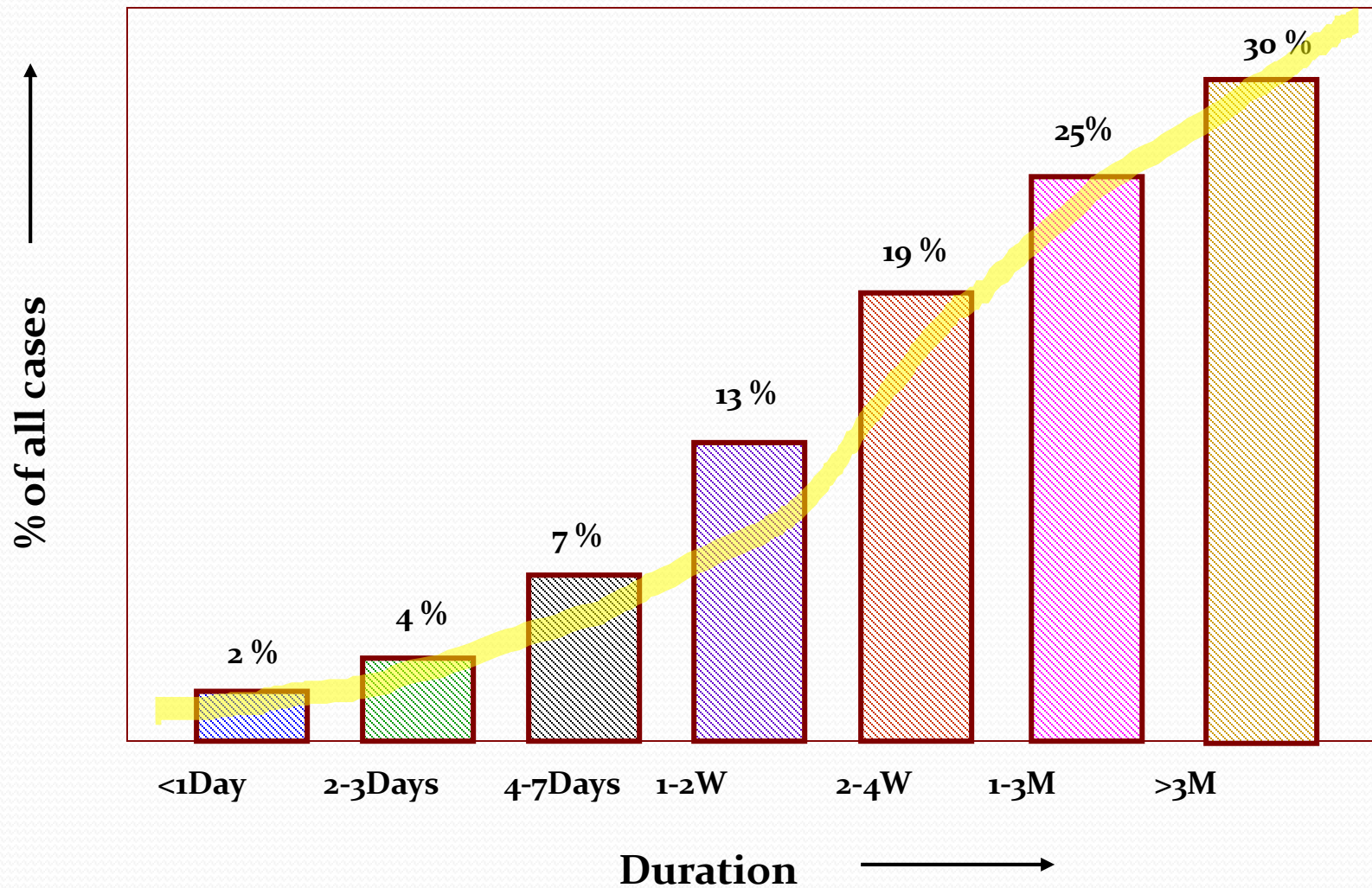
Cost Effectiveness of Different Types of Manufacturing



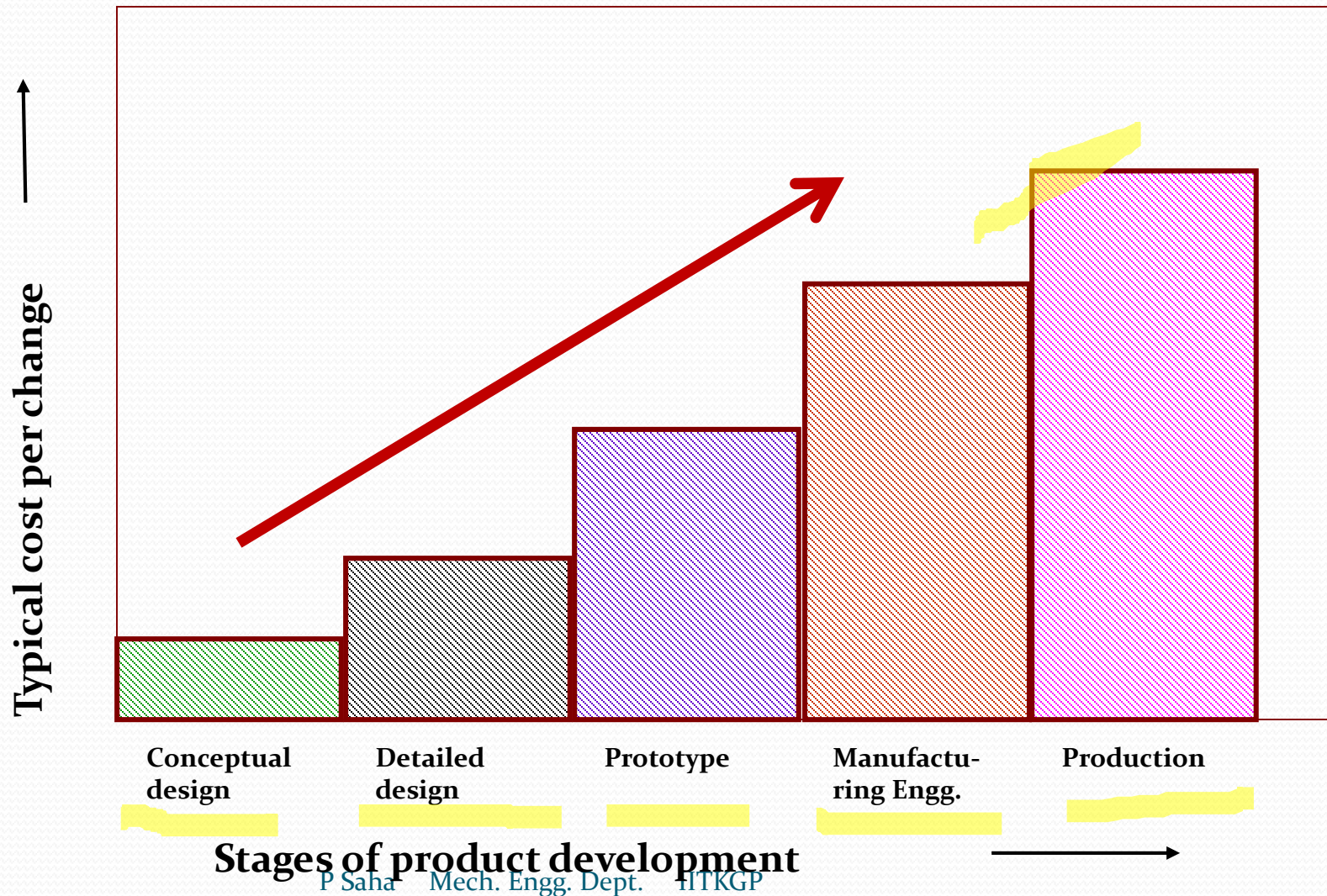
Typical duration of Product Development



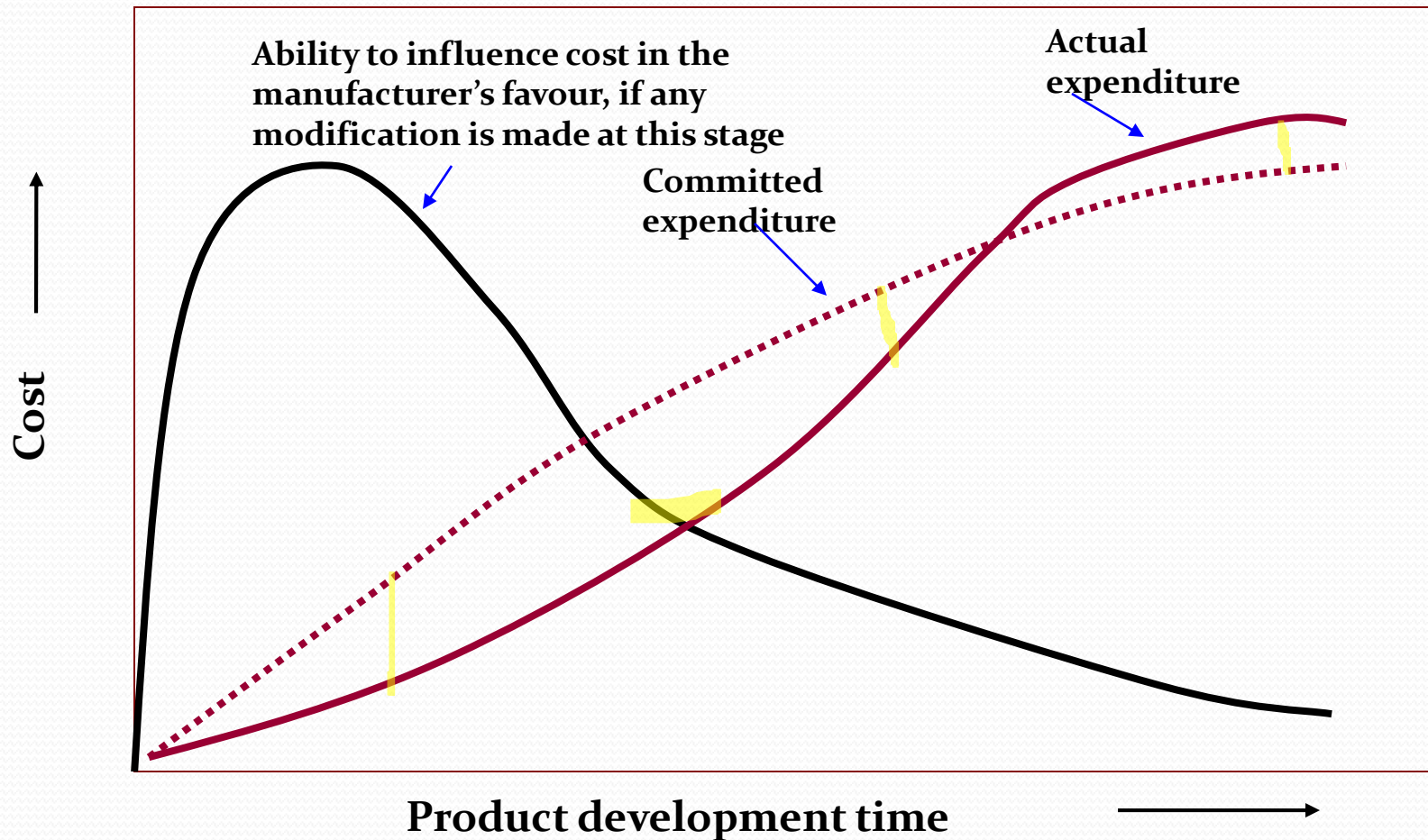
Typical duration of Prototype Development



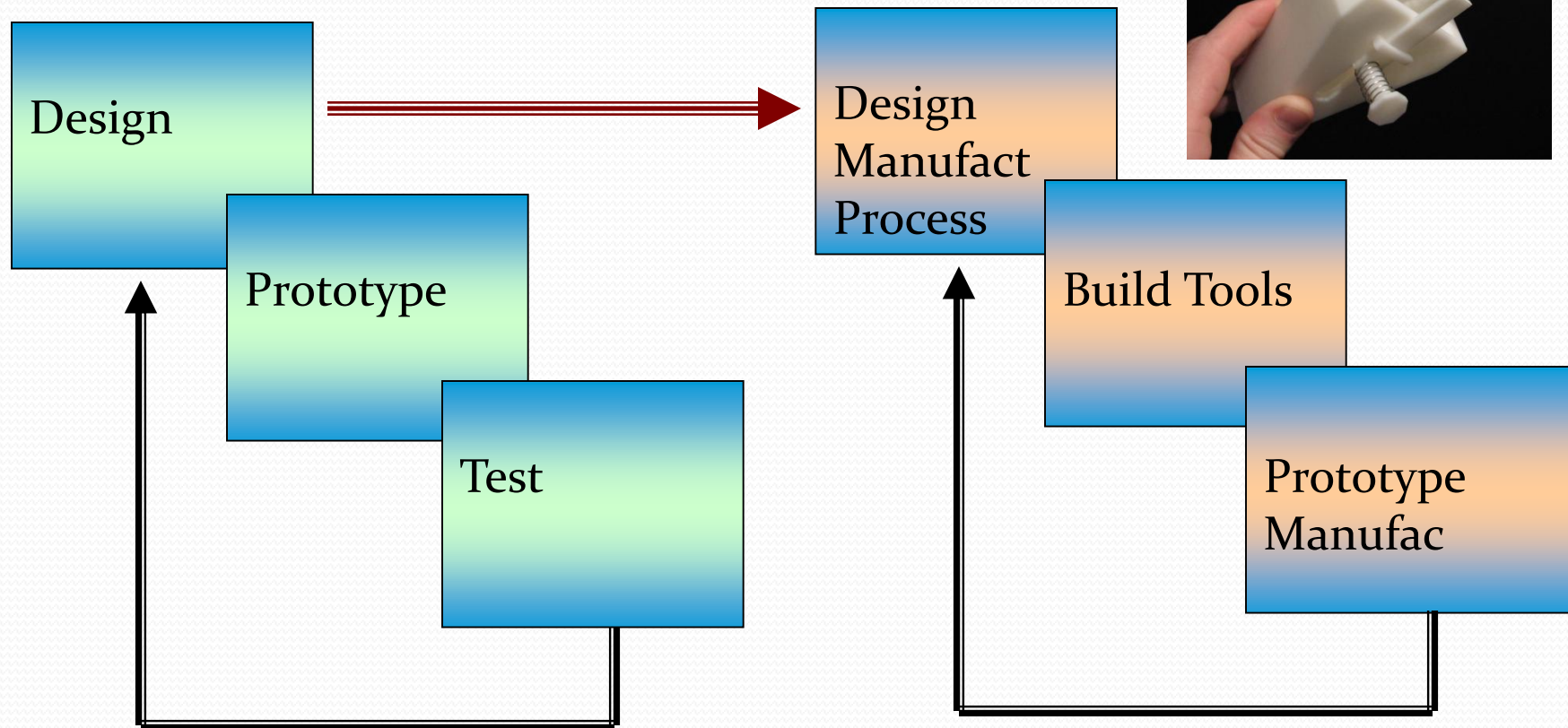
Cost of changes during various stages of product development



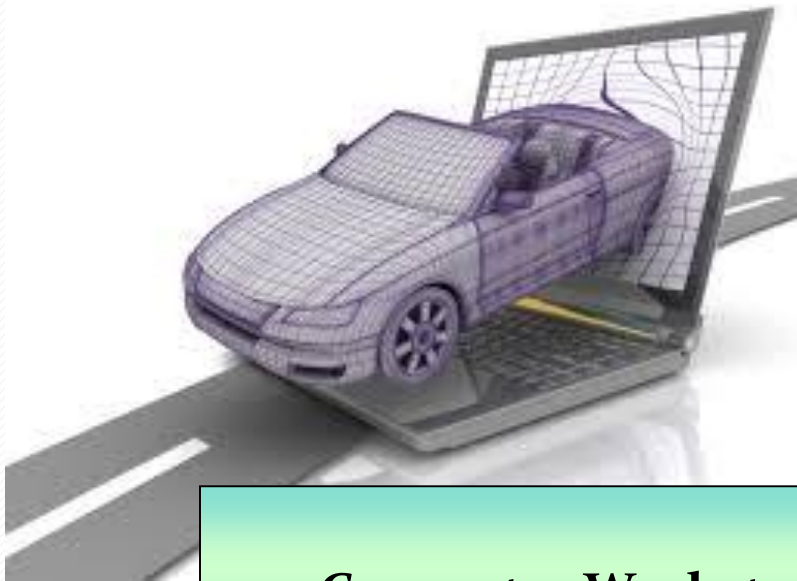
Various cost characteristics during product development



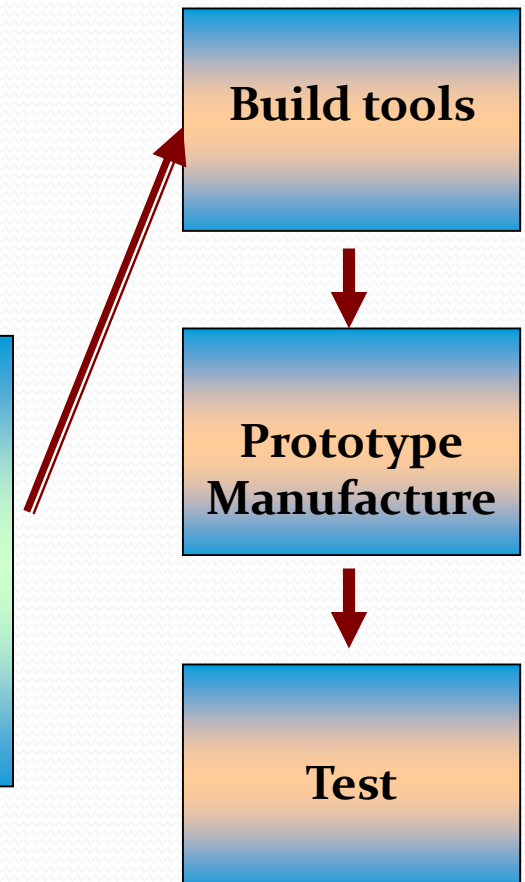
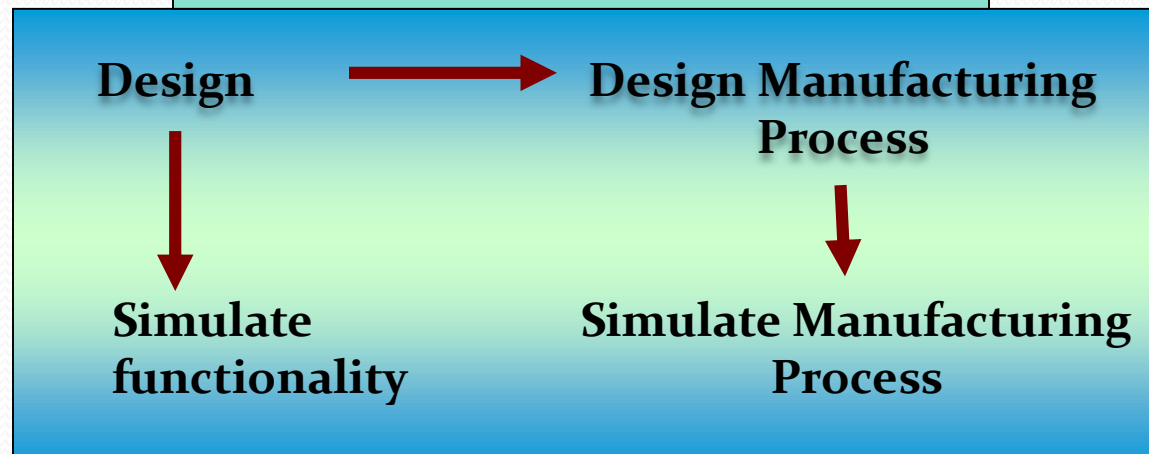
New Product Development - Comparison of Traditional Methods with Testing and Virtual Prototyping



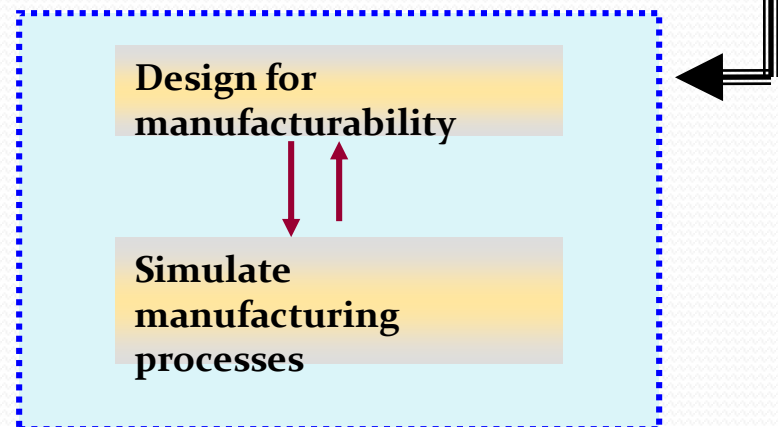
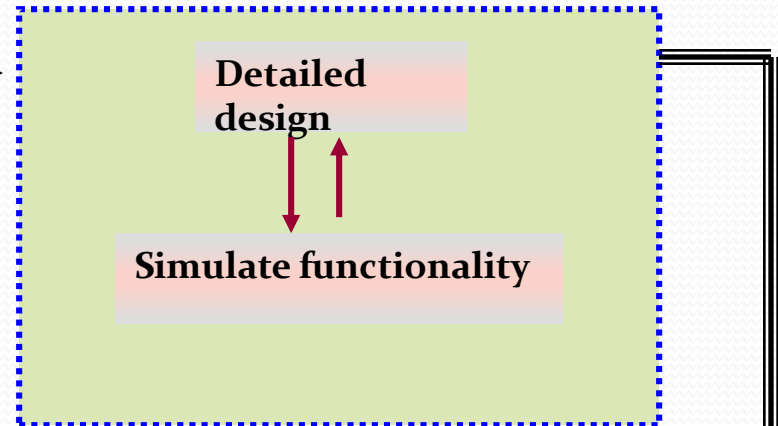
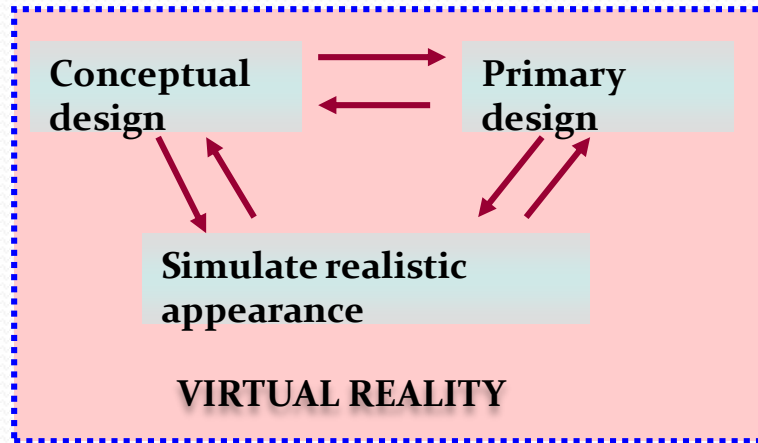
Virtual Prototyping



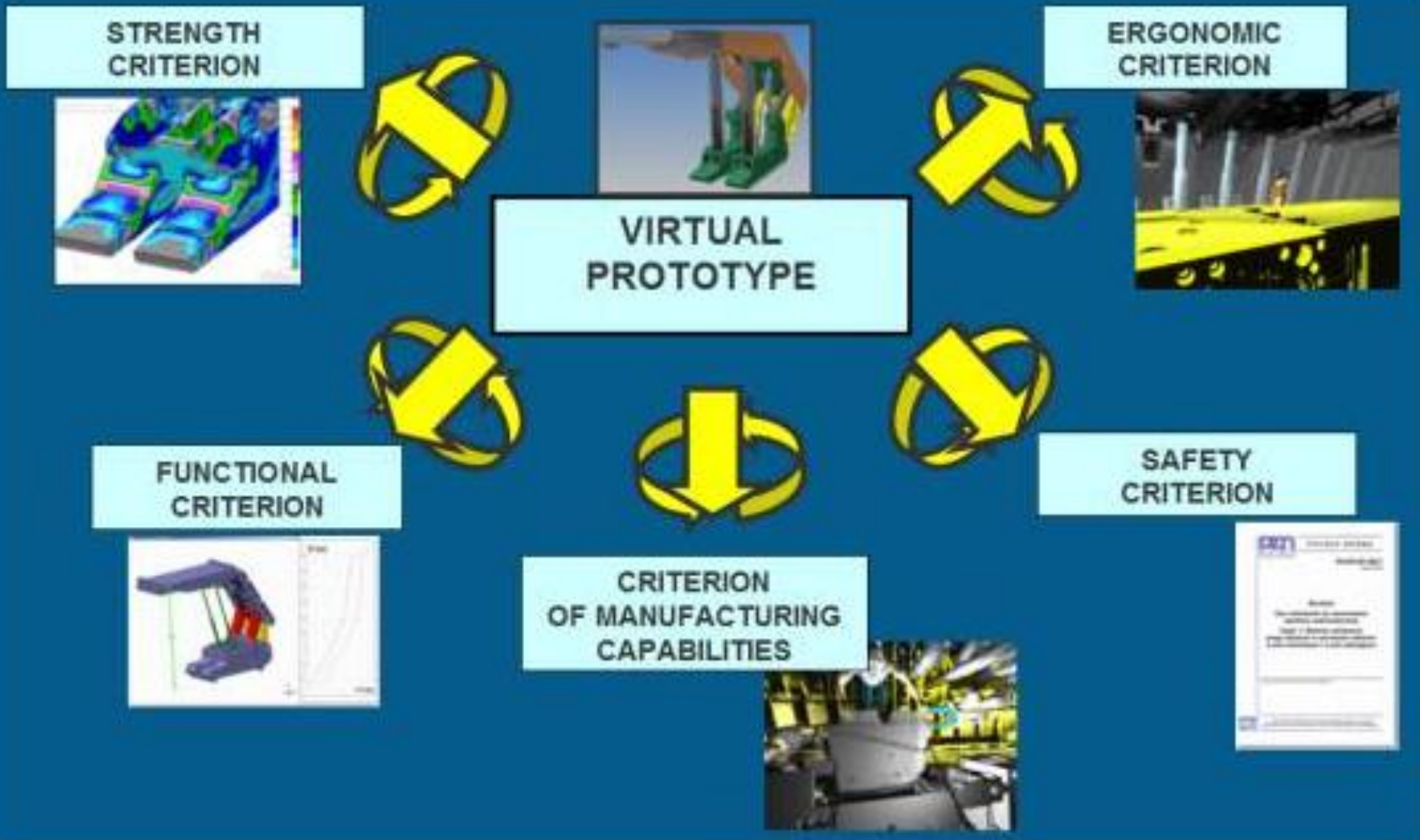
Computer Workstation



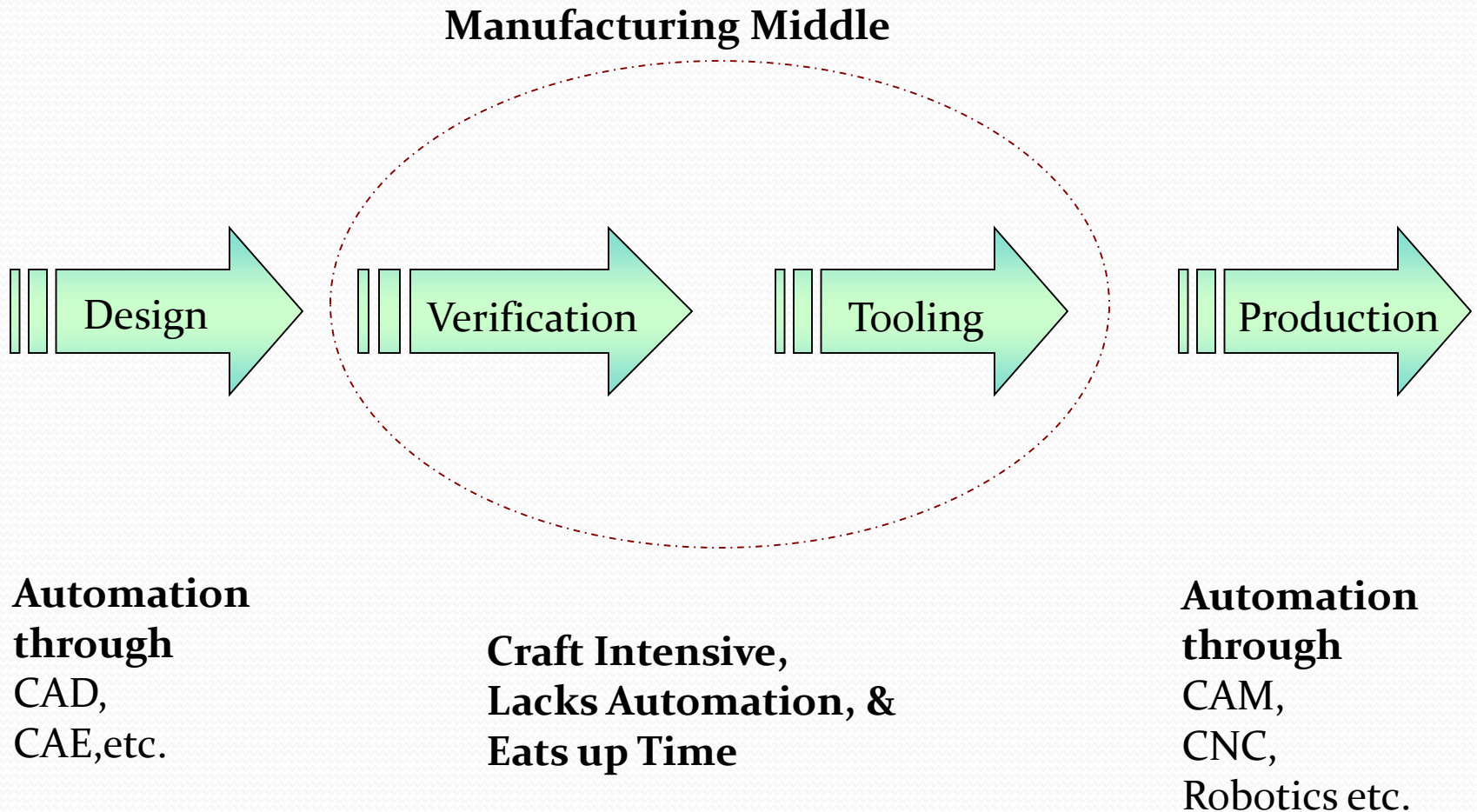
Virtual Prototyping



Role of Simulation in Virtual Prototyping

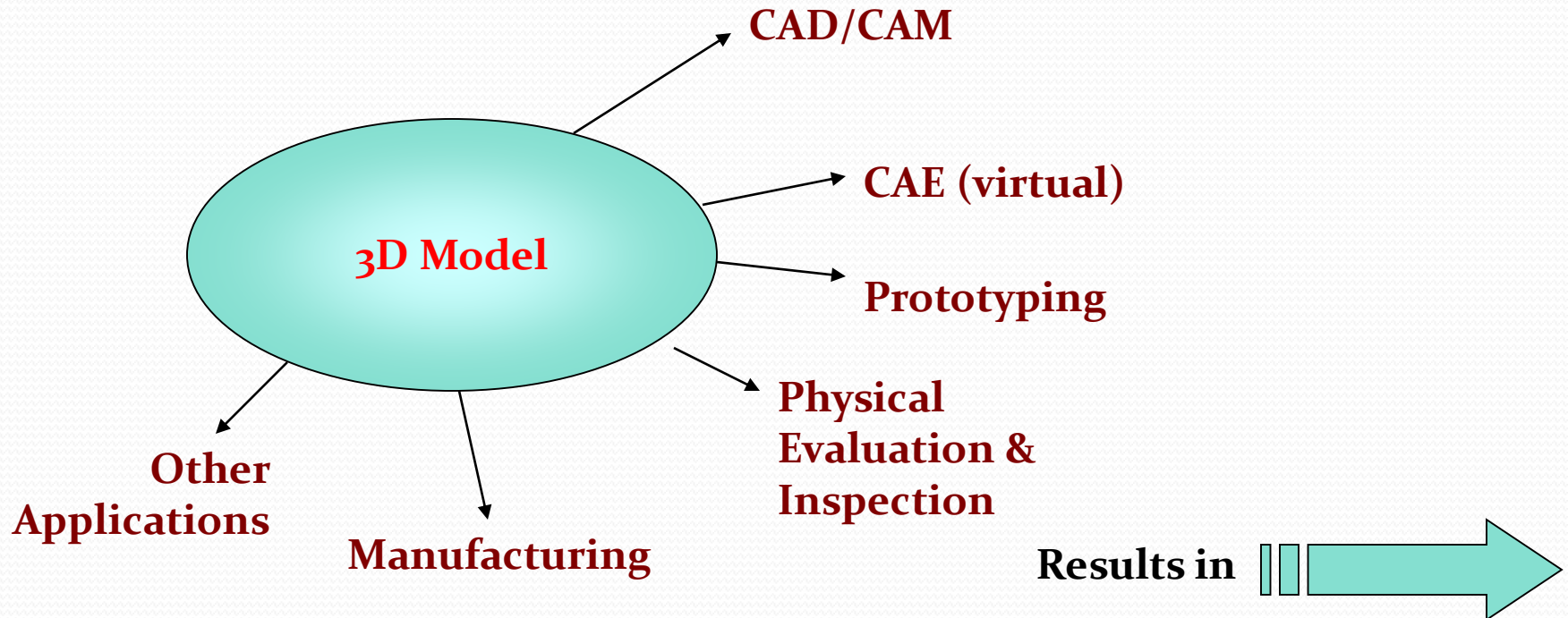


Addressing the Manufacturing Middle



Concurrent Engineering

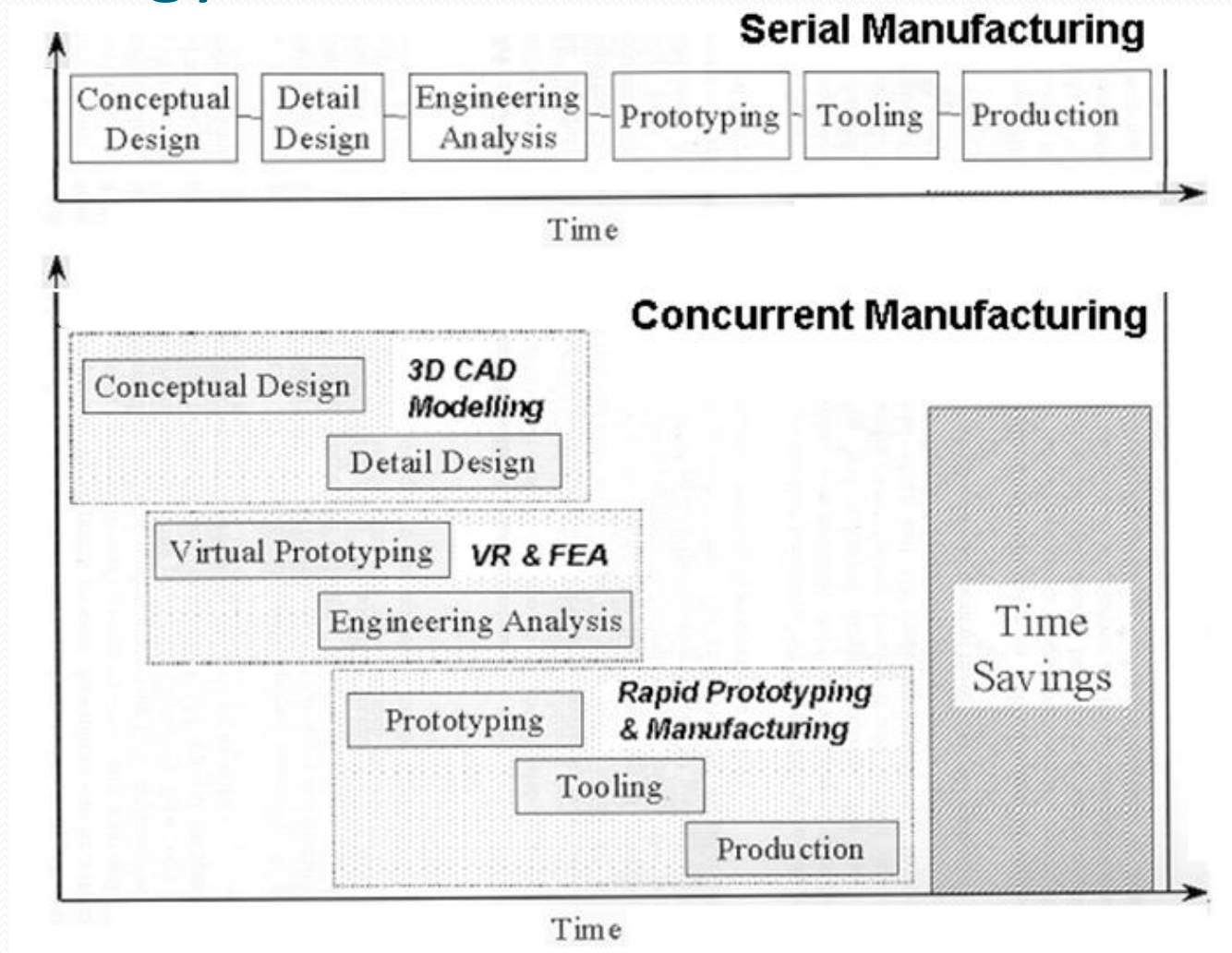
- Design engineers + Engineers from Production Shop works together



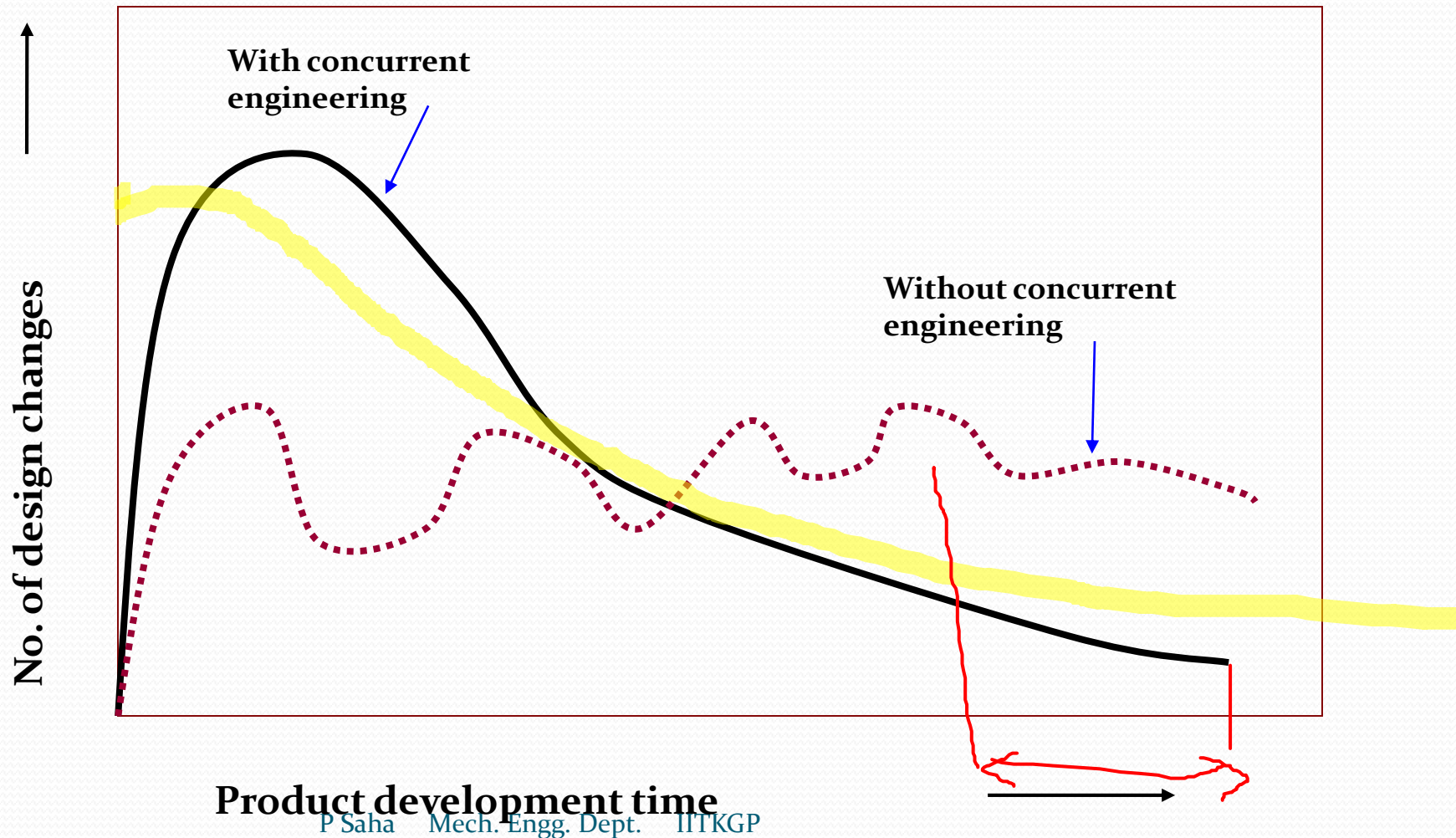
Concurrent Engineering

- All design, analysis and manufacturing activities utilizes the same data
- There is no duplication or misunderstanding
- Product information base can be copied and reused.
- It can be readily available for different downstream applications

Time compression through concurrent technology



Typical number of design changes



Process Chain for Prototype Development

