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# Collaborative Manufacturing Systems

## I Collaborative Manufacturing Management

### Evolution of Manufacturing Systems

Curriculum Development
of Master's Degree Program in
Industrial Engineering for Thailand Sustainable Smart Industry

# Contents of Module I

Module I: Collaborative Manufacturing Management

- Evolution of Manufacturing Systems
- Collaborative Manufacturing Management Model
- Collaborative Manufacturing Management Fundamentals and Infrastructure
- Ontology for Collaborative Manufacturing

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# Learning Outcomes of Module I

Recognize a potential collaborative manufacturing in a factory

- Understand

Identify a value network for collaborative manufacturing for a business

- Apply

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# Brainstorming Ideas about Evaluation of Manufacturing System

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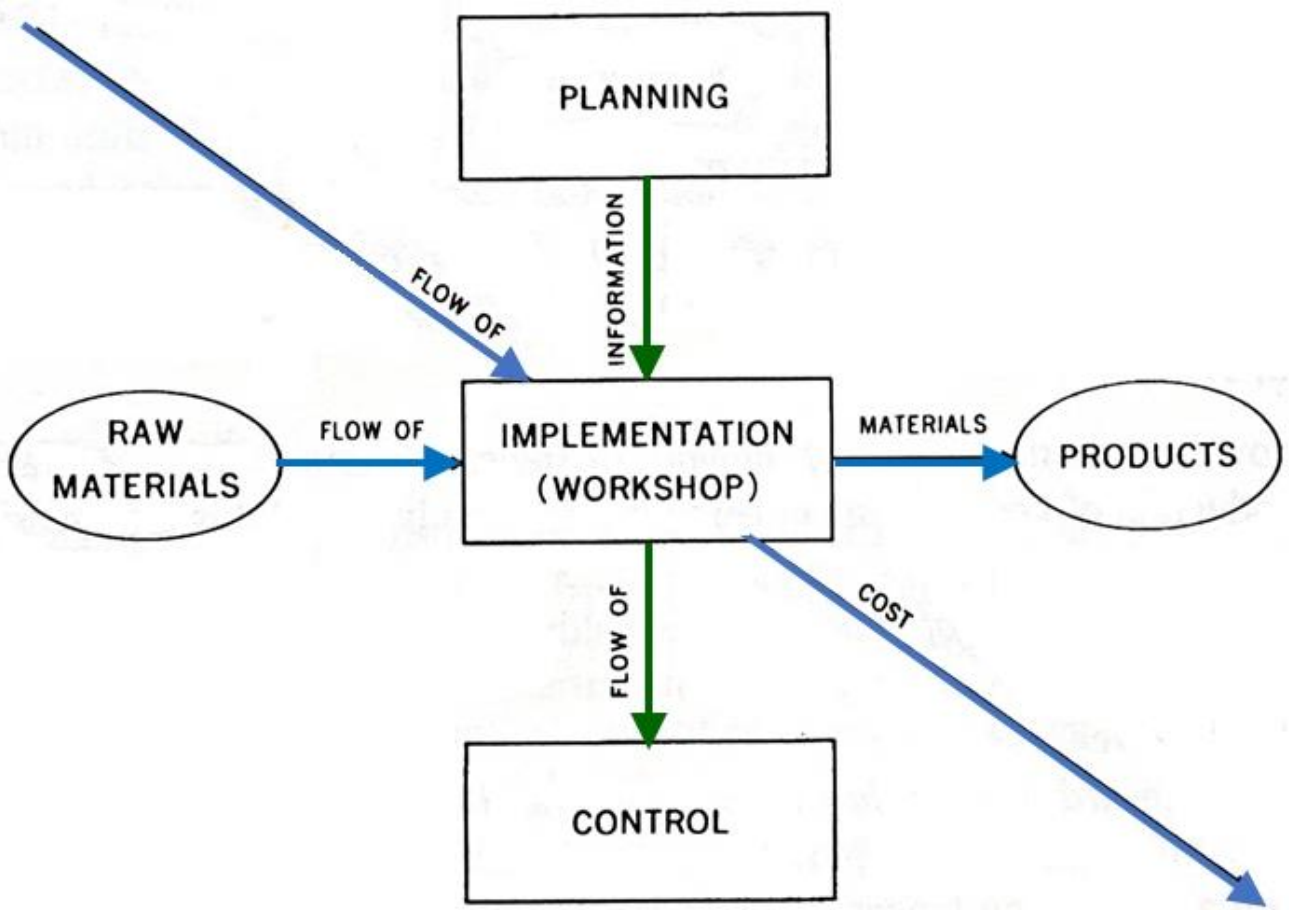
# Production system

**Production system considers 3 main flows;**

- **Flow of cost**
- **Flow of material**
- **Flow of information**

**for planning and controlling the manufacturing process**

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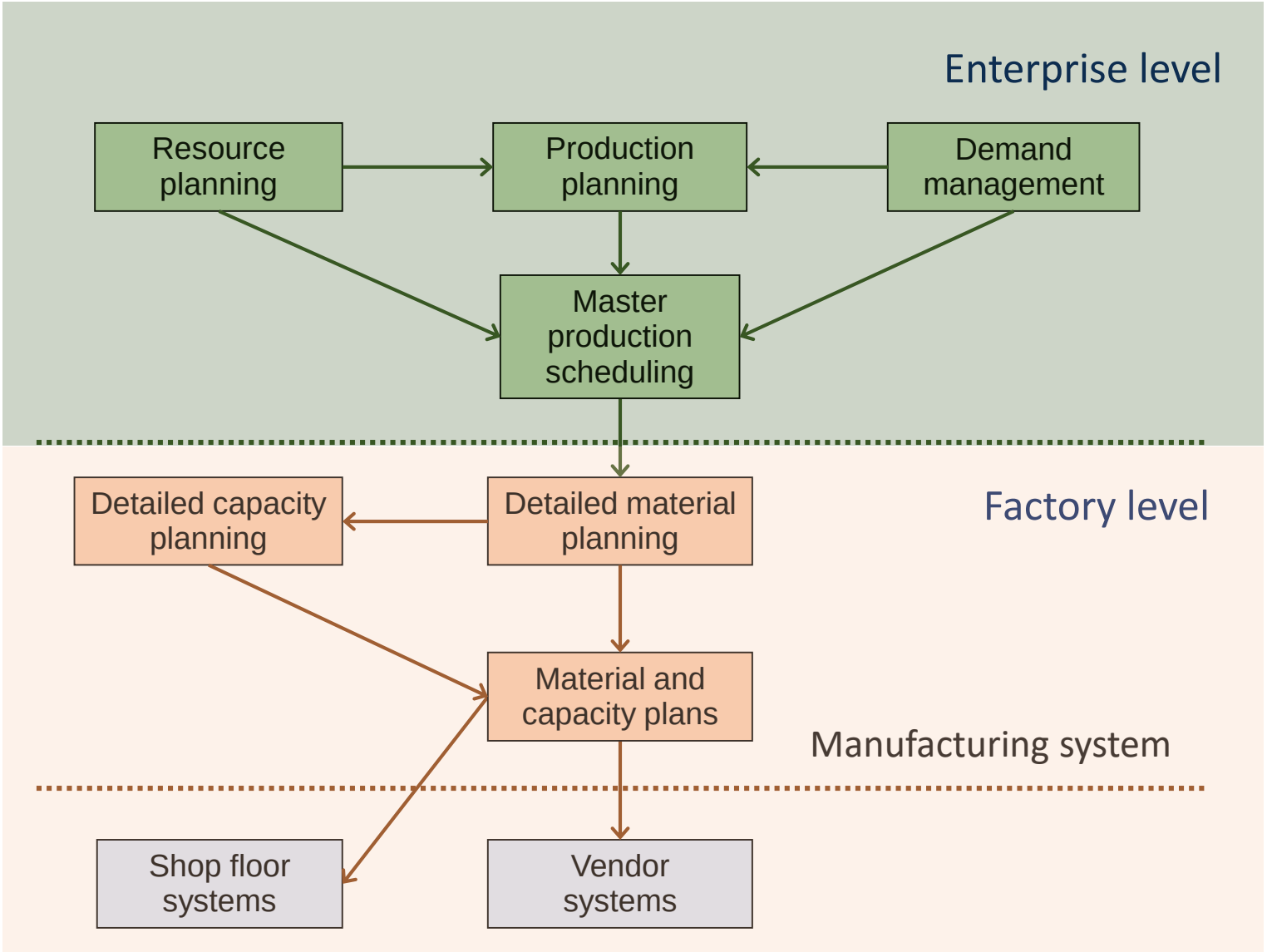
# Production system

**There are 2 main levels in production systems:**

- **Enterprise level, involving resource planning, production planning and customer demand management**
- **Factory level, involving detailed manufacturing process such as material and capacity plans**

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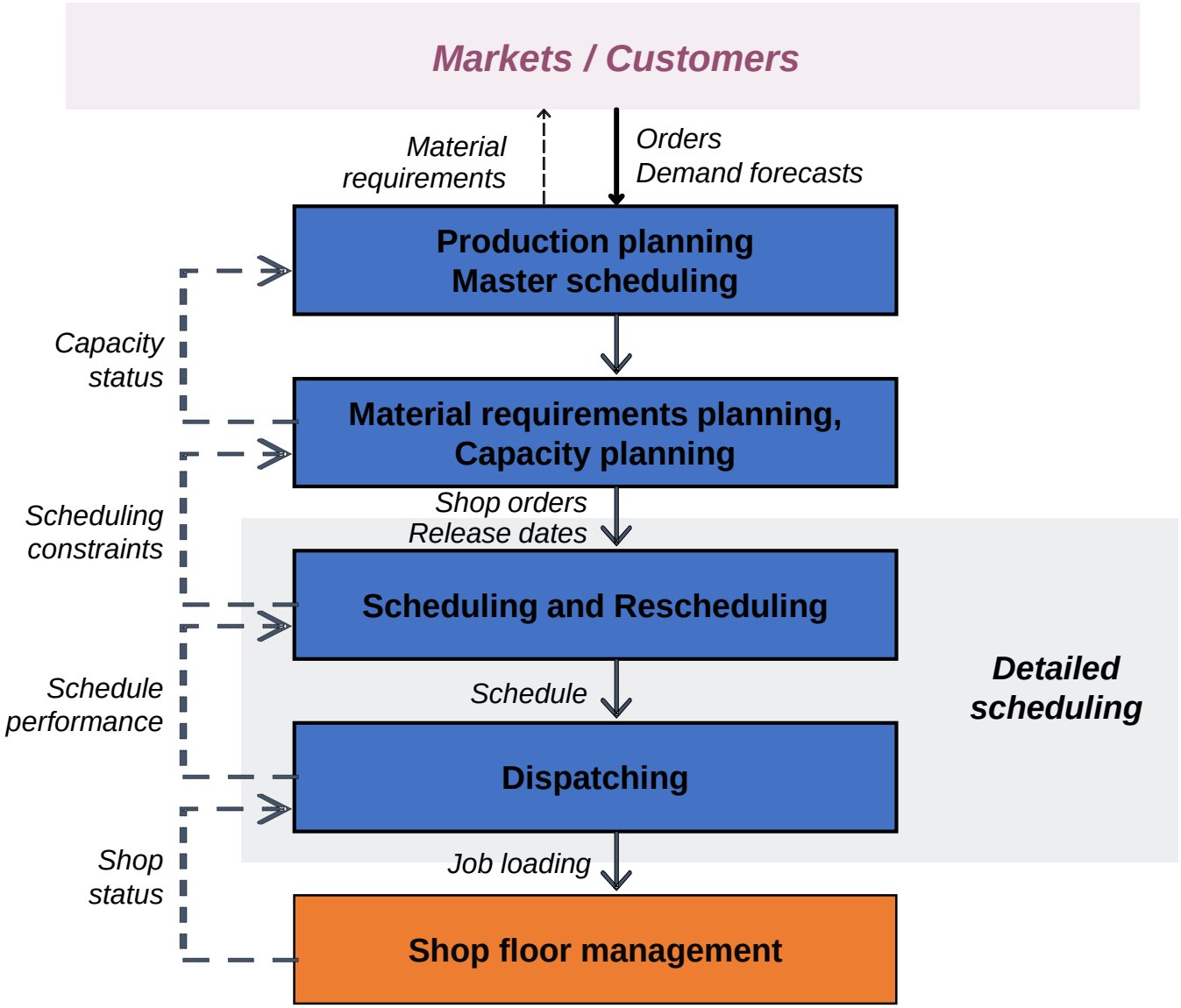
# Information Flows in Production system

For information flow, collaborative manufacturing system is important to integrate working and communicating with each other operations.

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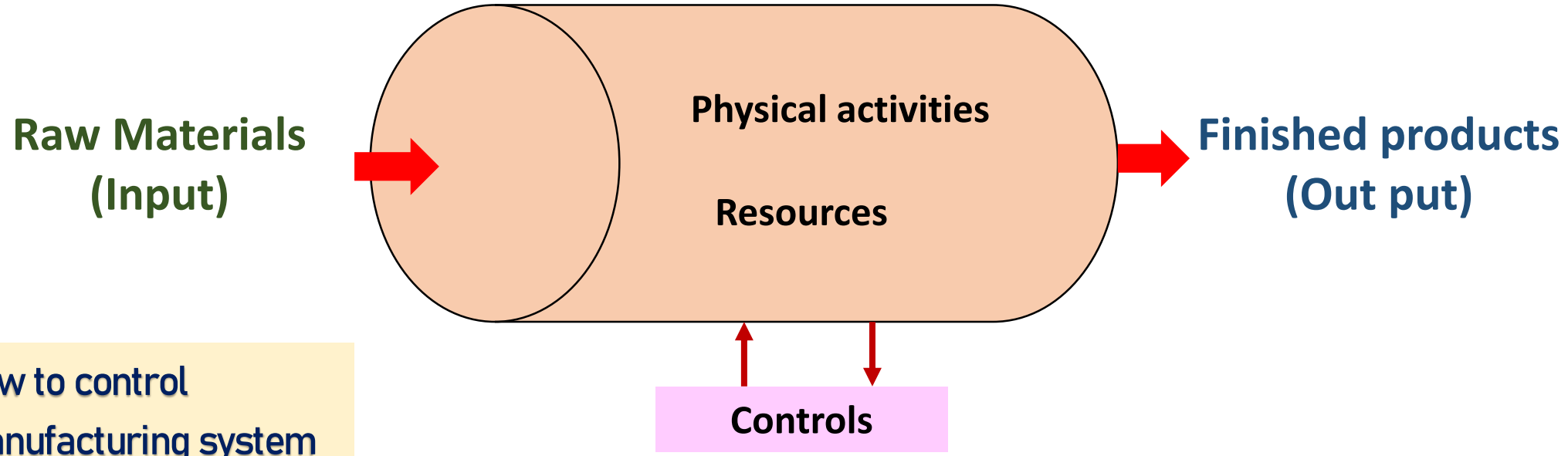
# Manufacturing Systems

**A manufacturing system is made up of entities (input and outputs), activities, resources and controls.**




How to control manufacturing system effectively?

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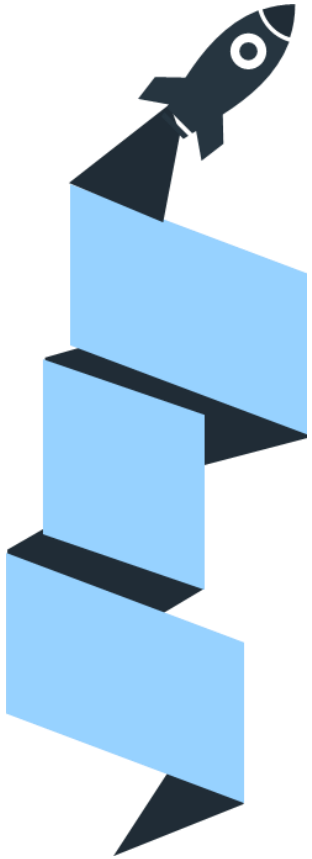
# Components of Manufacturing System

## Equipment :

- **Production machines and tools**
- **Material handling** and work positioning devices
- **Computer system** to coordinate and/or control the preceding components



## Human resources:

- **Workers** operates the equipment
- **Managers** manages the system

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# Classification of Manufacturing Systems

## Factors to define manufacturing systems:

1. Types of operations performed
   - Types of materials processed
   - Size and weight of work units
   - Product complexity
   - Product variety
   - Product quality
2. Number of workstations
3. System layout
4. Manual, Semi-automation and Automation
5. Environment: Weather, Government policy, Culture etc.

https://study.com/academy/lesson/process-product-fixed-position-layouts.html

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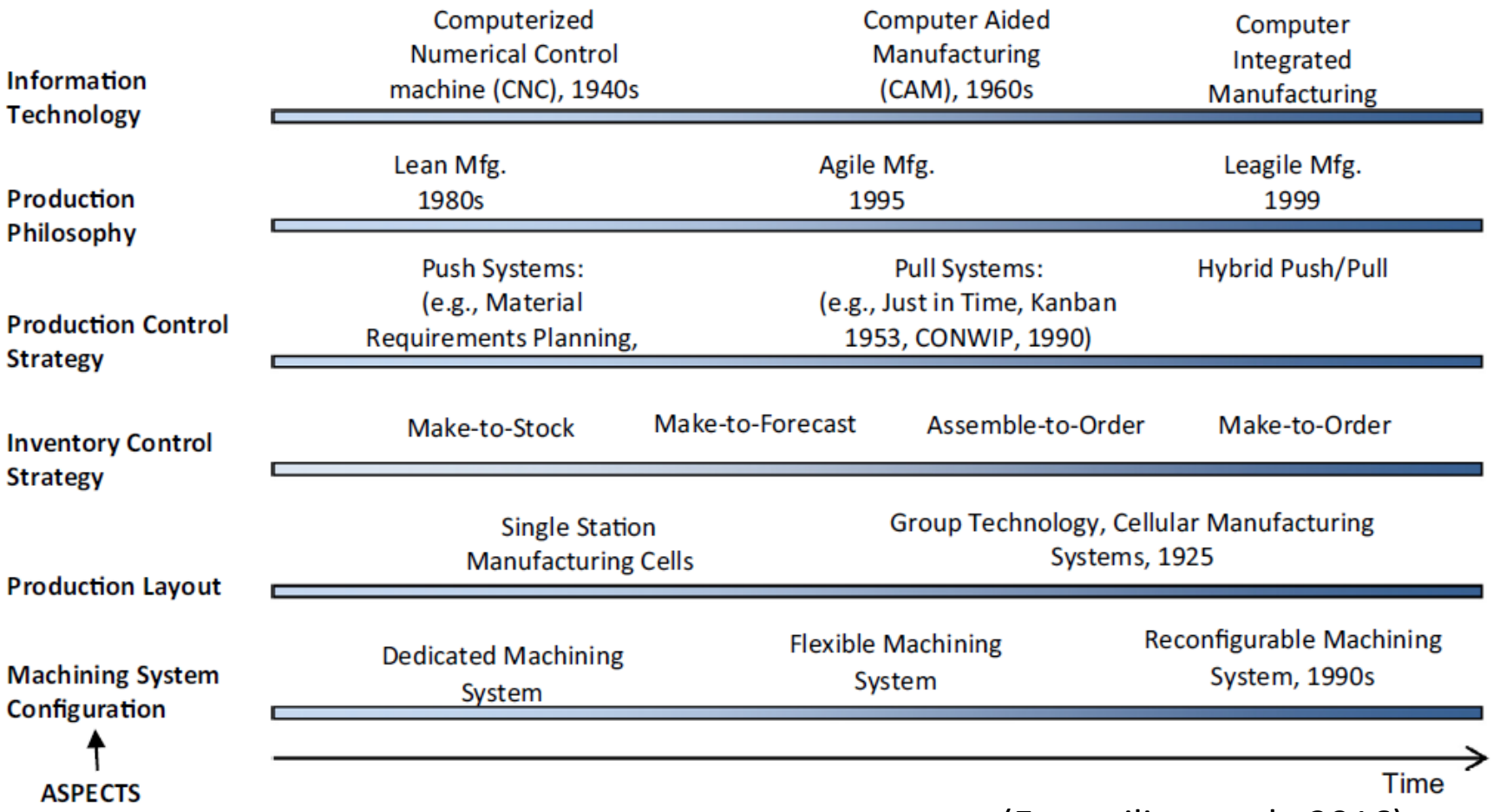
# Classification of Manufacturing Systems

A multidisciplinary representation of the **taxonomy of manufacturing systems** from six different perspectives over time.




(Esmaeilian et al., 2016)

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# Types of Manufacturing Systems

**By production volume:**

Intermittent production and

Continuous production

**By operation:**

Manual , Semi-automated and

Automated production

**Flexible manufacturing system:**

A highly automated machine cell that produces part or product families; often consists of workstations comprising CNC machine tools

Intermittent production (e.g. project , job shop and batch productions), the company produces multiple identical items at the same time. This is usually most effective for low-volume or limited production runs.

Continuous production (e.g. mass/flow and process productions), a product moves along an assembly line, with various specialized workers performing actions to assemble the product at stations along the way.

Manual **production line**: consists of a series of workstations at which operations are performed to build gradually a product

Automated **transfer line**: consists of a series of automated workstations that perform processing operations such as machining, with transfer of parts between workstation also being automated

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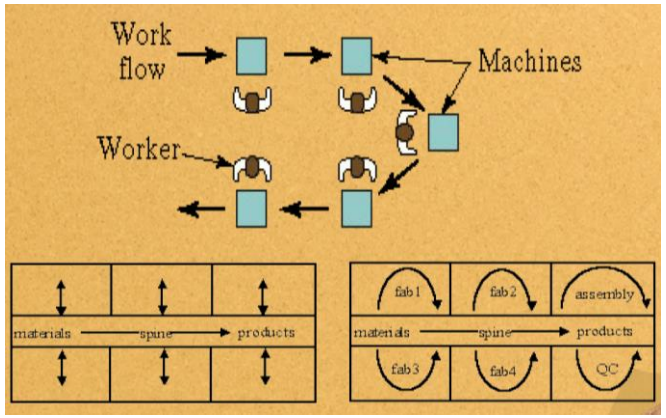
# Types of Manufacturing Systems

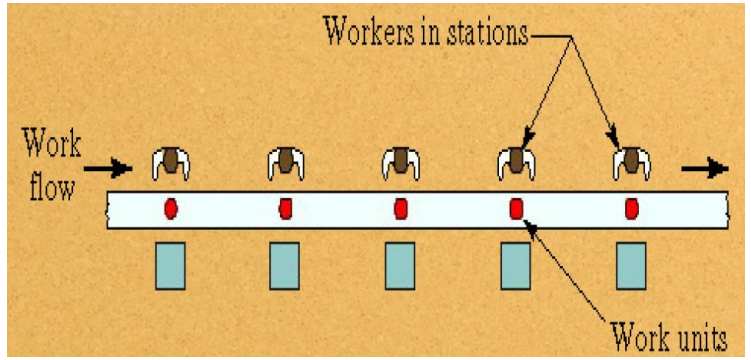
## Cellular layout



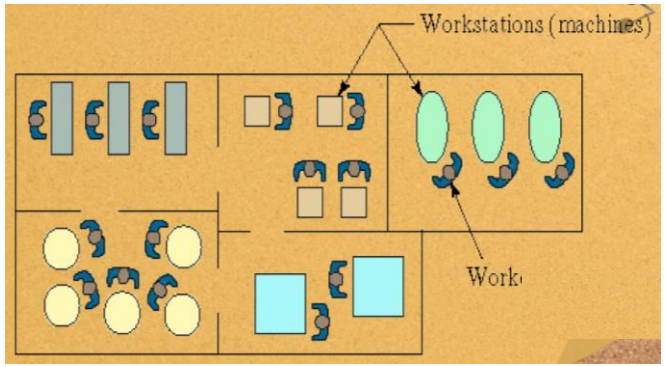

The most effective cells manufacture a small portion of similar products and contain all of the needed equipment and supplies to complete the process for that cell.

## Flow line production

Flow line production is appropriate when firms are looking to produce a high volume of similar items.




## Job shop




A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

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# Manufacturing planning: Product factors

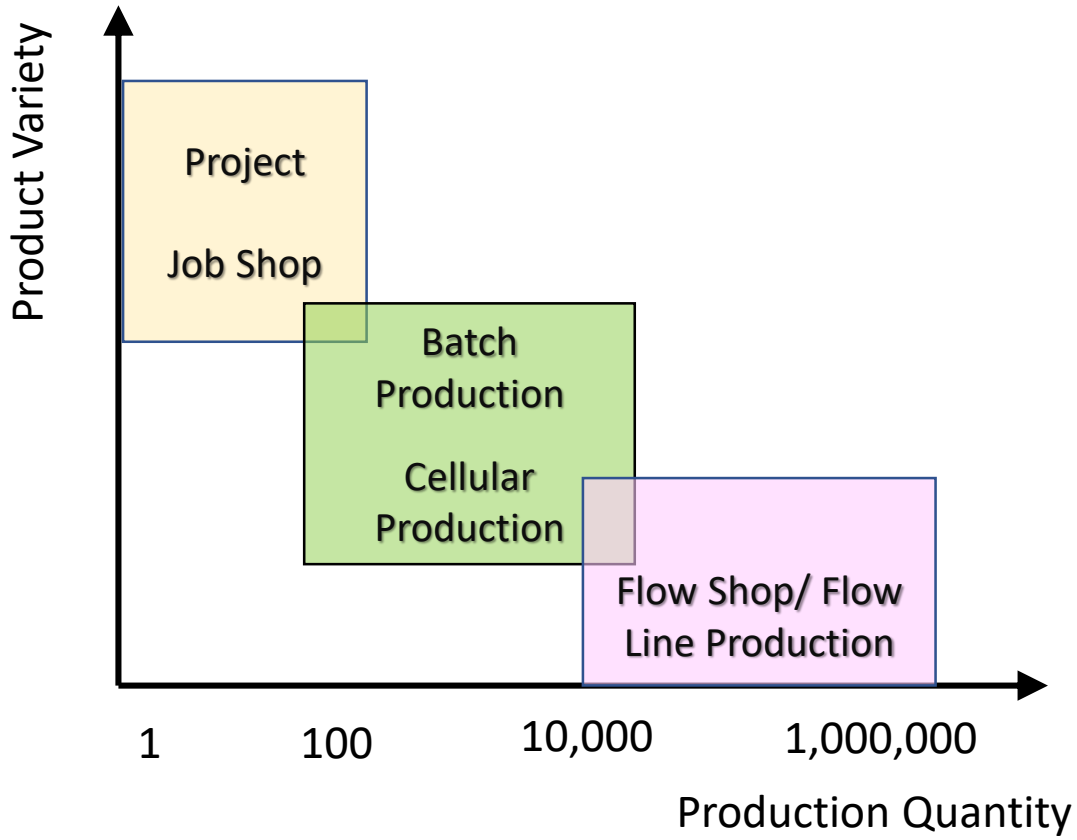
**Manufacturing planning based on**

**Production Quantity**

**vs. Product Variety**

Types of facilities and layouts used for different levels of production quantity and product variety

e.g. flow line production is suitable for low product variety but high production quantity

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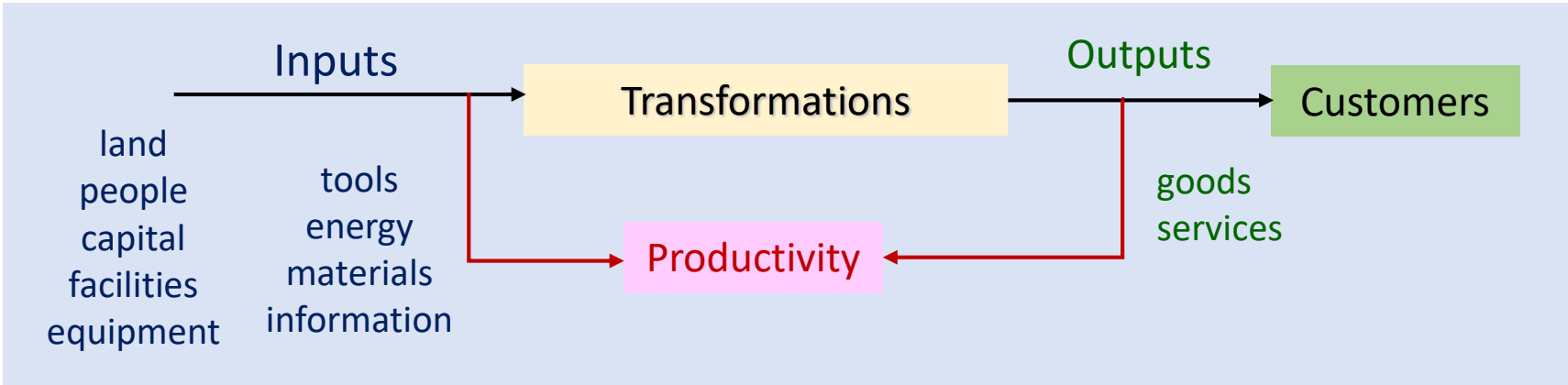
# Manufacturing productivity

## Productivity (P)

$$P = \frac{\text{Outputs}}{\text{Input}}$$

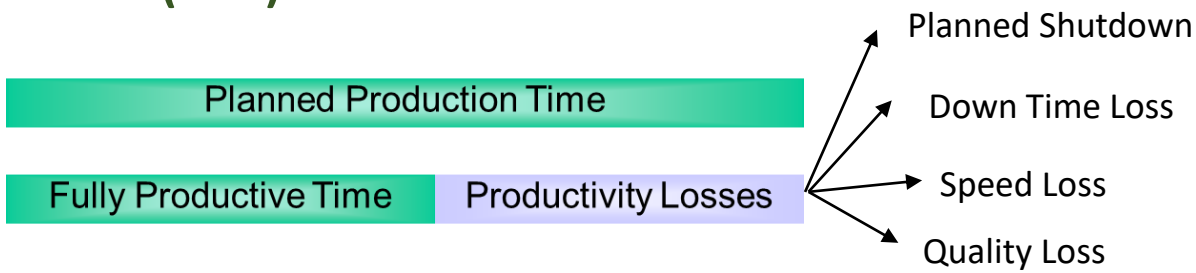
Productivity is normally used for evaluating the effectiveness of manufacturing process

OEE is normally used for evaluating the effectiveness of machines




## Overall Equipment Effectiveness (OEE)

$$OEE = \frac{\text{Full Productive Time}}{\text{Planned Production Time}}$$

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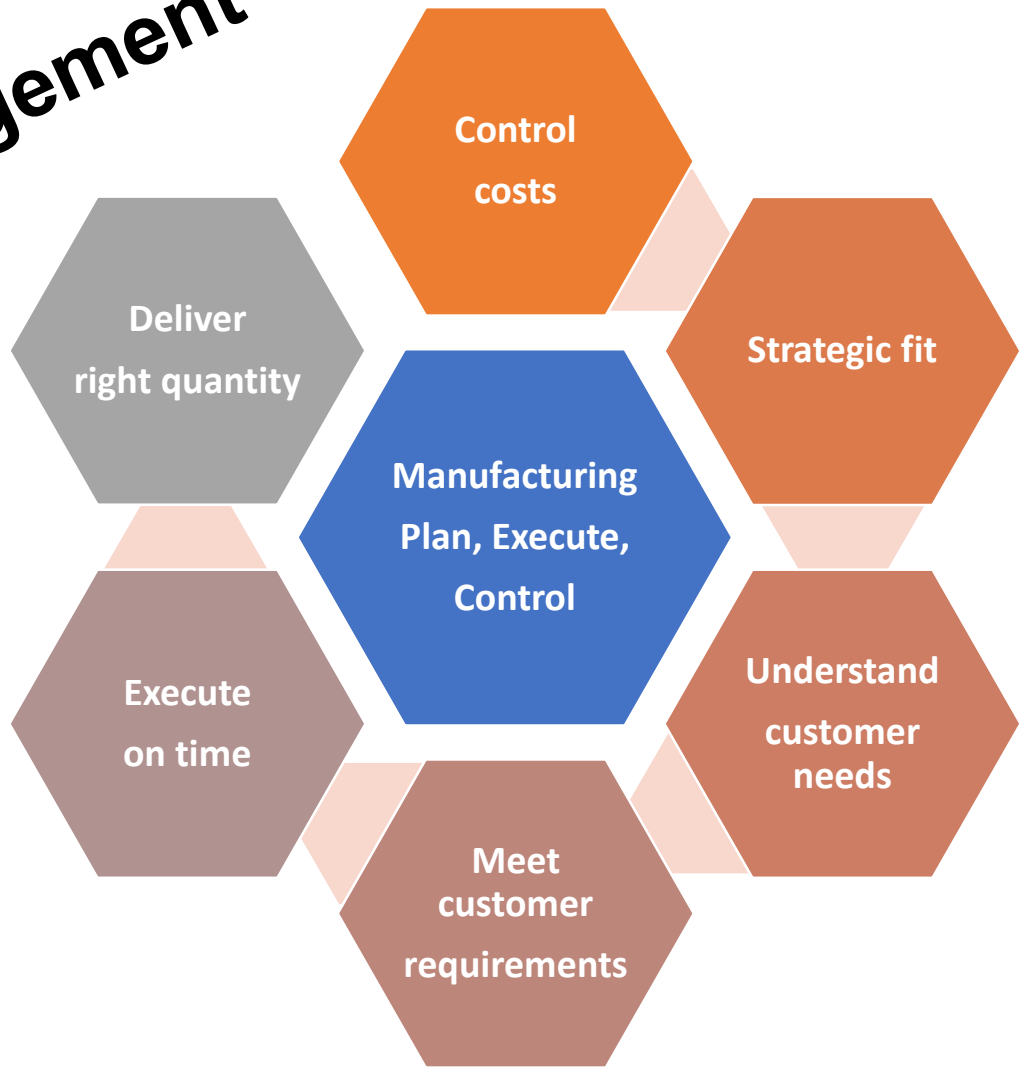
# Role of Manufacturing Management




In order to achieve customer requirements, there are many factors are necessary to manage

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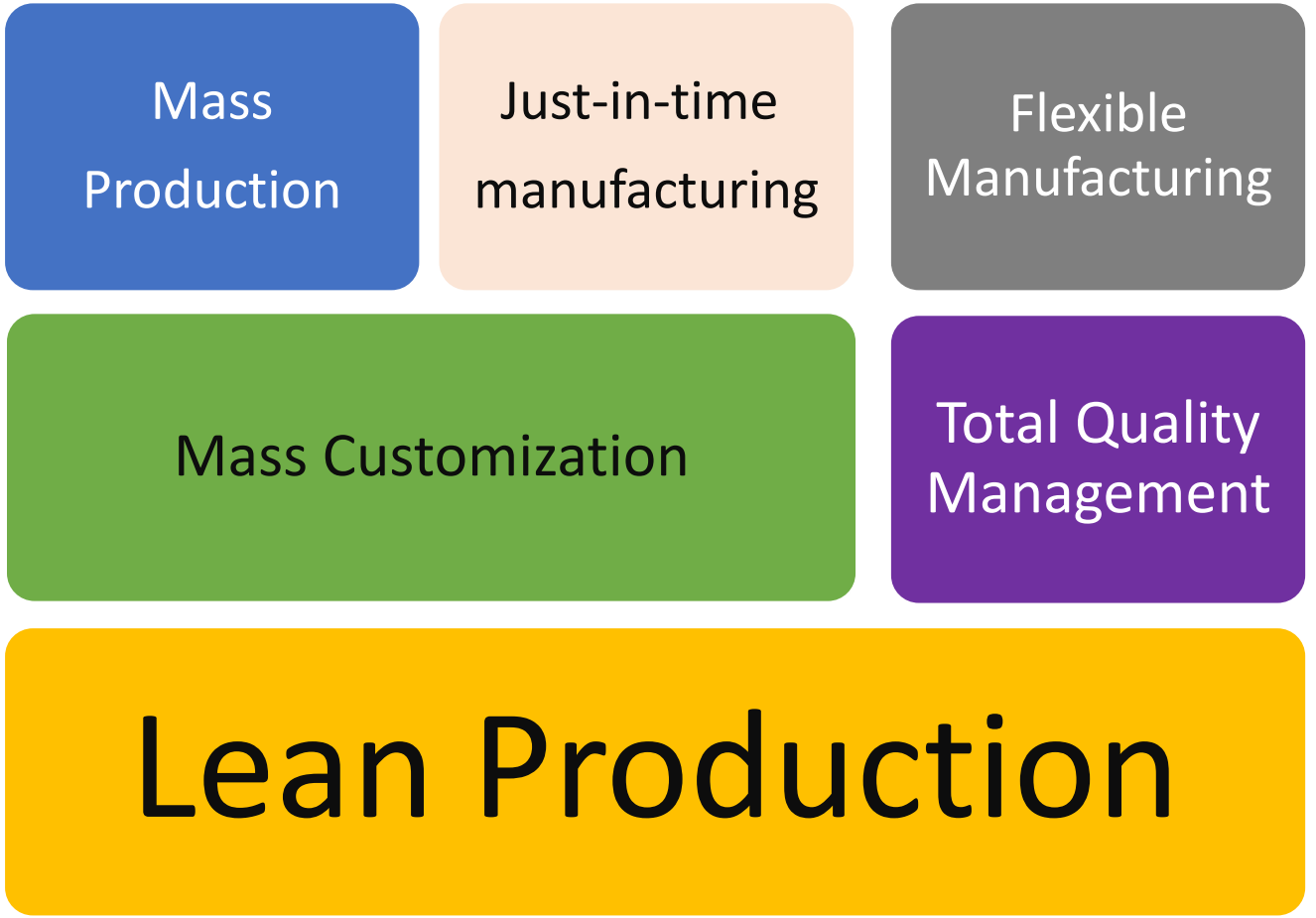
# Production management techniques

A variety of production management techniques have been develop to improve production system

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# Differences of Mass, Lean Production and Mass Customization

| | Mass Production | Lean Production | Mass customization |
|---|---|---|---|
| **Focus** | Efficiency through stability and control | The reduction of waste and improvement of the services | Variety and customisation through flexibility and quick responsiveness |
| **Goal** | Developing, producing, marketing and delivering goods and services at prices low enough that nearly everyone can afford them | Elimination of waste, value flow and perfection by continuous improvement | Supply of varied products that fit the specific customer's needs in order to increase his interests with maintaining low prices |
| **Key features** | Stable demand Large, homogeneous markets, Long product development time, Long product lifecycle | Avoid high cost, teams of multi skilled workers, flexible automated machines to produce volumes of products in enormous variety | Fragmented demand, Heterogeneous niches, Short product development time, Short product lifecycles |
| **Market** | Demand > Supply | Demand > Supply | Demand < Supply |
| **Conditions** | Homogenous markets | Homogenous markets | Fragmented markets |
| **Products** | A few products – Long product lifespan | A few products – Long product lifespan | Variety of products – Short product lifespan |
| **Business strategy** | Ignore niche markets (Economies of scale) | Economies of scale | Sell to niche markets (Economies of scope) |

(Esmaeilian et al., 2016)

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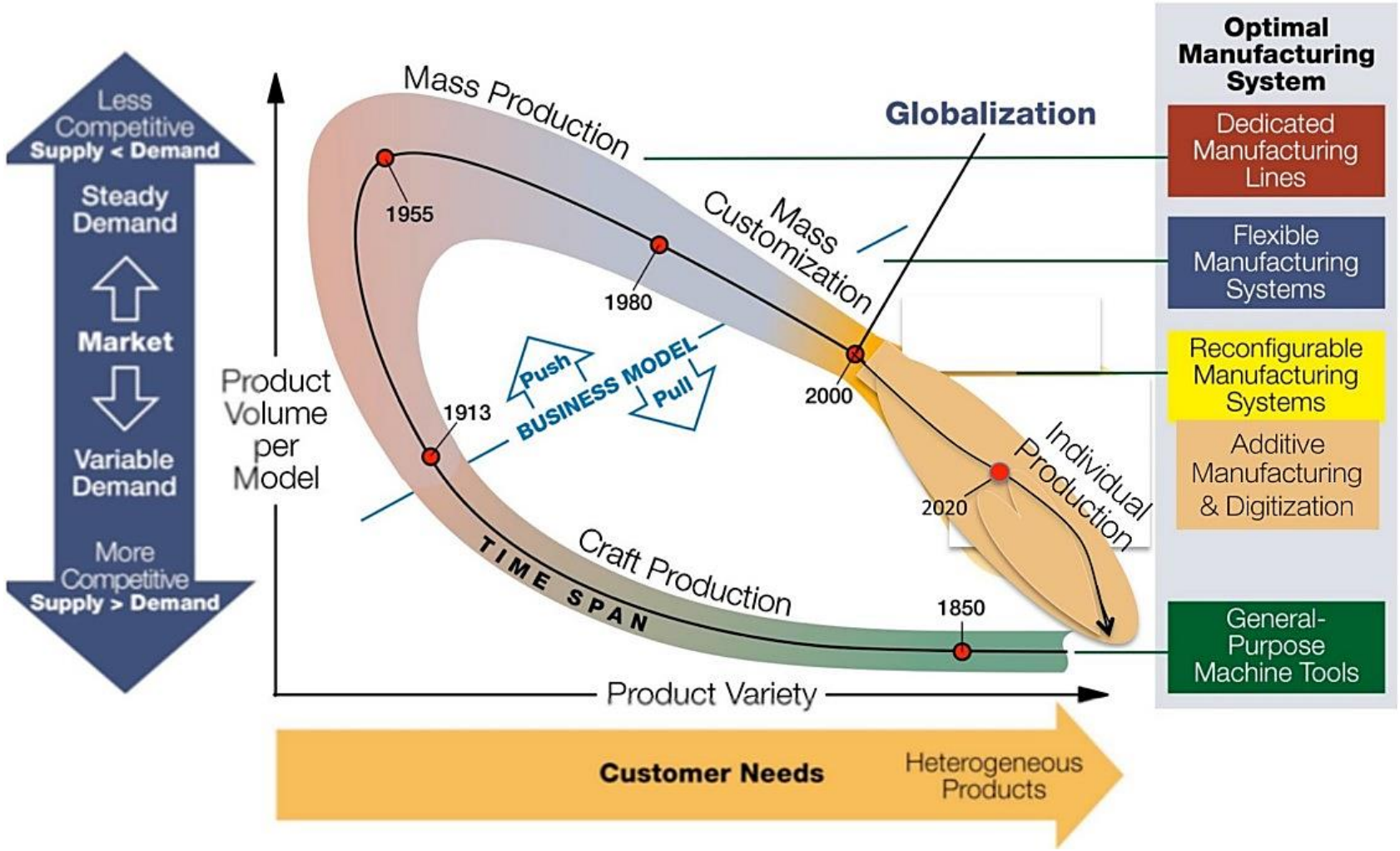
# Evolution of Manufacturing Systems




Evolution of Manufacturing Systems based on Product volume and Product variety

https://new.siemens.com/global/en/company/stories/industry/the-factory-of-the-future.html

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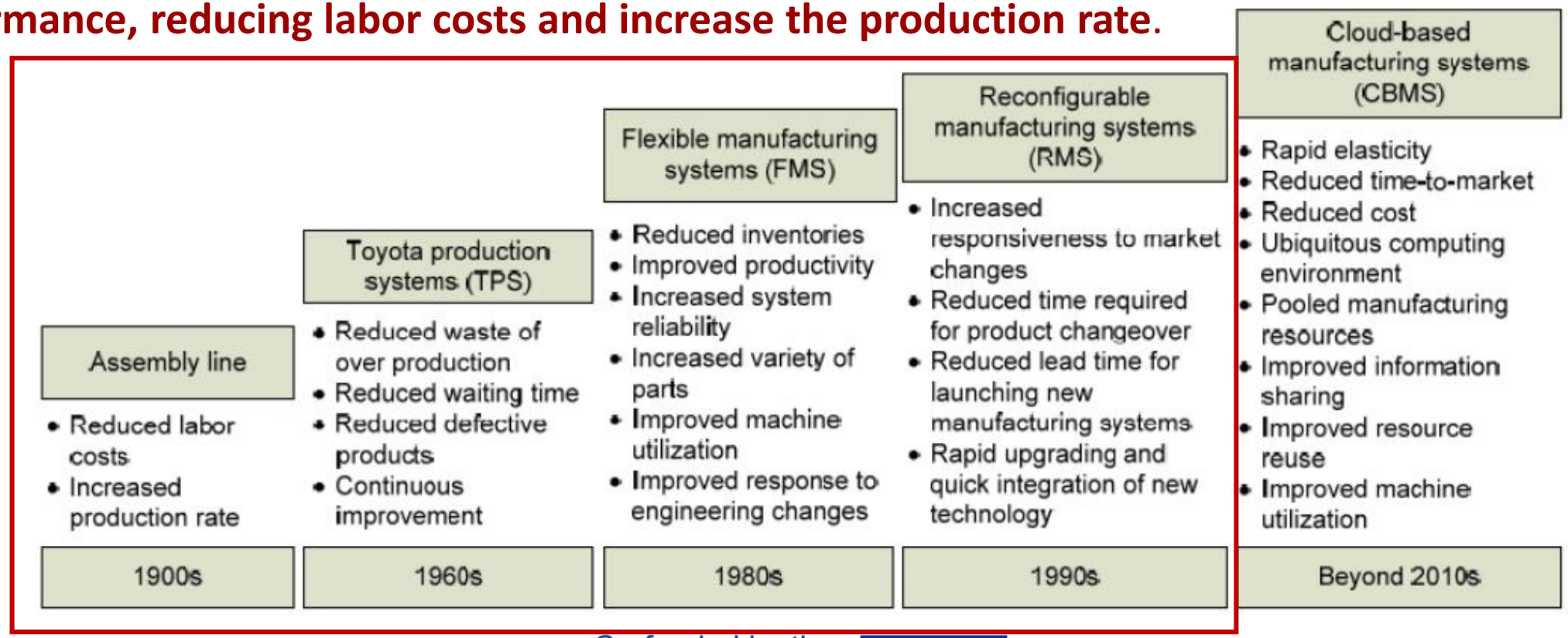
# Evolution of Manufacturing Systems

**Previously,** manufacturing process just evolved around assembly lines, where at the **times, manufacturers are more than satisfied with it performance, reducing labor costs and increase the production rate.**




(Kassim et al., 2017)

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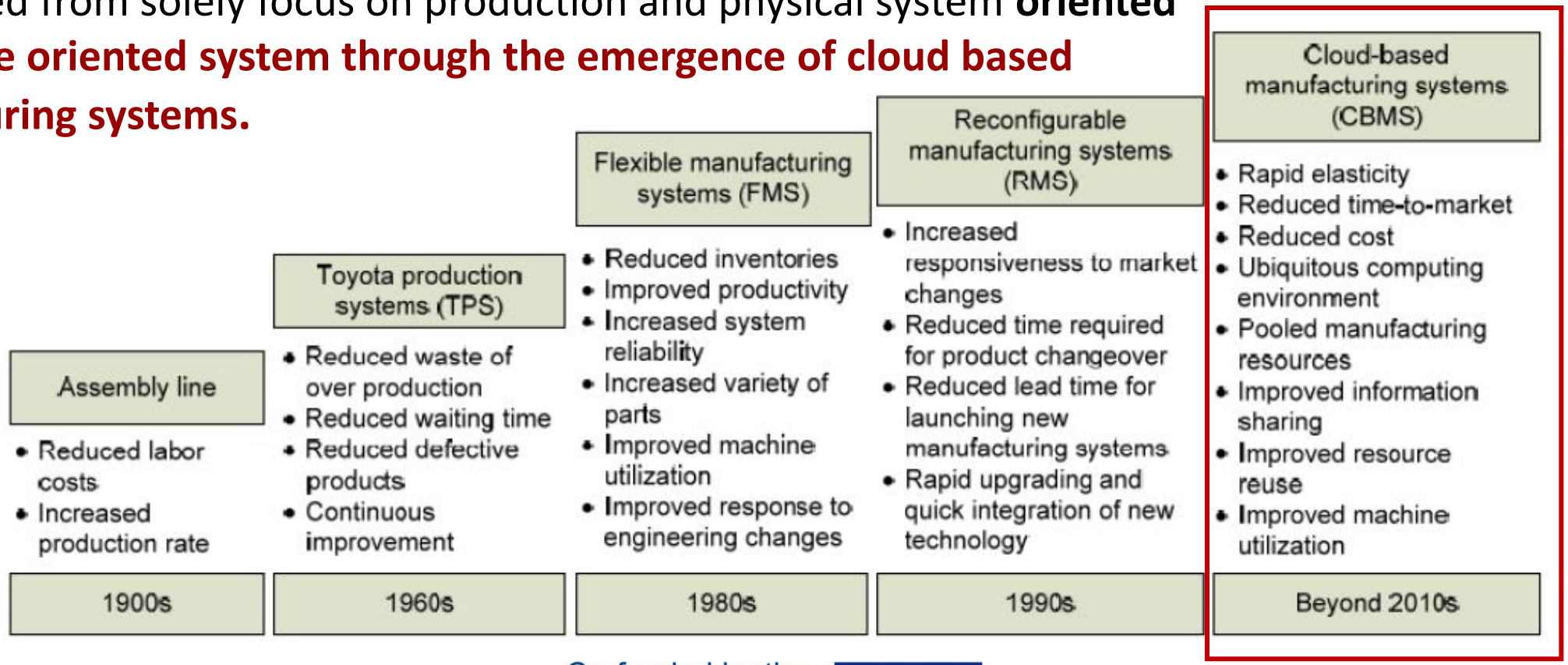
# Evolution of Manufacturing Systems

**Currently,** the manufacturing businesses and concept has been transformed from solely focus on production and physical system **oriented to a service oriented system through the emergence of cloud based manufacturing systems.**




(Kassim et al., 2017)

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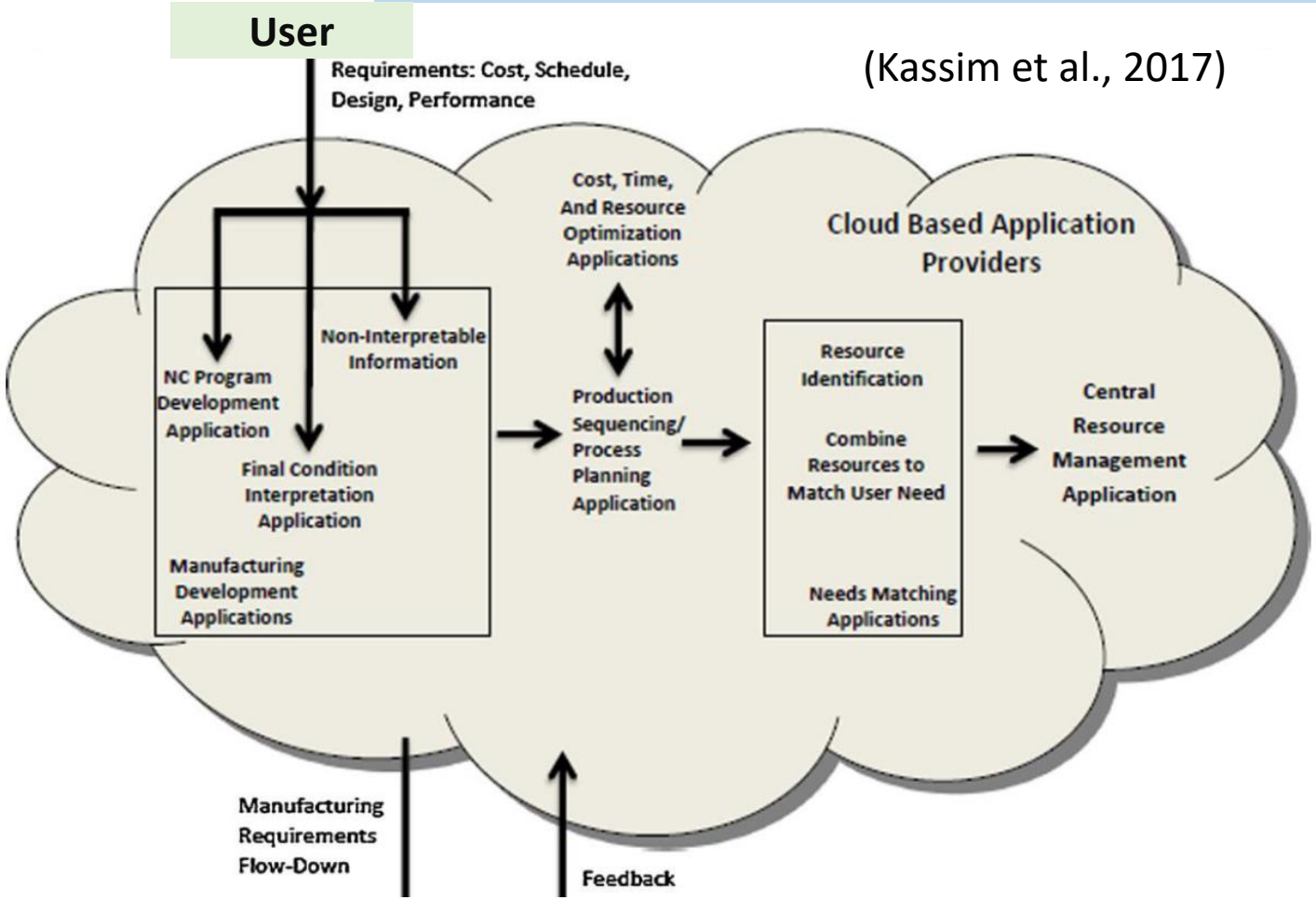
# Cloud Based Manufacturing Systems




(Kassim et al., 2017)

In **Cloud Based Manufacturing Systems (CBMS)**, manufacturers will be able to provide **rapid elasticity to their service, scale their resources, eliminating loss** and **reducing cost**.

At the same time, the manufacturing resources will be **pooled at one place** and it can **enhance information sharing and machine utilization** as well as **improved reuse of resources**.

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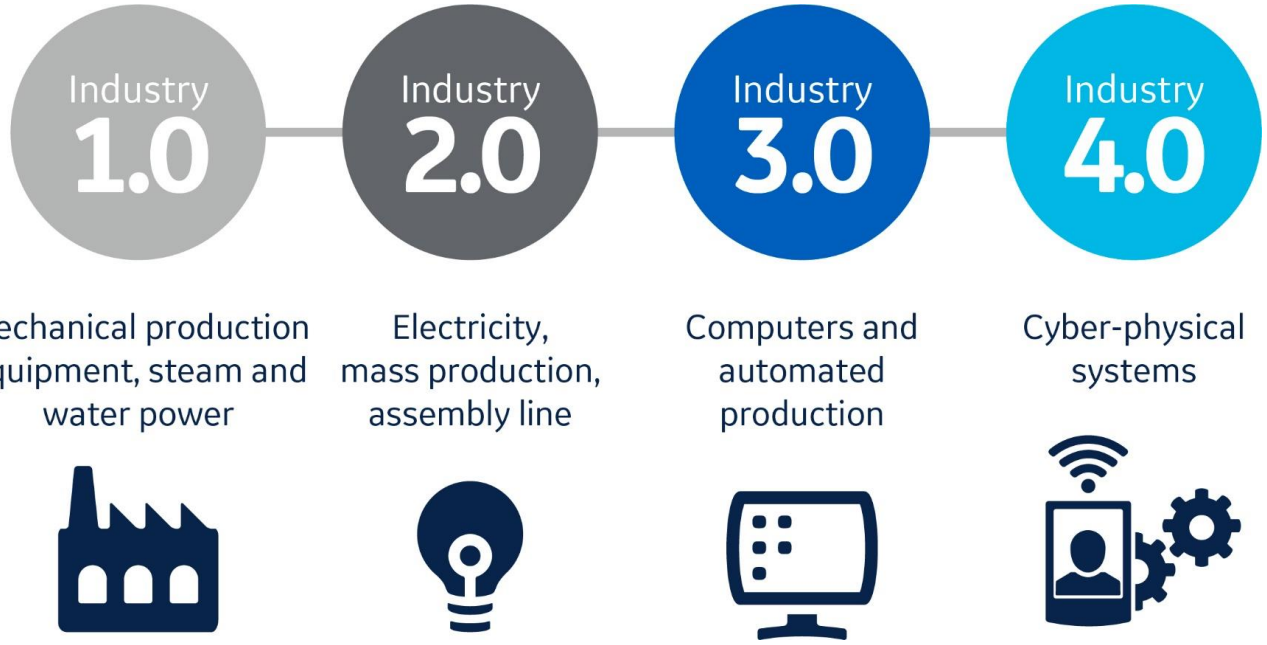
# How to Deal With Industry Competition

## Businesses need to adapt and response for the industrial evaluation




**Evolution of Industry**

https://www.cytivalifesciences.com/en/us/solutions/bioprocessing/knowledge-center/digital-transformation-in-biomanufacturing
https://www.desouttertools.com/industry-4-0/news/503/industrial-revolution-from-industry-1-0-to-industry-4-0

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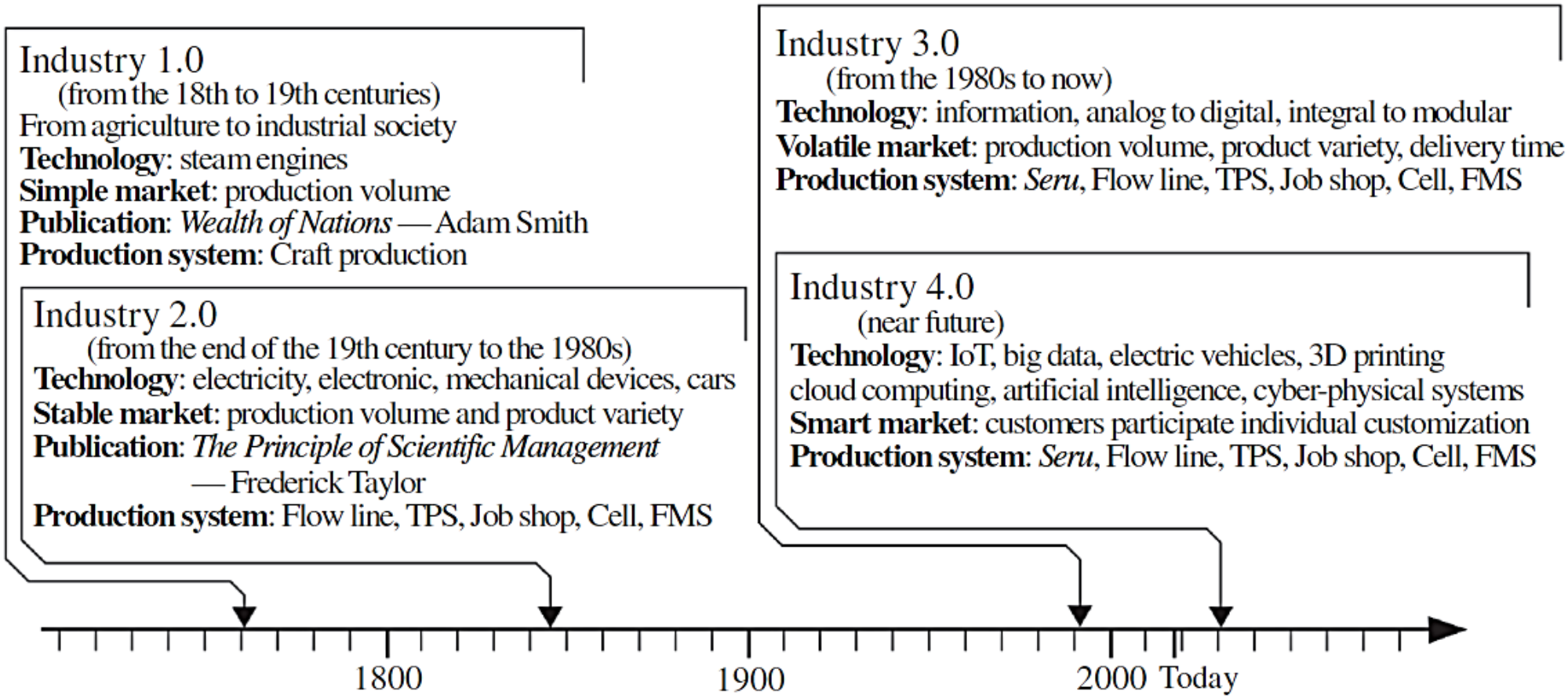
# Evolution of Industry




(Yin et al., 2018)

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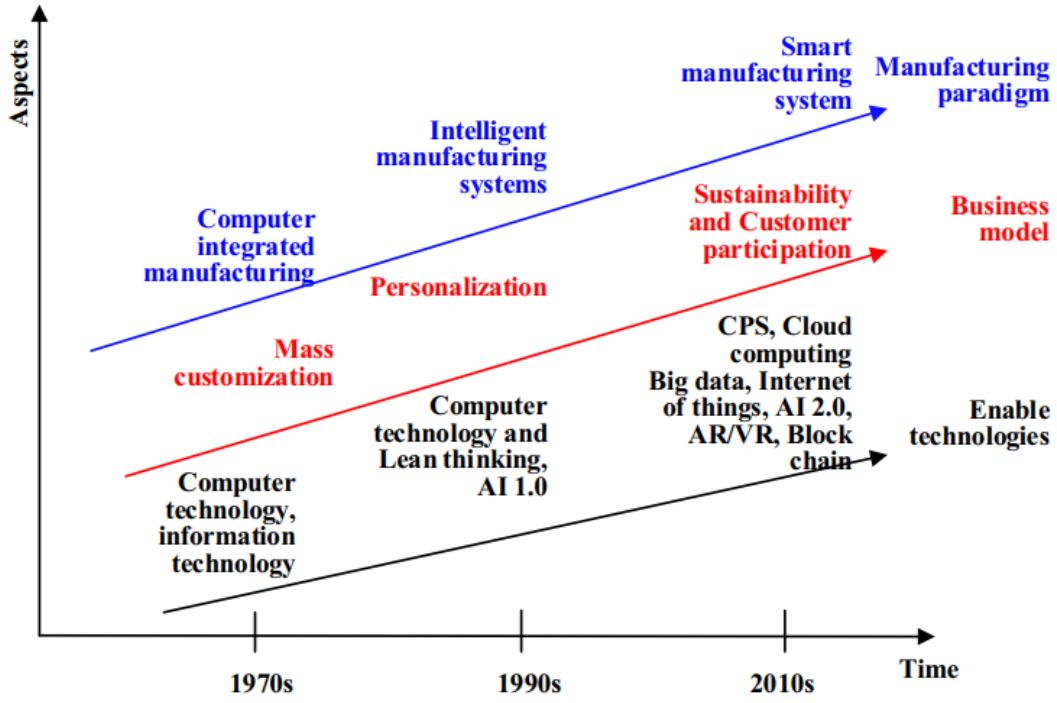
# Smart manufacturing system

## Smart manufacturing system




The evolution of smart manufacturing systems

(Qu et al., 2018)

**Smart manufacturing:** employs computer-integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible manufacturing.

**The evolution of Smart manufacturing is** related to the technological development, the dynamic requirements of stakeholders and innovative business model.

**Smart manufacturing systems** can improve the accuracy of decision making, and increases overall productivity

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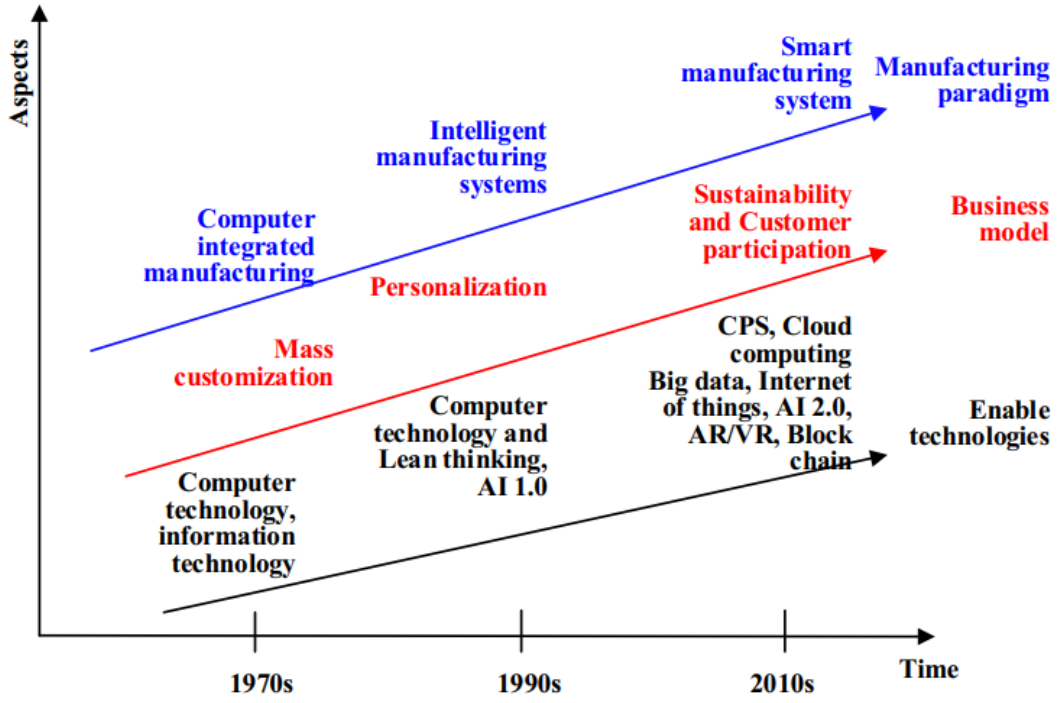
# Smart manufacturing system

## Smart manufacturing system

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# Smart manufacturing system (SMS)

**Key objectives of SMS:** Autonomous lean Operation, Sustainable value , and Win-win Partnership

**Requirements of SMS:**

| Function | Business | Emerging technologies |
|---|---|---|
| Self-sensing | Business planning & logistics | Big data |
| Self-adaptive | Operations managements | Cyber Physical Systems |
| Self-organization | Control | IoTs, Cloud & fog computing |
| Self-decision | | AI, Block chain |
| | | AR,VR, 3D Printing |

(Qu et al., 2018)

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# Smart manufacturing system (SMS)

## Components of SMS




### Physical level

- Smart machine, smart storage and communication device
- Smart logistic

### Smart connection and communication level

- Local network, CPS, RFID
- Industrial IoTs

### Application level

- Product lifecycle management
- Smart production system
- Smart manufacturing systems: state of the art and future trends


(Qu et al., 2018)

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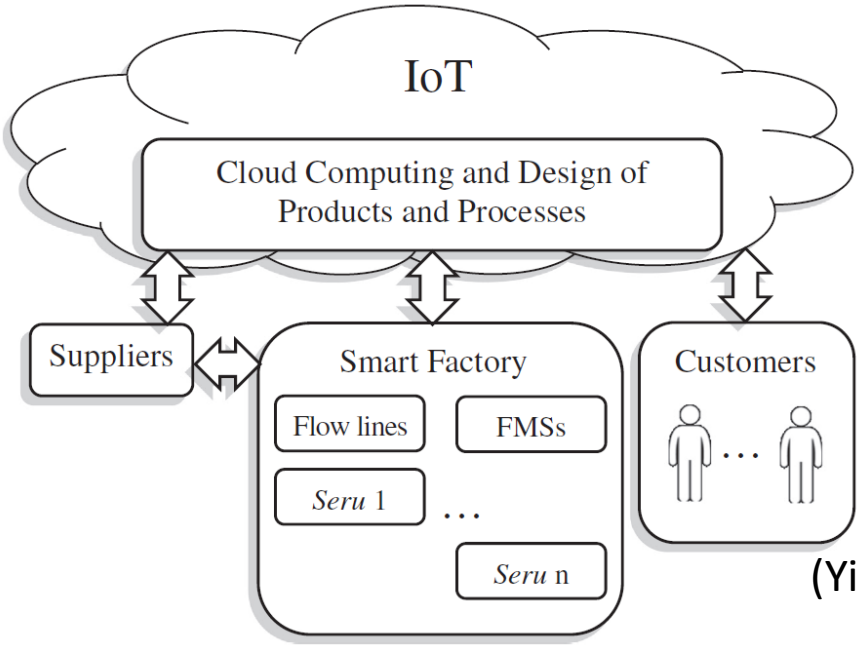
# Potential manufacturing for Industry 4.0

## Smart manufacturing for Industry 4.0




(Yin et al., 2018)

The construction of **IoT** and **big data cloud** allows **communications** among **customers**, **assemblers, suppliers** and other **service providers.**

## Demand dimensions for Industry 4.0

**Variety:** standard functions for general customers and some customer participation in product design for individual product can be important.

**Time:** product life cycles may become more uncertain. For example, life cycles of personally design to provide specific functions may be short because of possible frequent upgrades.

**Volume:** volumes of personal designed modules may be very low. Volumes of standard modules may fluctuate drastically with a wide range from low to high.

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# Digital Factory

- Digital factory is the **key topic in Industry 4.0**.
- According to the Association of German Engineers (VDI), digital factory is
  - ‘‘a comprehensive network of **digital models**, **methods and tools**, including **simulation** and 3D/virtual reality & **visualisation**,
  - which are **integrated through continuous DATA management**’’,
  - with the goal to **design, model, simulate, evaluate and optimise products, processes and systems before any modification is actually carried out on an existing (or new) physical system**.
- Its **meaning in Industry 4.0 is extended**, implying **an entire value network**.

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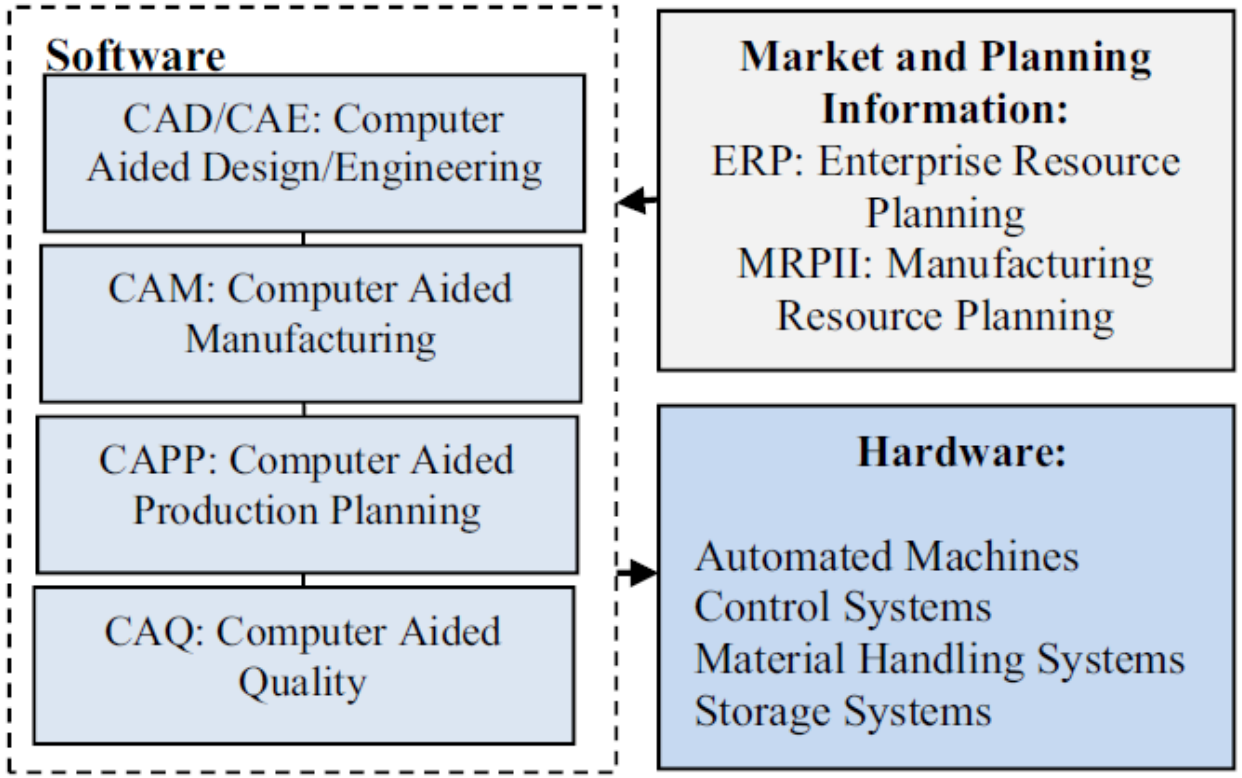
# Computer Integrated manufacturing (CIM) system

From the technology perspective, the **evolution of automation tools** and **advanced technologies** in production systems can be described as **Computerized Numerical Control machine** (CNC),**Computer Aided Manufacturing** (CAM), and **Computer Integrated Manufacturing** (CIM).

CIM is defined as the **full integration of information technology** with all manufacturing processes

## Elements of CIM system




(Esmaeilian et al., 2016)

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# Network collaborative manufacturing system

The network collaborative manufacturing system is to accomplish the goals

- **To strengthen** the information communication between enterprises and to realize the adjustment of produce tasks
- **To promote** the operating efficiency of enterprises
- **To improve** the effectiveness and correctness of decision-making
- **To finish** the supervision of the products manufacturing, coordination of upstream and down stream corporations
- **To build** an open communication system between enterprises and the third-party logics corporation.

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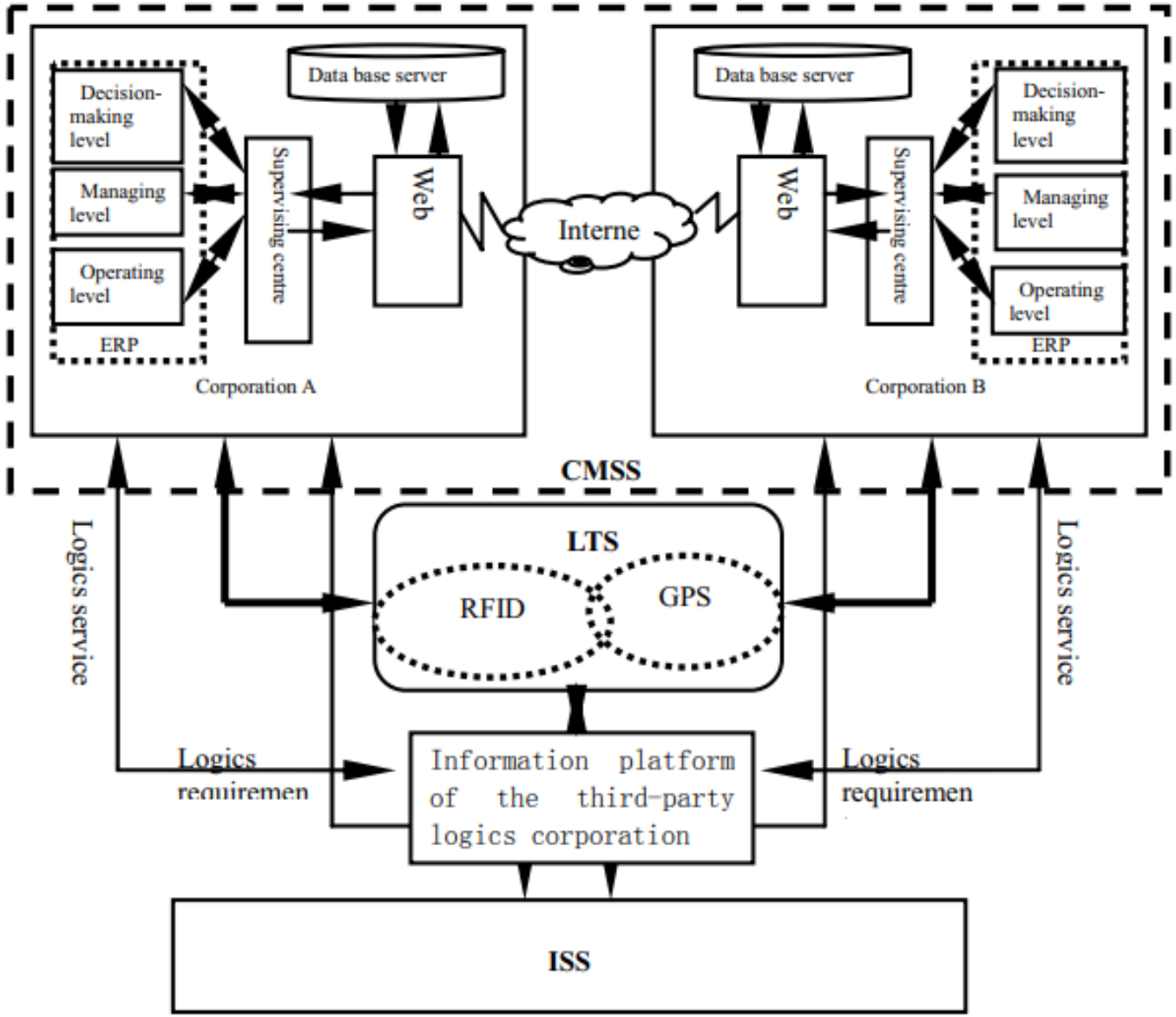
# Components of Network collaborative manufacturing system

Note:

- Collaborative manufacturing long-range supervising system (CMSS)
- Information sharing system (ISS)
- Logics tracking system (LTS)




(Xiong et al., 2008)

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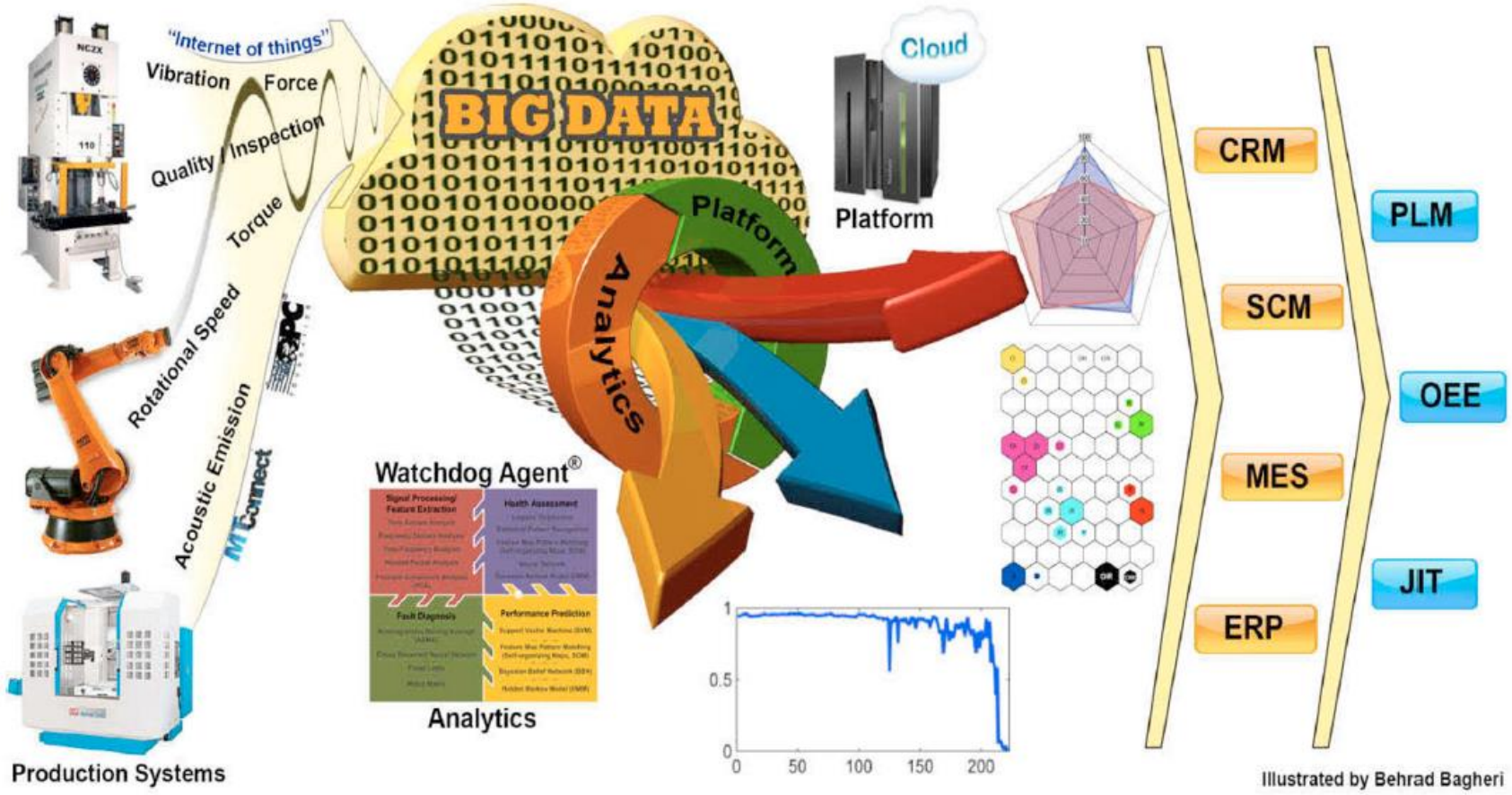
# Predictive Manufacturing System Framework

## Watchdog Agent® Analytics for Intelligent Maintenance Systems

The **tools and algorithms** found in the Watchdog Agent® can be categorized into four sections: **signal processing** and **feature extraction**, **health assessment, performance prediction**, and **fault diagnosis.**




(Lee et al., 2013)

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# New manufacturing paradigms originated form data analytics

- Smart manufacturing, smart supply chain, data analytics in manufacturing
- Social manufacturing
- Cloud manufacturing
- Cloud-based remanufacturing
- Cyber-physical systems

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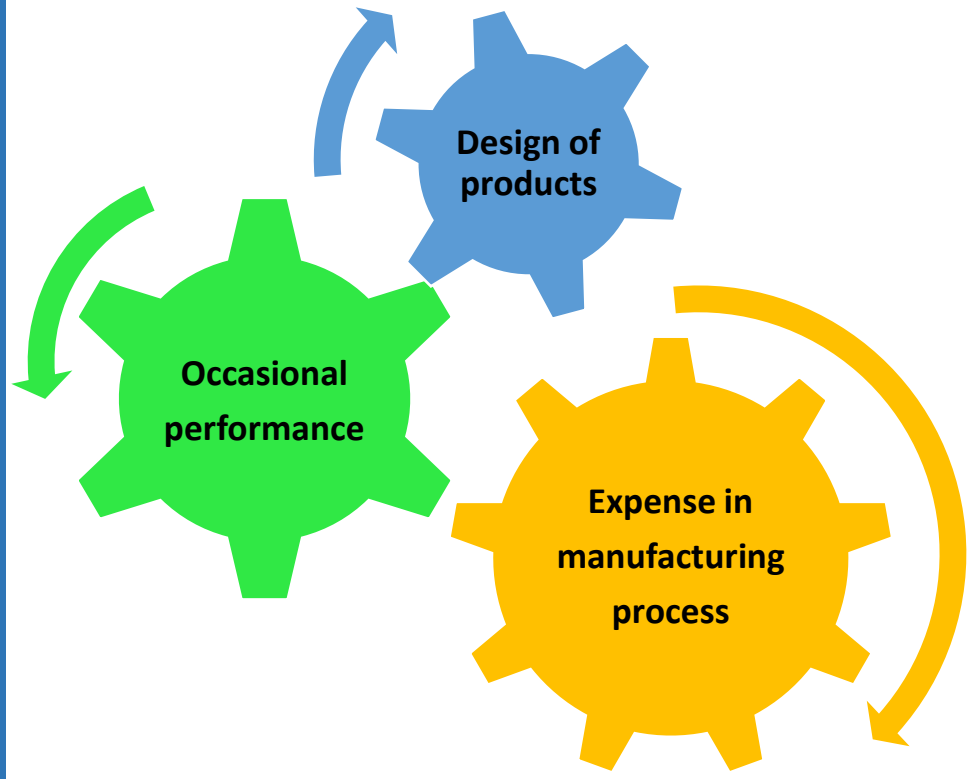
# Collaborative manufacturing system: CMS

**CMS** is Sharing information between business processes across internal or external partners in the value chain network




Meet customer requirement effectively

**Good collaboration**

Well production plan

Companies are **increasingly cooperating** in what are often referred to **collaborative manufacturing** that have enabled companies to focus on their **core competencies** and **participate in the design** and **manufacturing process**.

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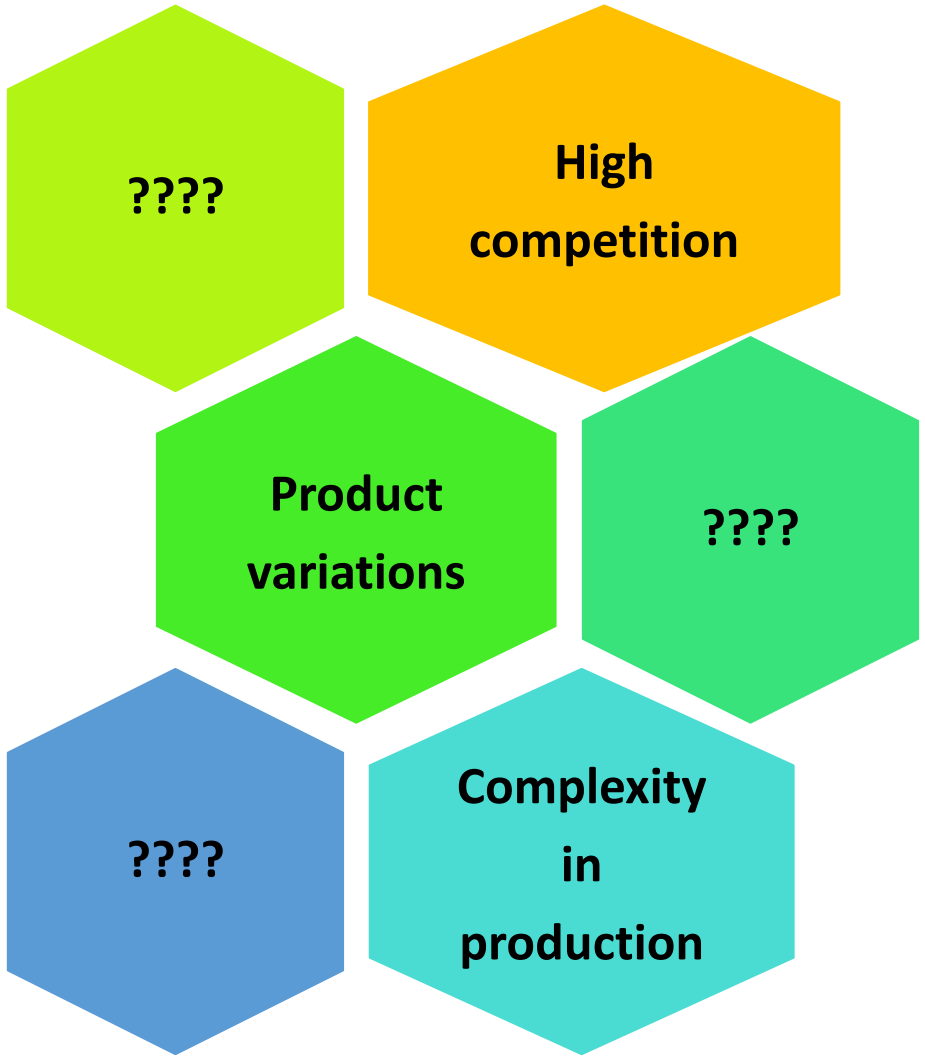
# Why is

# Collaborative manufacturing systems (CMS) ?




Today's **extremely turbulent, global and cross-industrial business climate** is frequently characterized by **corporate merges, acquisitions**, and **strategic alliances**, a situation that has forced organizations to **integrate and find new and efficient ways of working** and **communicating with each other.**

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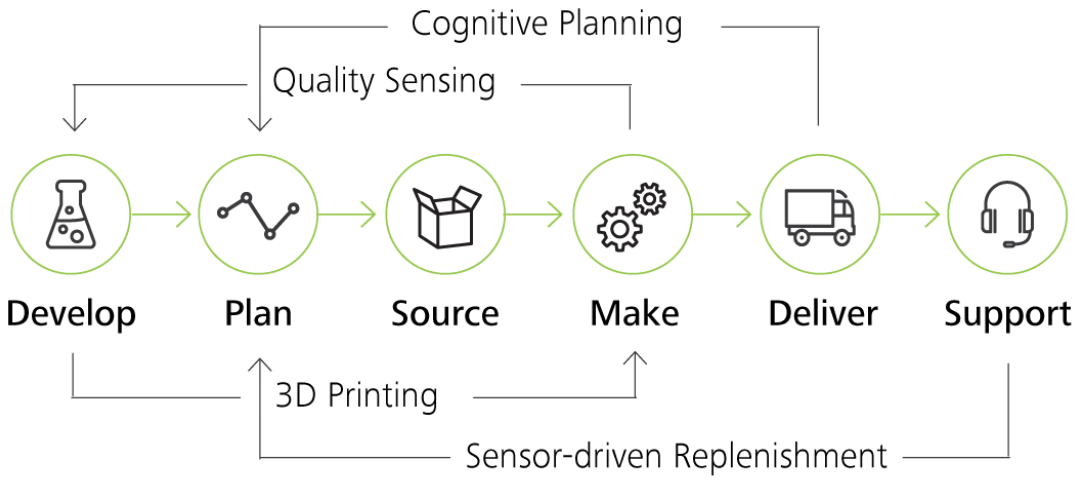
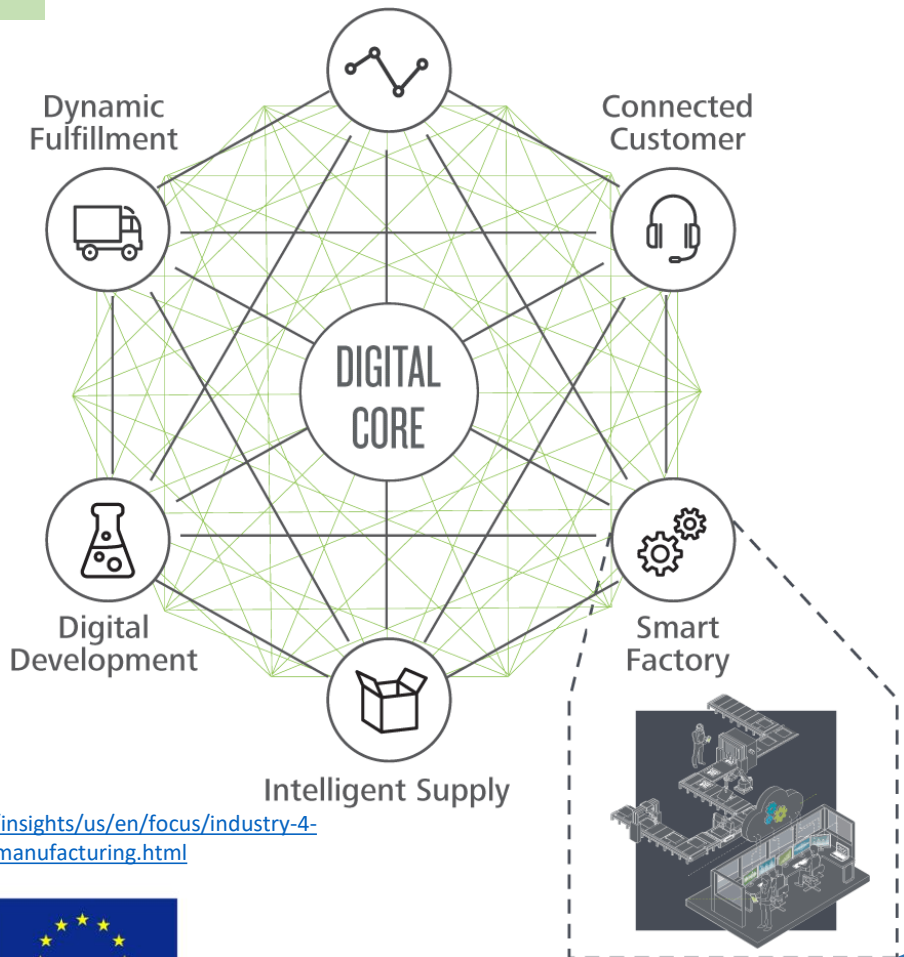
# Collaborative manufacturing system

## Traditional vs. Digital communication

### Traditional supply chain




### Digital supply networks




**Digital core** can overcome Non-traceable WIP, Inconsistent product quality, Uncontrollable waste, Lack of flexibility, Ineffective strategic planning and Higher production cost in the long run

https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html

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# Collaborative manufacturing system

## System Integration

**Horizontal Integration**

Inter-company integration

**Vertical Integration**

Intra-company integration

**End-to-End Integration**

Integration of digital and real worlds

## Horizontal Integration

- **On the production shopfloor**:
  - machine to machine (internal)
  - machine to production unit (internal)
  - production unit to production unit (internal)
  - stakeholder to stakeholder (external)
- **Across multiple production facilities:** for example interconnecting logistics, warehousing, production, marketing and sales
- **Across the entire supply chain** (some refs mention it as "End-to-End Integration)

**https://www.mbtmag.com/business-intelligence/article/13251083/horizontal-and-vertical-integration-in-industry-40**

(A. Chiarini & M. Kumar, 2020)

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# Collaborative manufacturing system

## System Integration

### Vertical Integration

From shop floor, the system could be linked up to

- CPPS (Cyber-physical Production Systems) to detect changes in plants, allowing for fast changes to be made in relation to the manufacturing of products.
- Maintenance
- R&D
- Management and Strategic Policy

### End-to-End Integration

It is an integration of technologies throughout the value chain, from product development until after-sales.

(A. Chiarini & M. Kumar, 2020)

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# Activity: THINK PAIR SHARE

*Students are grouped in pairs to discuss their thoughts about*

- Evolution of Manufacturing Systems
- What is potential manufacturing for Industry 4.0?
- How is important of collaborative manufacturing system for Industrial 4.0?

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# Assignment:

## Self Study (evaluation of production system )

**After reading the article:** ***"The evolution of production systems from Industry 2.0 through Industry 4.0"(Yin, 2018)***

**Discussion:**

1. What is potential manufacturing for Industry 4.0?
2. How appropriate production systems have been utilized to match different demand dimensions over the time?

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