Ch 13: Introduction to Manufacturing Systems

Learning Objectives:

By the end of the lecture the student should be able to:

- Explain what manufacturing system is?
- Outline major phases in the history of manufacturing.
- Outline and explain components/activities (and their relationships) of production and manufacturing systems.
- Classify and explain manufacturing systems depending on its characteristics/complexity.
- Highlight the challenges/complexity of manufacturing systems.
- Briefly explain what agile/lean manufacturing is?
- Briefly explain what data-rich manufacturing is?

NOTE: Materials used to create this presentation were supplied from:

Lecture notes designed by 2008 Pearson Education Inc. Third Edition by Professor Mikell P. Groover

Lecture notes designed by Professor Darek Ceglarek, University of Wisconsin – Madison.

Manufacturing: An Introduction

- What is manufacturing?

Manufacturing (or Production): The process of converting raw materials into products that have value in the marketplace.

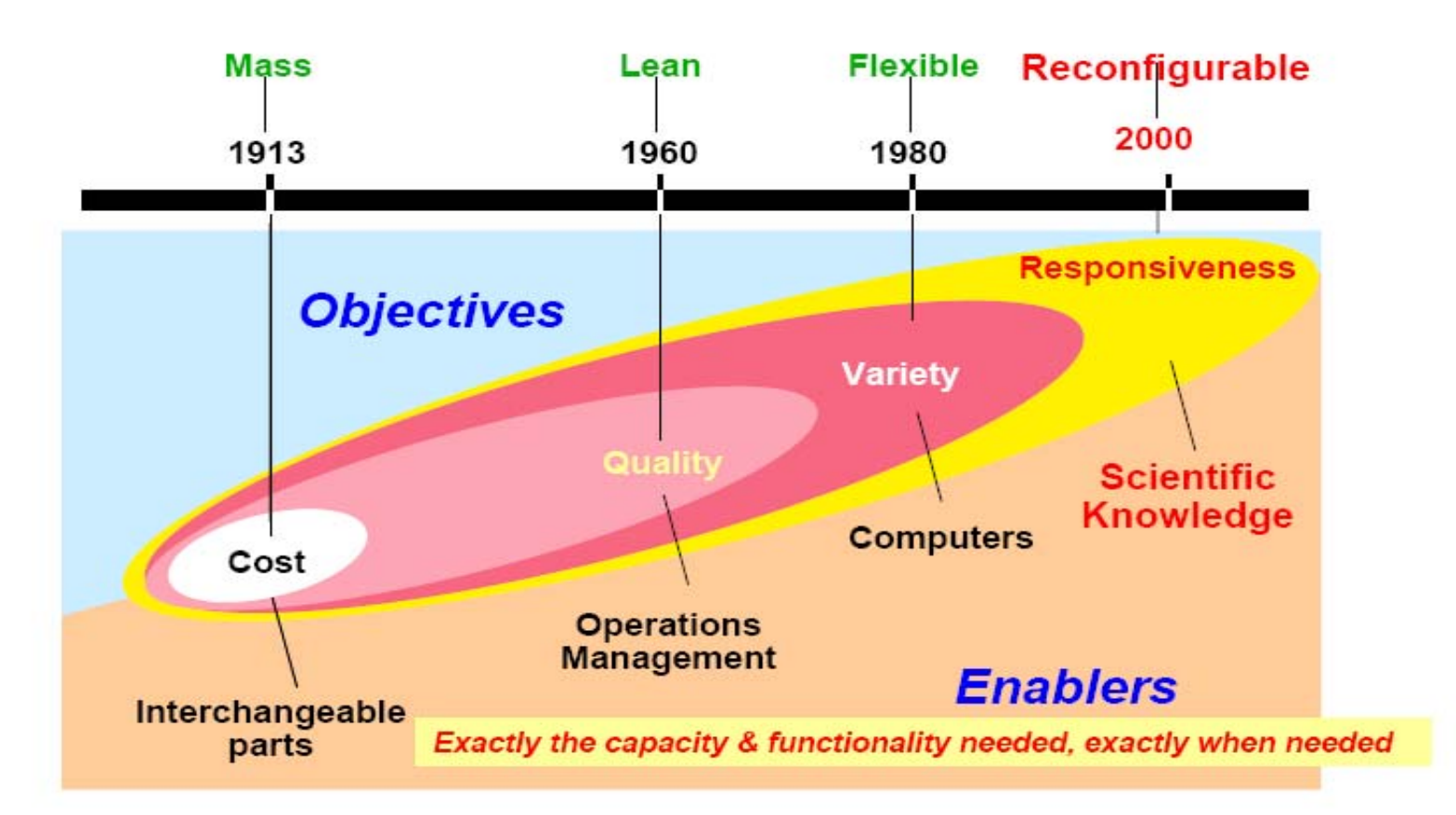
  - manufacturing concerns about making cars, airplanes, stoves, shoes, toys, TVs, mobile phones, and etc.
  - manufacturing engineering is the study of how to make maximal amount of desirable products with minimal production cost, and minimal time.
  - manufacturing is the backbone of modern society and creates the wealth of a nation

- The types of manufacturing
  - **Continuous:** gasoline, steel, plastic film, …
  - **Discrete:** car, airplane, computer, furniture, …

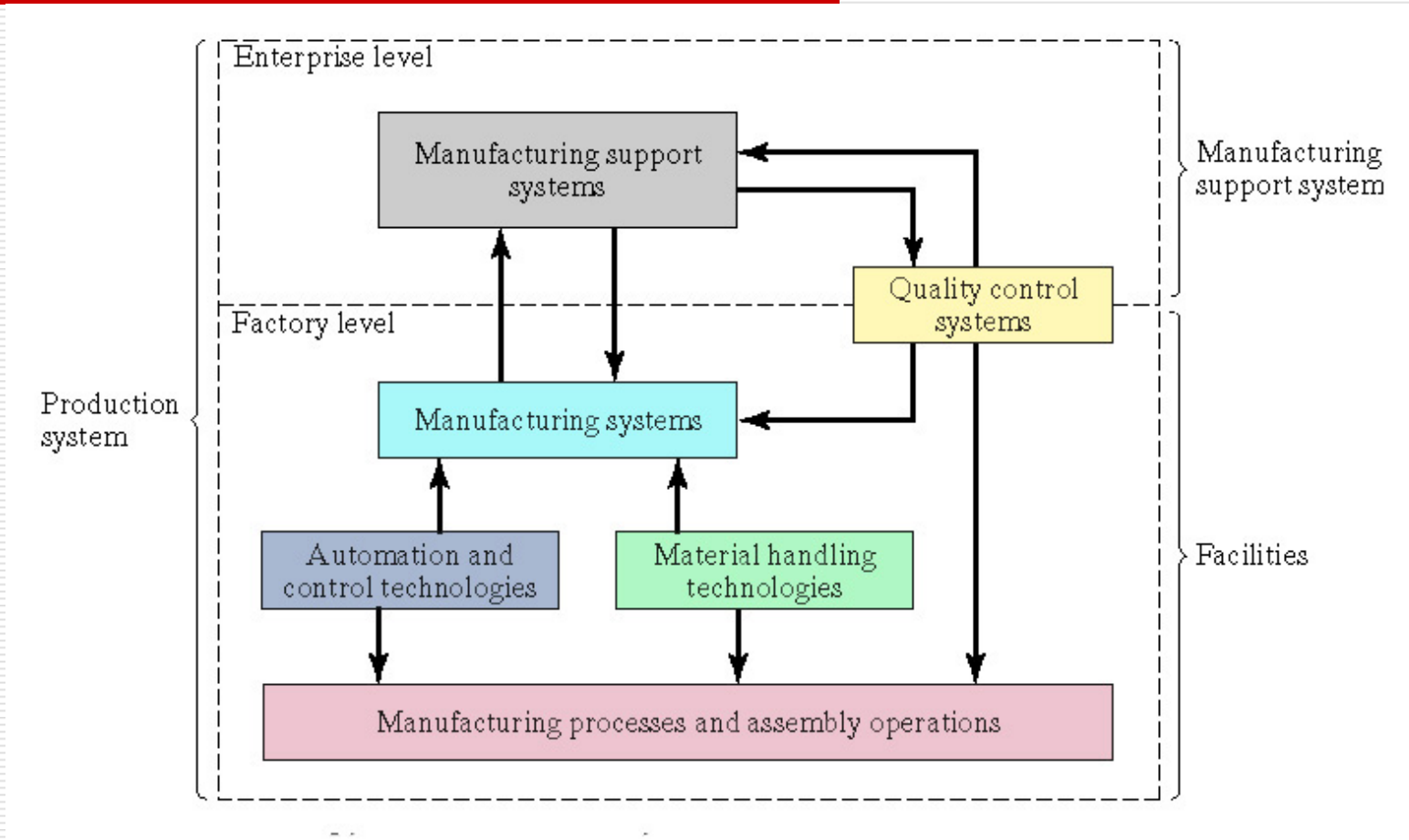
Brief History of Manufacturing

- **Discovery and invention of materials and processes to make things**
  - Neolithic period (8000-3000 B.C)
    - Woodworking, polishing of stone, firing of clay pottery, metallurgy (copper, gold, silver and tin)
  - Bronze Age (3500-1500 B.C)
    - Work with iron, quenching, tempering (heat treatment of steel)
  - Iron Age (starting 1000 B.C)
    - New properties of steel
- **Development of systems of production**
  - First Industrial Revolution (1760-1830) in England
    - Watt's steam engine
    - Machining operations (boring, milling, turning, drilling, etc.)
    - Eli Whithey: interchangeable parts
    - Adam Smith: division of labor
  - Second Industrial Revolution (1865-1900)
    - Railroads
    - Fredrick Taylor, Frank and Lilian Gilbreath: scientific management (motion study, time study, standardization, data collection, record keeping, cost accounting, etc.)
    - Henry Ford: assembly line (mass production
    - Henry Gantt: process planning (Gantt chart)
    - Electrification
  - Modern Manufacturing Systems (I&ME 471)

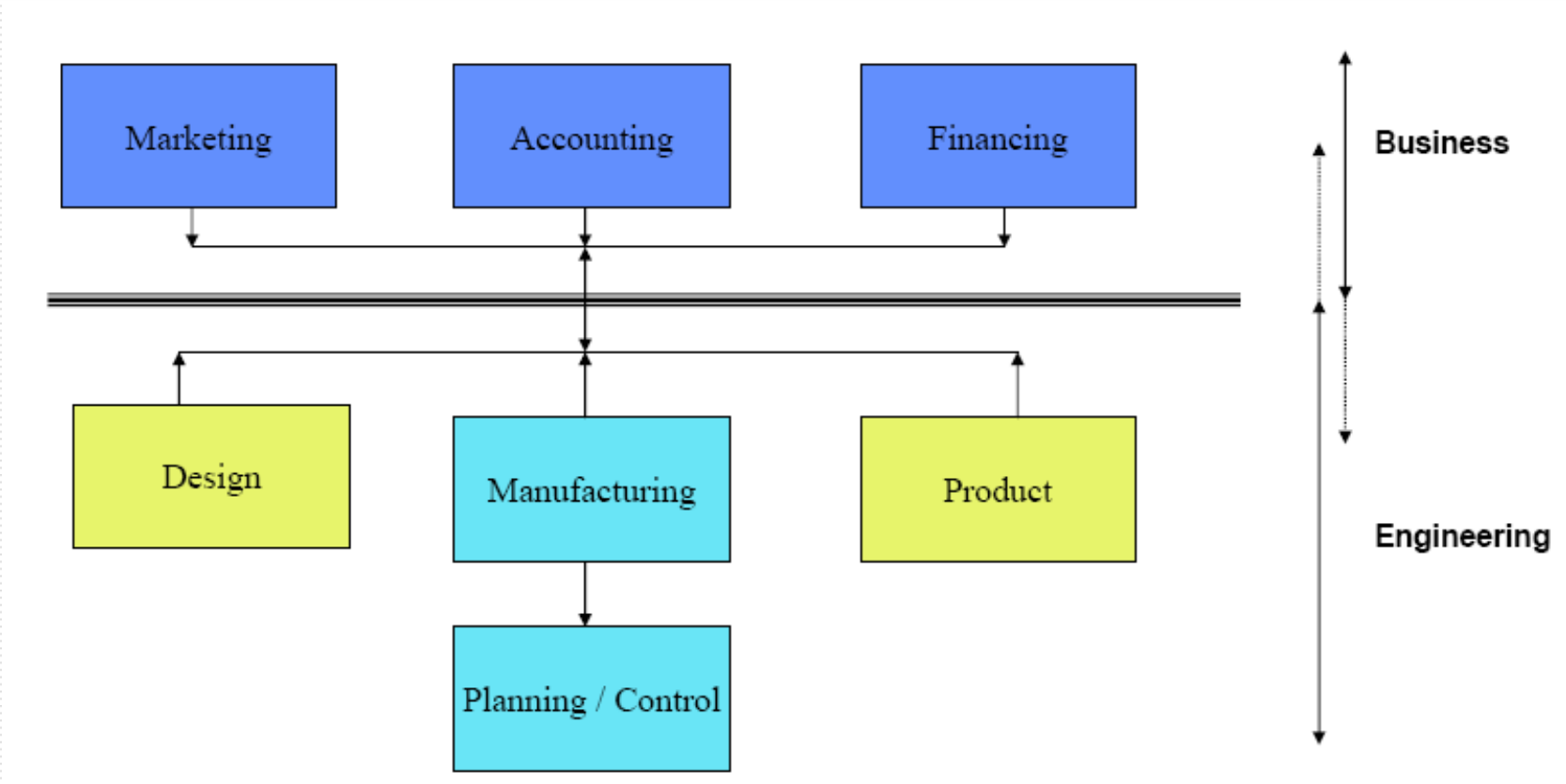
The change of characteristics of manufacturing



Modern Production System



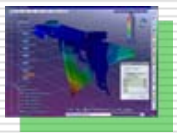
Functional Components of Modern Production System

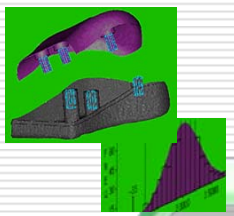


Manufacturing in the Product Life Cycle

Market analysis, R&D

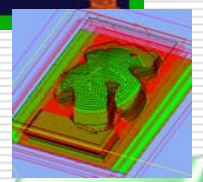
Engineering Modeling





Product design GD&T

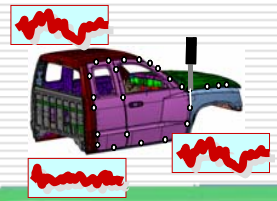
Process design GD&T



Prototyping

Production system

Quality control



Field warranty service

Computer Aided Design (CAD)

Computer Aided Manufacturing (CAM)

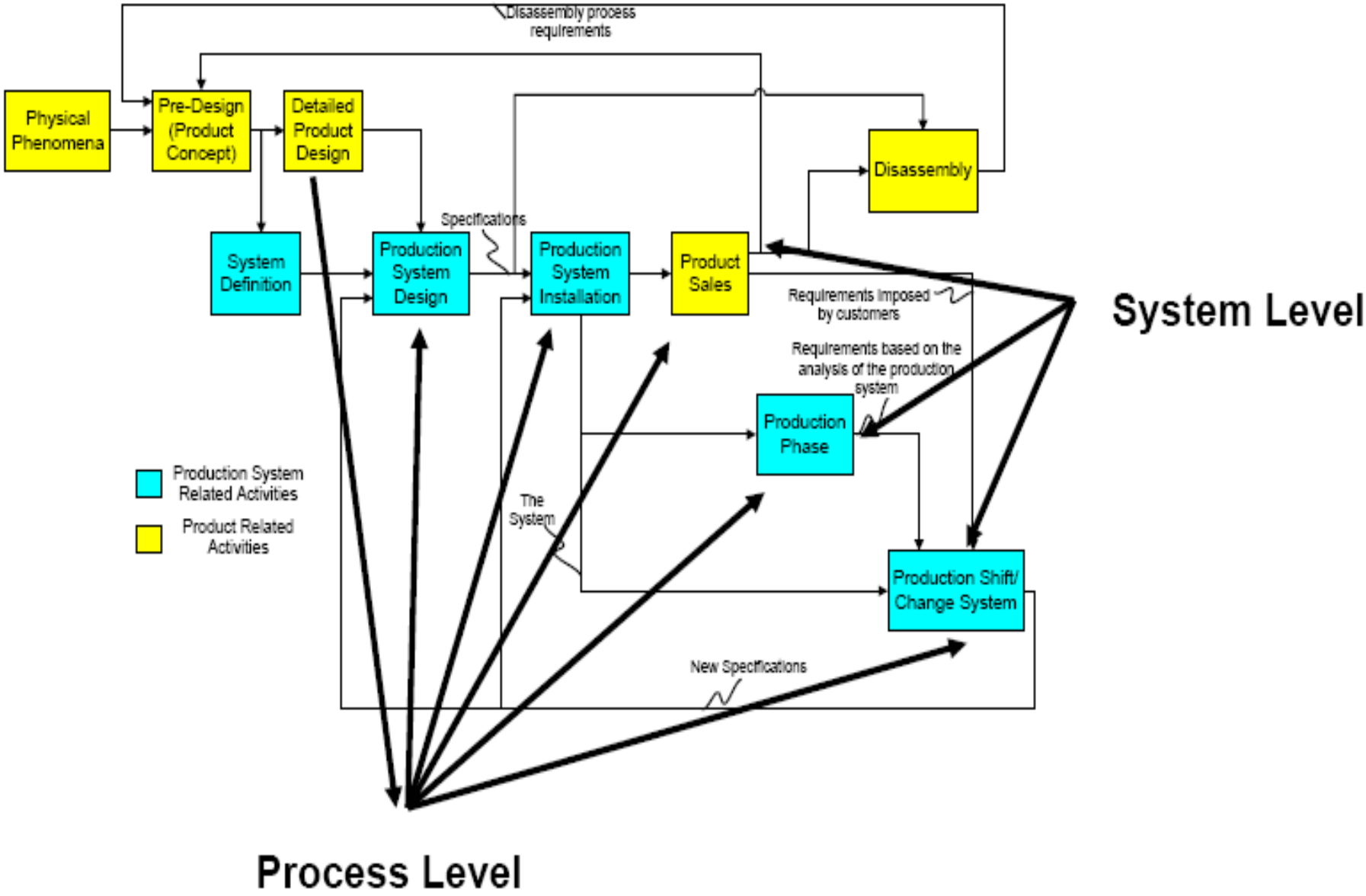
Rapid Prototyping

Manufacturing

Statistic Process Control (SPC)

Topics and related classes

Manufacturing System Activities



Manufacturing System: Defined

A collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts

- Equipment includes
  - Production machines and tools
  - Material handling and work positioning devices
  - Computer systems
- Human resources are required either full-time or periodically to keep the system running

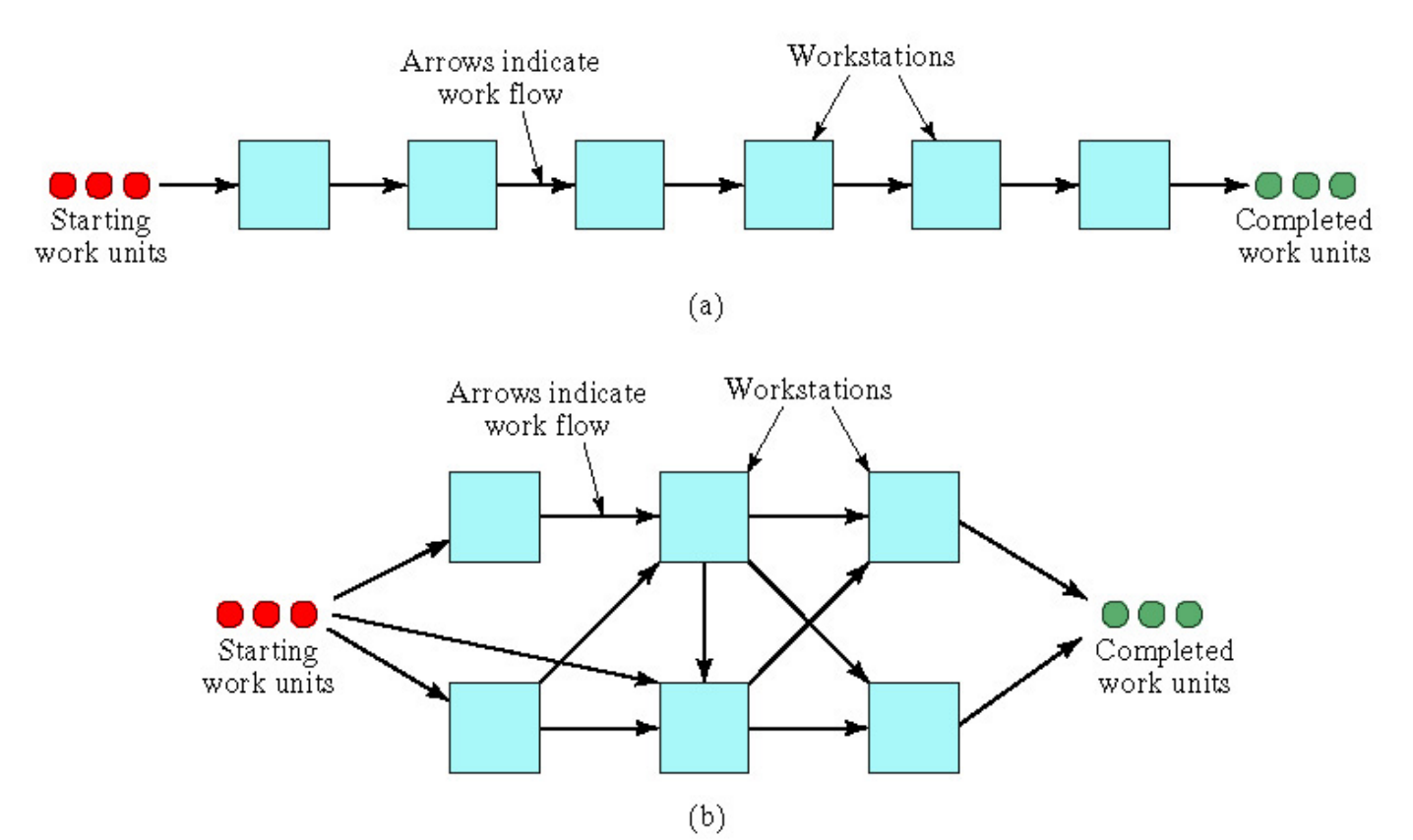
Production Machines

- In virtually all modern manufacturing systems, most of the actual processing or assembly work is accomplished by machines or with the aid of tools
- Classification of production machines:
  1. Manually operated machines are controlled or supervised by a human worker
  2. Semi-automated machines perform a portion of the work cycle under some form of program control, and a worker tends the machine the rest of the cycle
  3. Fully automated machines operate for extended periods of time with no human attention

Work Transport Between Stations

- Two general categories of work transport in multi-station manufacturing systems:
  1. Fixed routing
     - Work units always flow through the same sequence of workstations
     - Most production lines exemplify this category
  2. Variable routing
     - Work units are moved through a variety of different station sequences
     - Most job shops exemplify this category

a) Fixed routing; b) Variable Routing

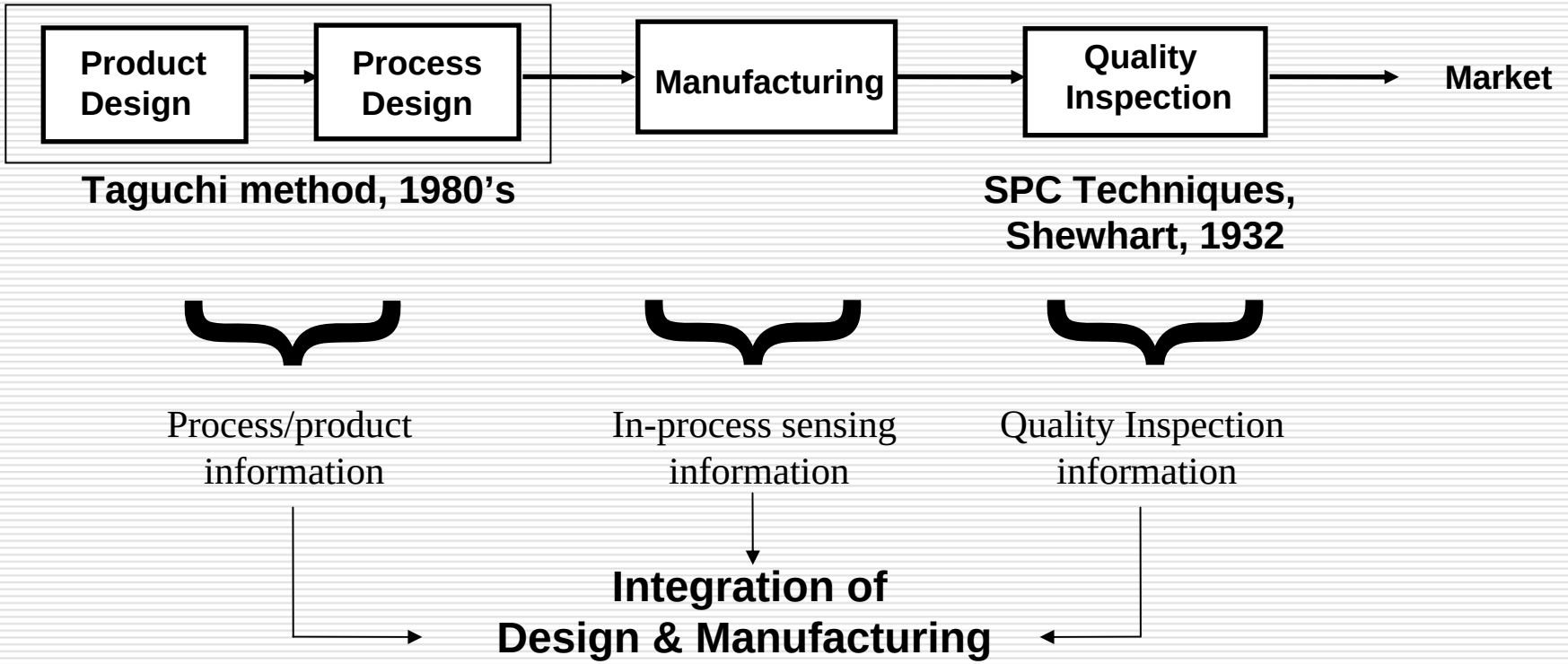


Material Handling System

In most manufacturing systems that process or assemble discrete parts and products, the following material handling functions must be provided:

1. Loading work units at each station
2. Positioning work units at each station
3. Unloading work units at each station
4. Transporting work units between stations in multi-station systems
5. Temporary storage of work units

Example:
Multistage Manufacturing System

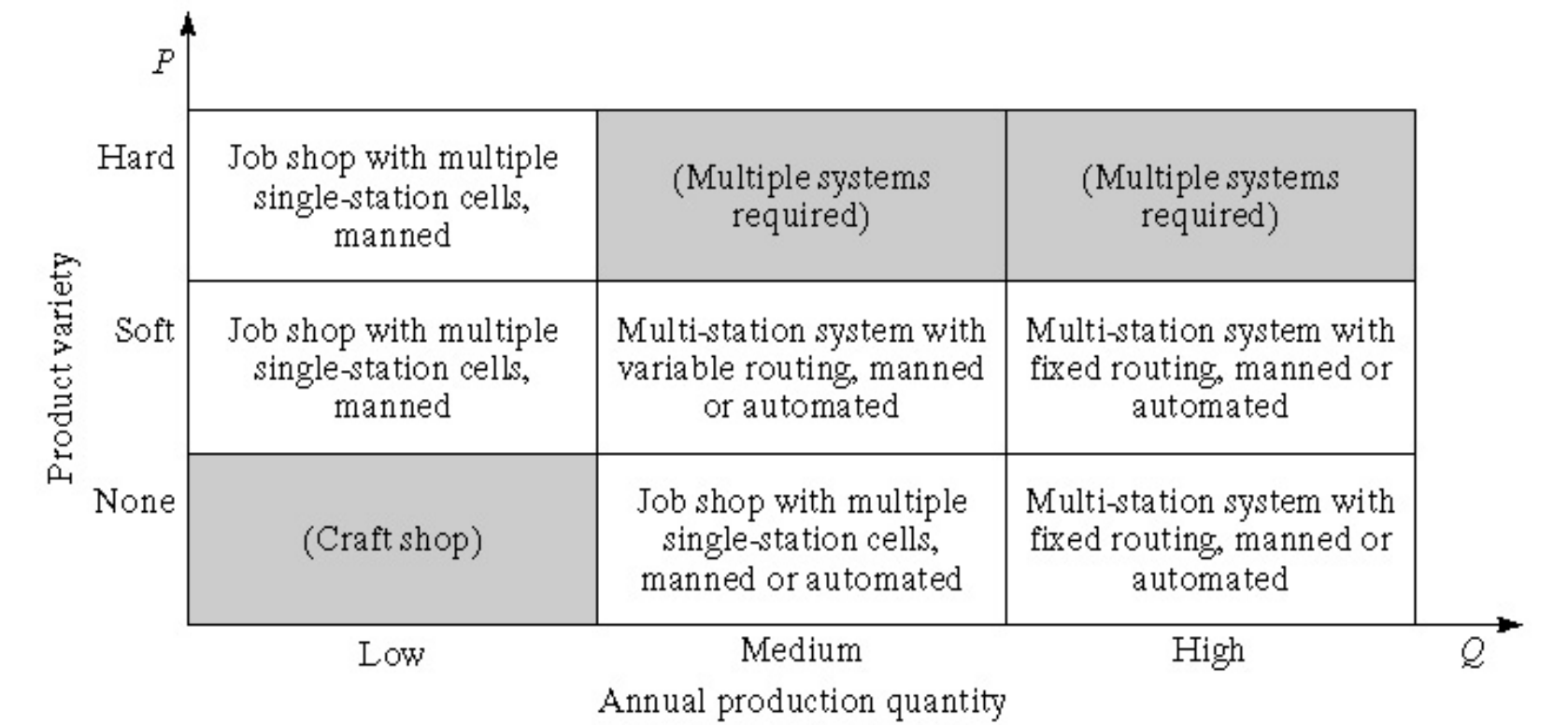


- Product/process design determines process performance
- Information integration is a critical area in developing such methodologies

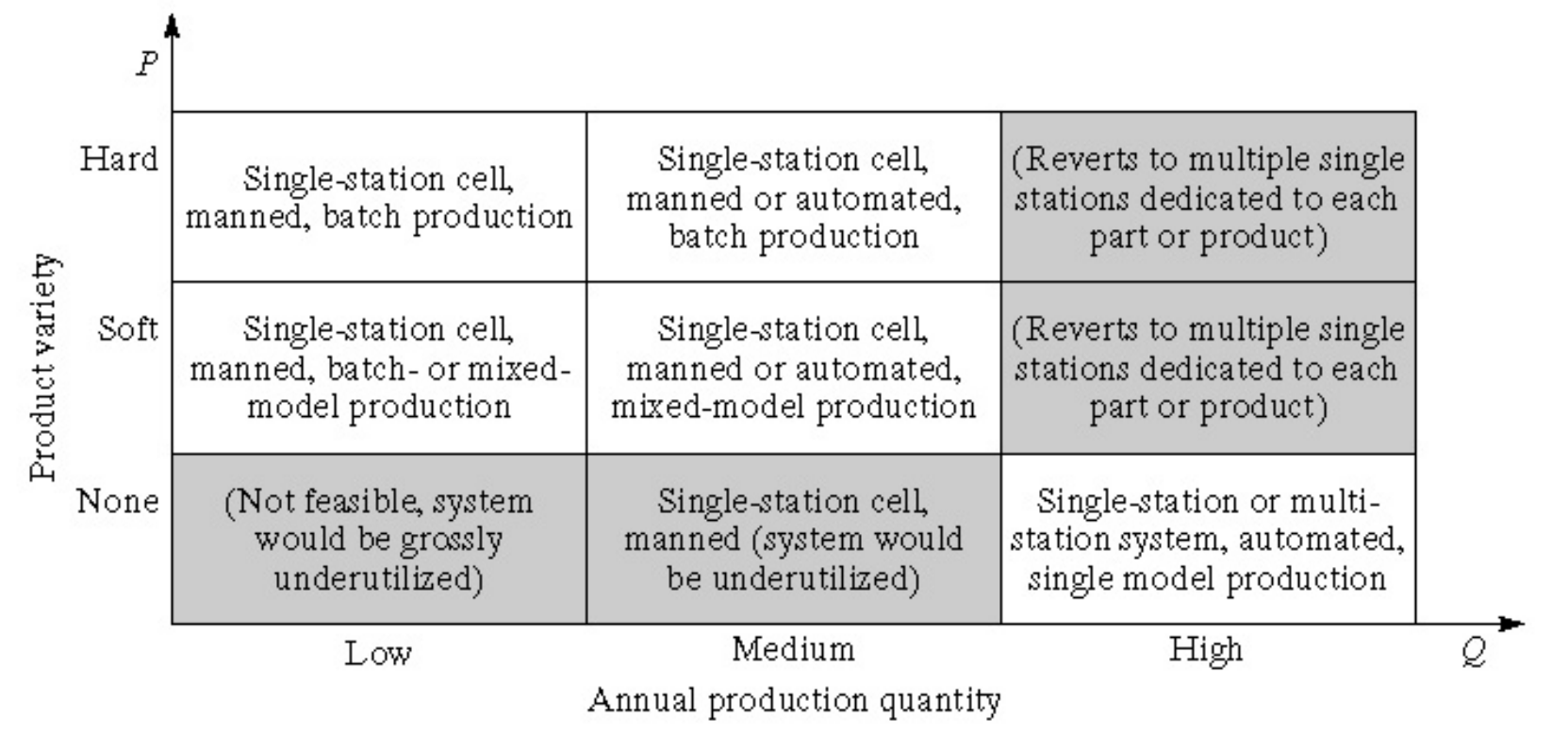
Classification of Manufacturing Systems

- Factors that define and distinguish manufacturing systems:
  1. Types of operations
  2. Number of workstations
  3. System layout
  4. Automation and manning level
  5. Part or product variety

Manufacturing Systems for Medium or High Product Complexity



Manufacturing Systems for Low Product Complexity



Manufacturing Challenges

- Rapid changing market
- Fast development of new technology
  - Example: nano-engineering, bio-engineering
- Competition
- A “use brain” generation, not willing to learn the trade which requires hand skills

To Survive

(1) Lower cost

(2) High quality

(3) Faster product development cycle

Complexity in Manufacturing Systems

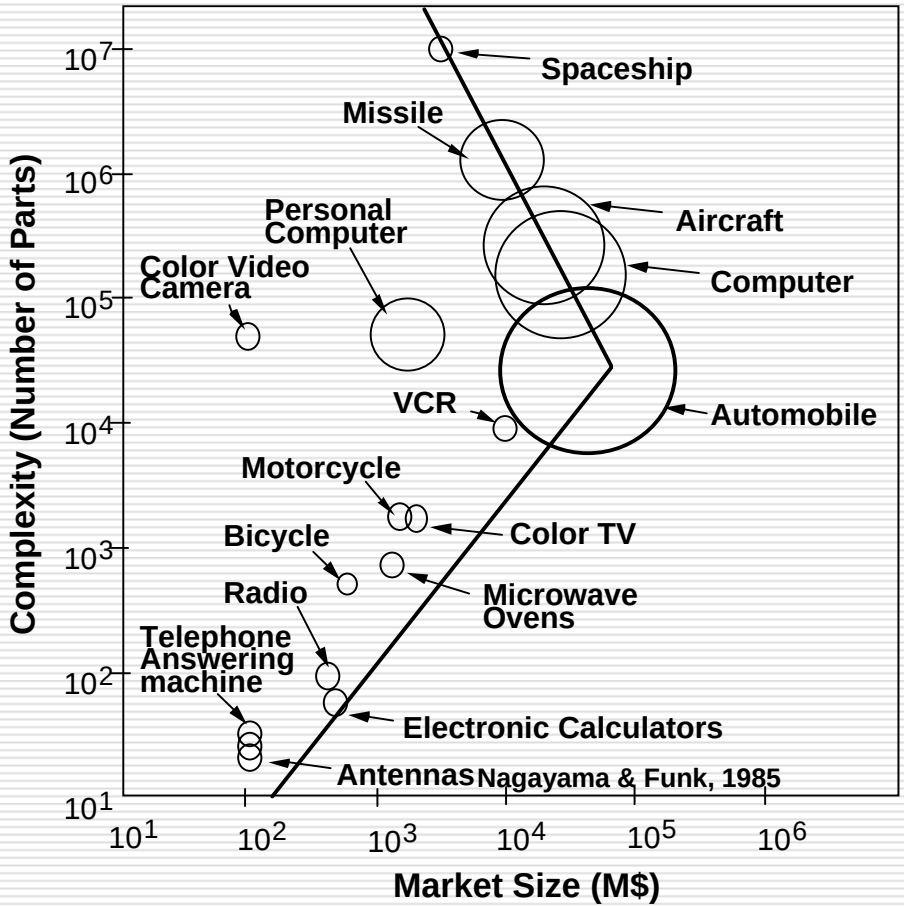
Design

- New product realization time 48->36->24->18 months

- Shorter lead time (6mo->4mo->..)

- Reduce/avoid # of mfg. system failures

Examples of Manufacturing Systems



Process Control

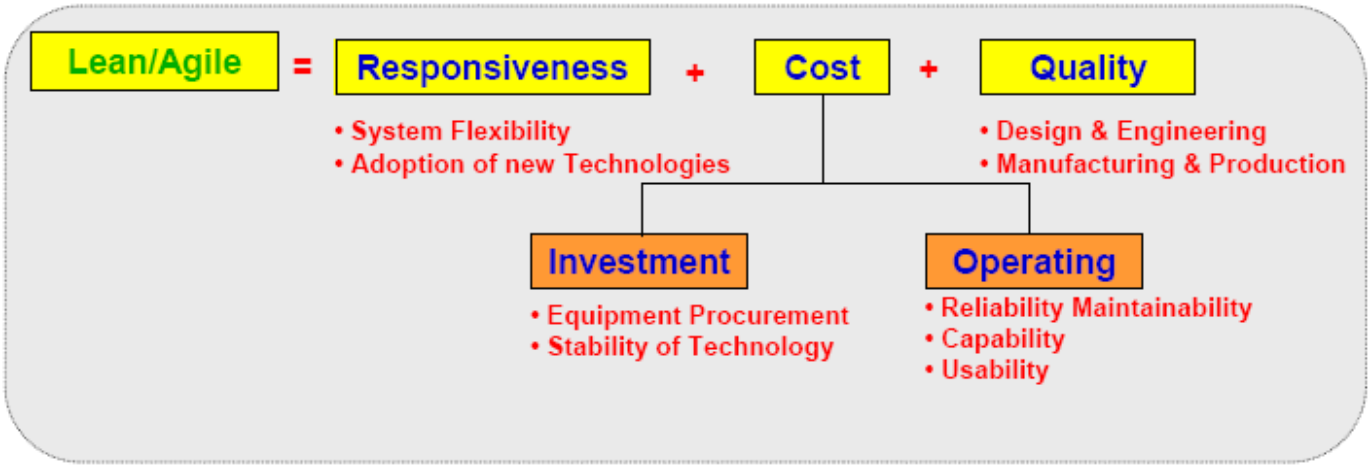
- Aircraft has over 100K distinctly oriented surfaces to be aligned

- 3 billion opportunities for error per day per factory

- To have less than 100 defects/day => process control has error rate< 1/30 ppm

Current Direction: Lean/Agile Manufacturing

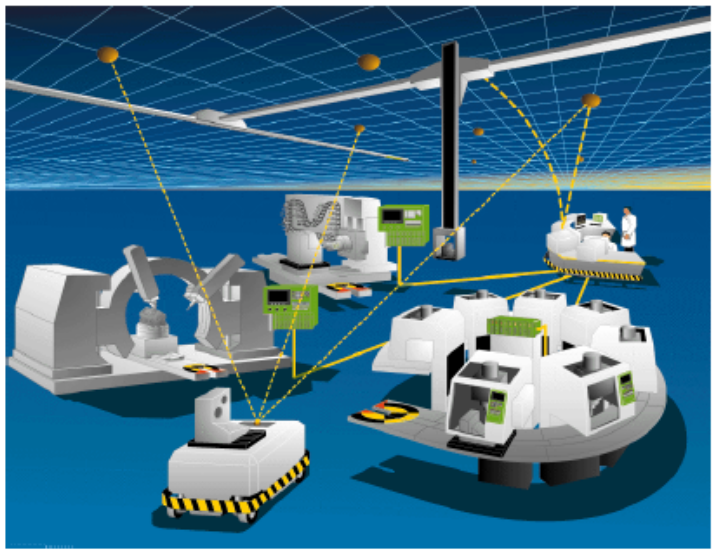
- "Lean/Agile" Manufacturing Objectives
  - Reduce Costs
  - Increase Responsiveness
  - Improve Quality



Future Direction: Data-rich Manufacturing Environment

Data-rich Manufacturing Environment

With in-process sensors flooded in manufacturing processes, the amount of information will increase exponentially in the future.



Curtsey of NSF Engineering Research Center for Reconfigurable Machining Systems

- **Data-rich ≠ Information-rich**