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Introduction to production systems

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Operations management

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Operations management (OM) is defined as the design, operation, and improvement of the systems that create and deliver the firm's primary products and services through:

- strategic decisions
- tactical decisions
- operational

Production Process Definition

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A production process is the TRANSFORMATION of materials into products (economic goods), which takes place in an industrial plant...

…the TRANSFORMATION occurs thanks to energy exchanges that imply changes in the physical and chemical features of materials.

Production System Definition

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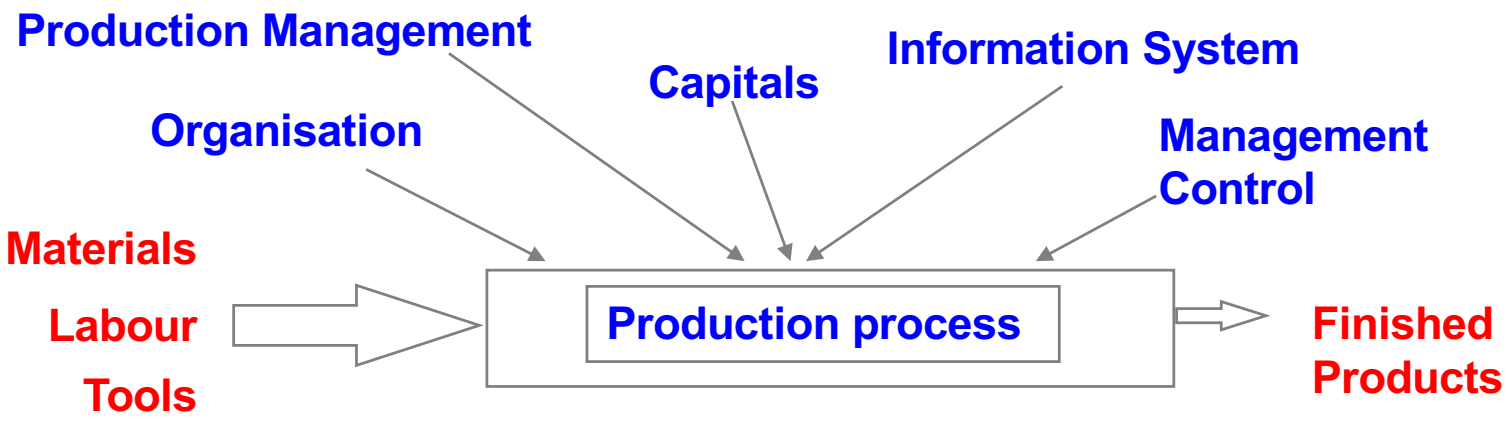
The PRODUCTION SYSTEM can be considered as the production process together with all management subsystems that lead to the achievement of the transformations

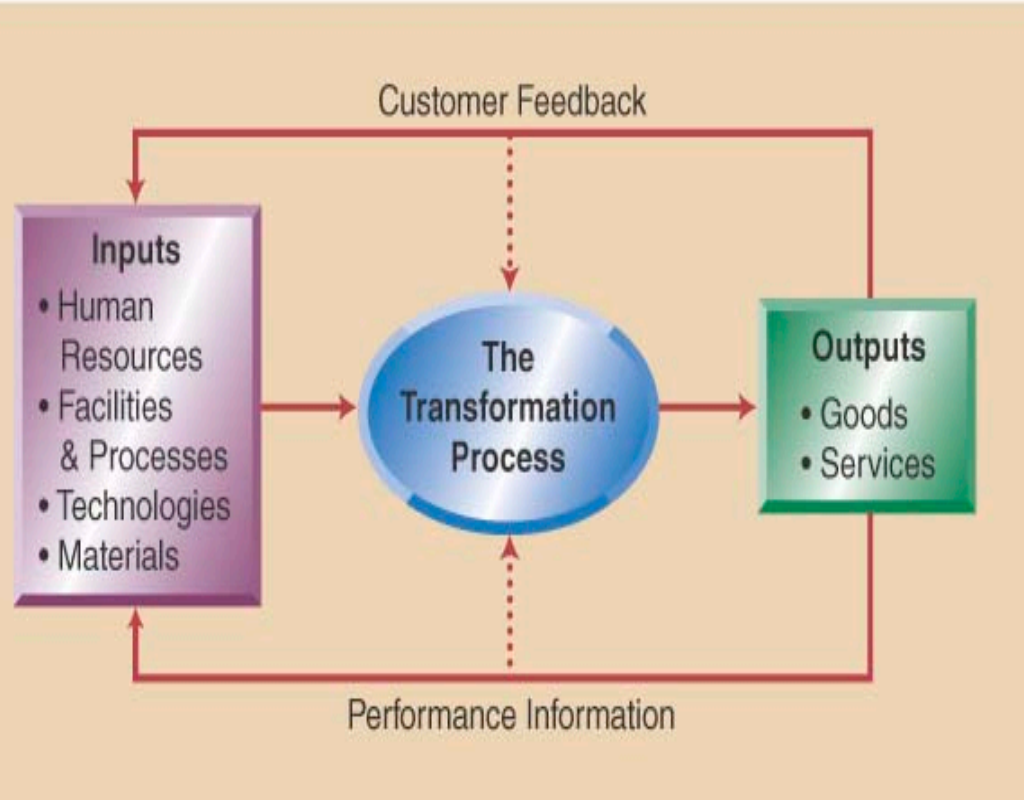


Definition of production process

From a more general point of view a production process is a transformation process by which a set of resources (process inputs) is converted into goods and/or services (process outputs).

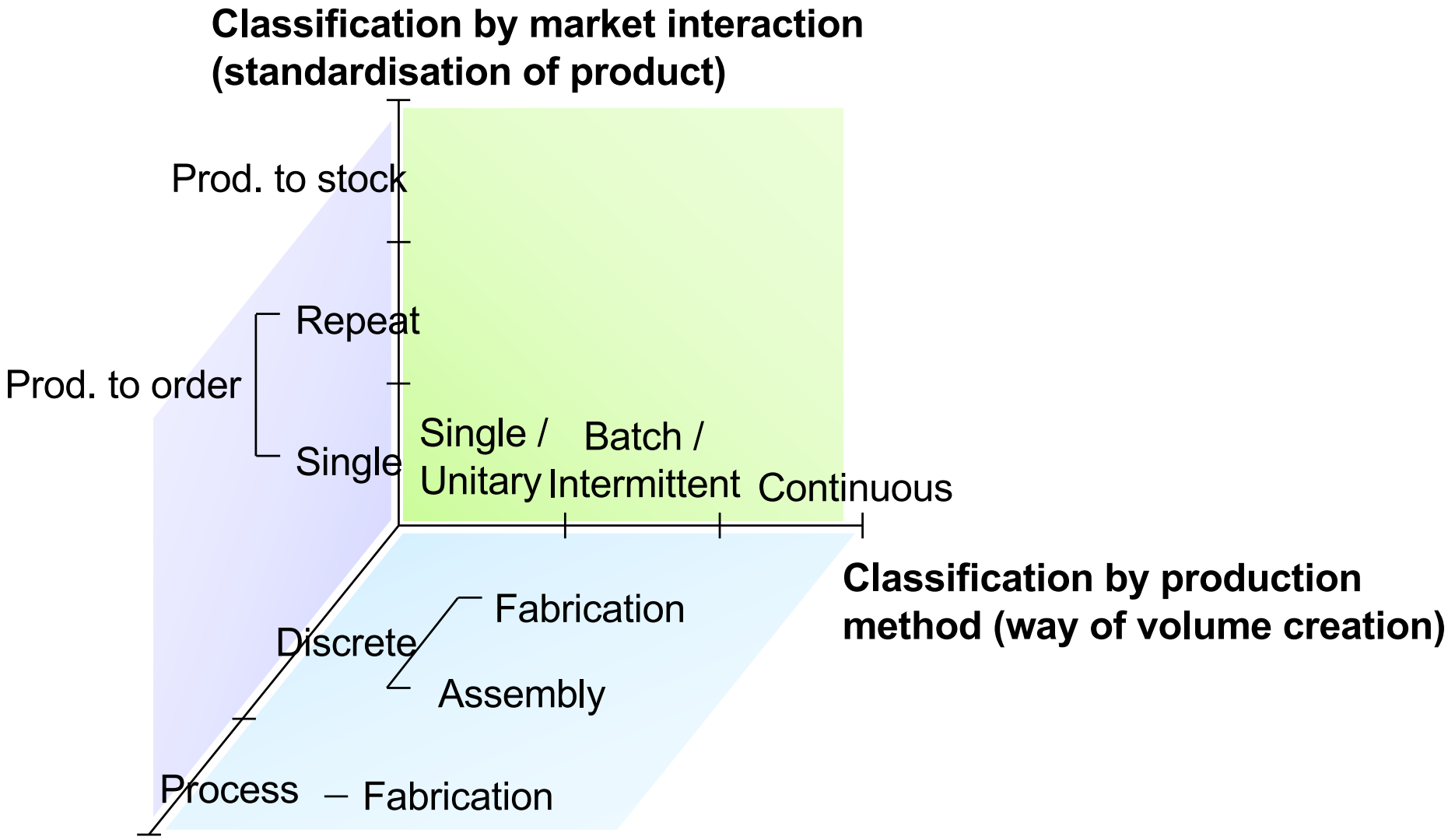
The transformation process may be of different types:

- *physical (e.g. machining)*
- *chemical (e.g. pharmaceutics)*
- *location (e.g. transport)*
- *exchange (e.g. retail)*
- *storage (e.g. warehousing)*
- *physiological (e.g. health care)*
- *informational (e.g. telecom.)*



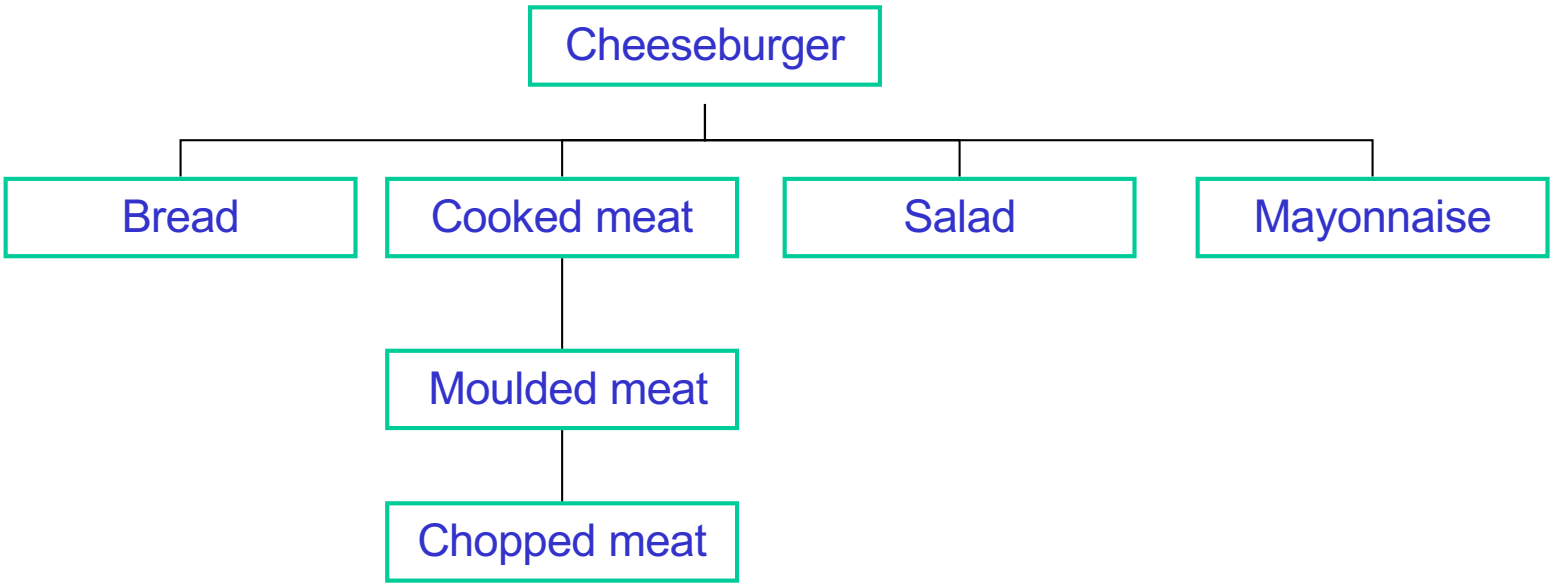
Source: Reid & Sanders

Production system classification



Bill of material (BOM)

Bill of Material: *hierarchical and structural* representation of all the objects (sub-assemblies, components and raw materials) that compone a product



Bill of material (BOM)

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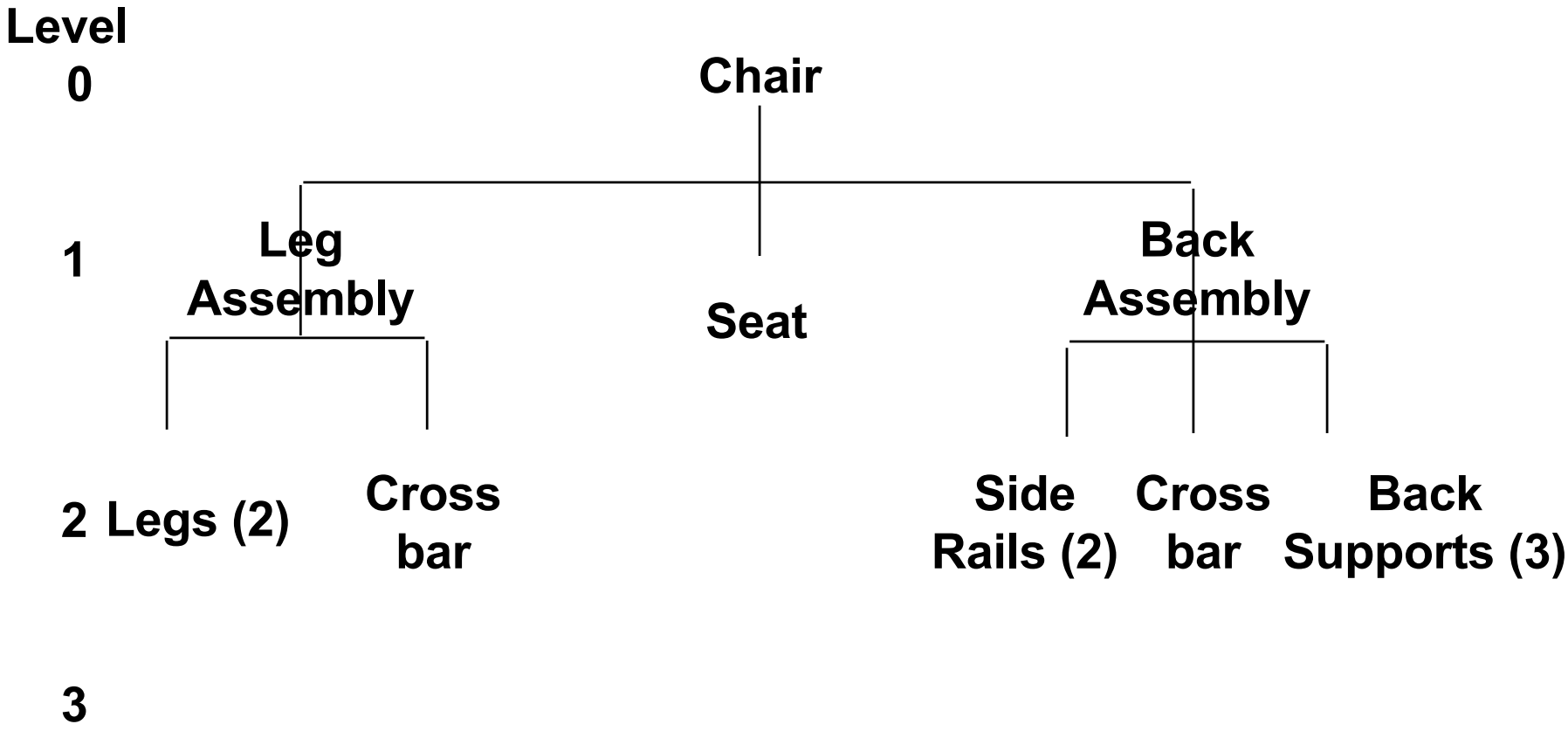
- Bill of material (BOM):
  a listing of all of the raw materials, parts, subassemblies, and assemblies needed to produce one unit of a product.

- BOM (product structure tree):
  visual depiction of the requirements in a bill of materials, where all components are listed by levels.

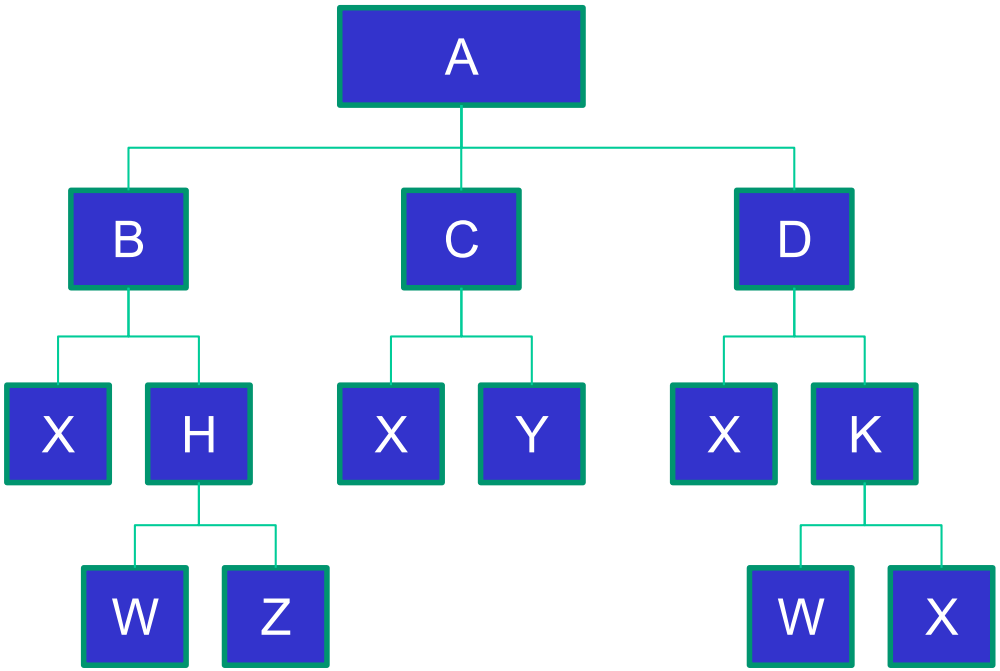
- Provides product structure:
  - Items above given level are called: parents
  - Items below given level are called: children

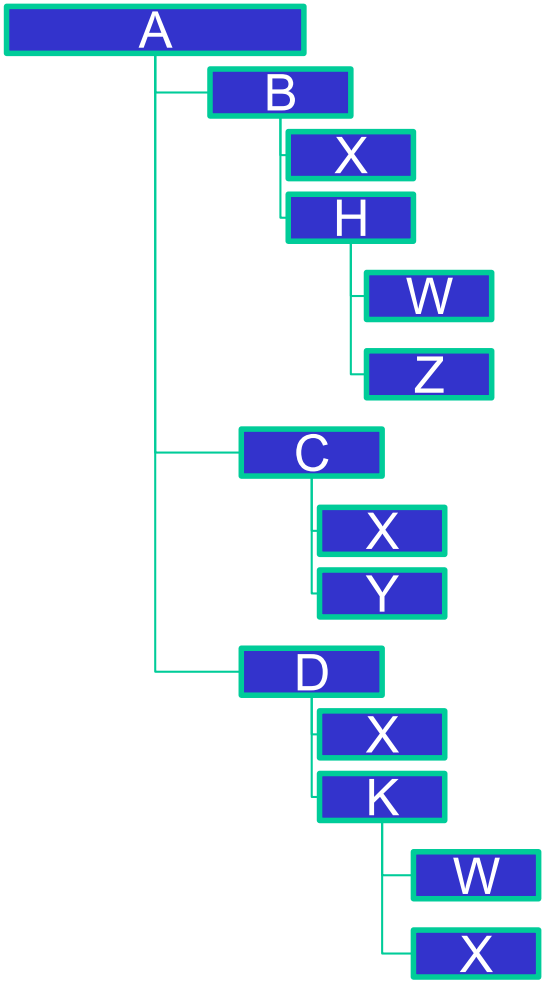
Bill of Material (BOM)
Product structure tree



(Stevenson)

Structural and indented BOM





Classification by nature of process

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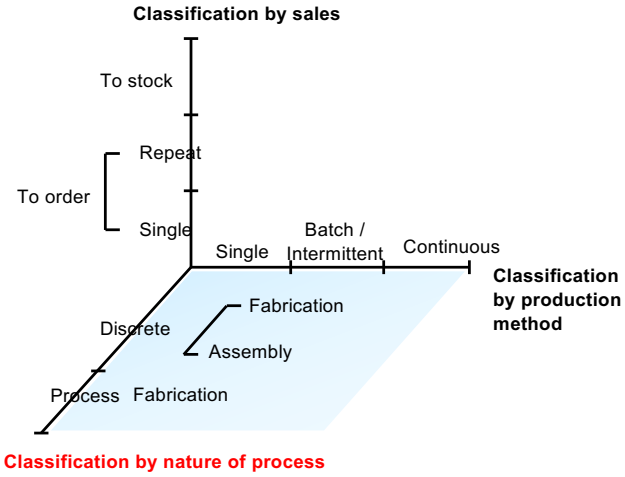
- **Process production**
  - Often concerned with liquids, powders, gases
  - Often very high levels of automation
  - Examples of products:
    - Cement
    - Sugar
    - Coffee



- **Discrete production (manufacturing)**
  - Individual items are produced and can be tracked
  - Volumes can be high
  - Levels of automation are lower
  - Can be the fabrication of individual products and / or the assembly of several components
  - Examples of products: cars, machine tools, electronic goods
  - See examples at this link:
    - Auto parts
    - Stapler

Process production features

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Technology

- Not-reversible chemical-physical transformation of raw materials
- Fixed technological route and mainly flow type
- Relevance and sensitivity of process technological parameters
- High level of automation

Management

- Relative (slight) relevance of management parameters (as WIP, lead time, phase synch, …)

Cost Structure

- High investments for infrastructure, machinery and automation
- Low labour cost
- High energy and maintenance costs

Discrete production (manufacturing) – overview

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Discrete production (manufacturing) typically has a closer relationship to end customers; often process industries act as suppliers

Characteristics

- **Products** are made of discrete parts that are produced in great number of variants
- **Fabrication (processing)** – use of (largely automated) mills, lathes, presses, grinding (machines), heat treatment (furnaces), etc.
- **Assembly** – use of manual or automated systems to create sub-assemblies and then final assemblies
- Significant use of human resources
- Significant inventory levels at all levels of production
- Lead time is not as predictable as in process production
- Typically flexible technological route (options)

Discrete production (manufacturing) – fabrication and assembly

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Fabrication (processing) of parts / components

- Can range from simple packaging of process production output (e.g. foodstuffs) to the complex machining of parts (e.g. aircraft wing segments, engine crankshafts)
- Often combined with assembly

Assembly of products

- Components produced in-house or bought from suppliers are assembled into products for either industrial customers or final consumers
- Examples: iPods, microwave ovens, gear boxes, turbines, car engines, cars, washing machines, airplanes, etc.

Discrete Production – Fabrication

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Technology

- Not reversible physical/shape transformations of raw materials and components
- Not fixed technology route, with options and variants, with variable level of flexibility
- Not particular relevance of process technology parameters, relevance of product technology parameters

Management

- Relevance of management parameters (WIP, lead time, delays, synchronizations, ...)
- Multiple resources with flexible utilization (operators, machines, tools, programs, ...).

Cost structure

- Relevance of fixed assets
- Labour intensity depending from automation and characteristics of machinery

Discrete Production - Assembly

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Technology

- Components assembly to make groups, sub-groups and finished products. Operation can be reversible (and also irreversible, e.g., welding)
- Free technology route, with degrees of freedom
- Low relevance of process technology parameters
- Process flow is synthetic

Management

- (High) relevance of management parameters (WIP, synchronization, lead time, delay, ...)

Cost structure

- Low relevance of fixed assets, depending on utilization and customization of machinery
- A lot of manual operations cause relevance of workforce utilization

Classification of Production Systems

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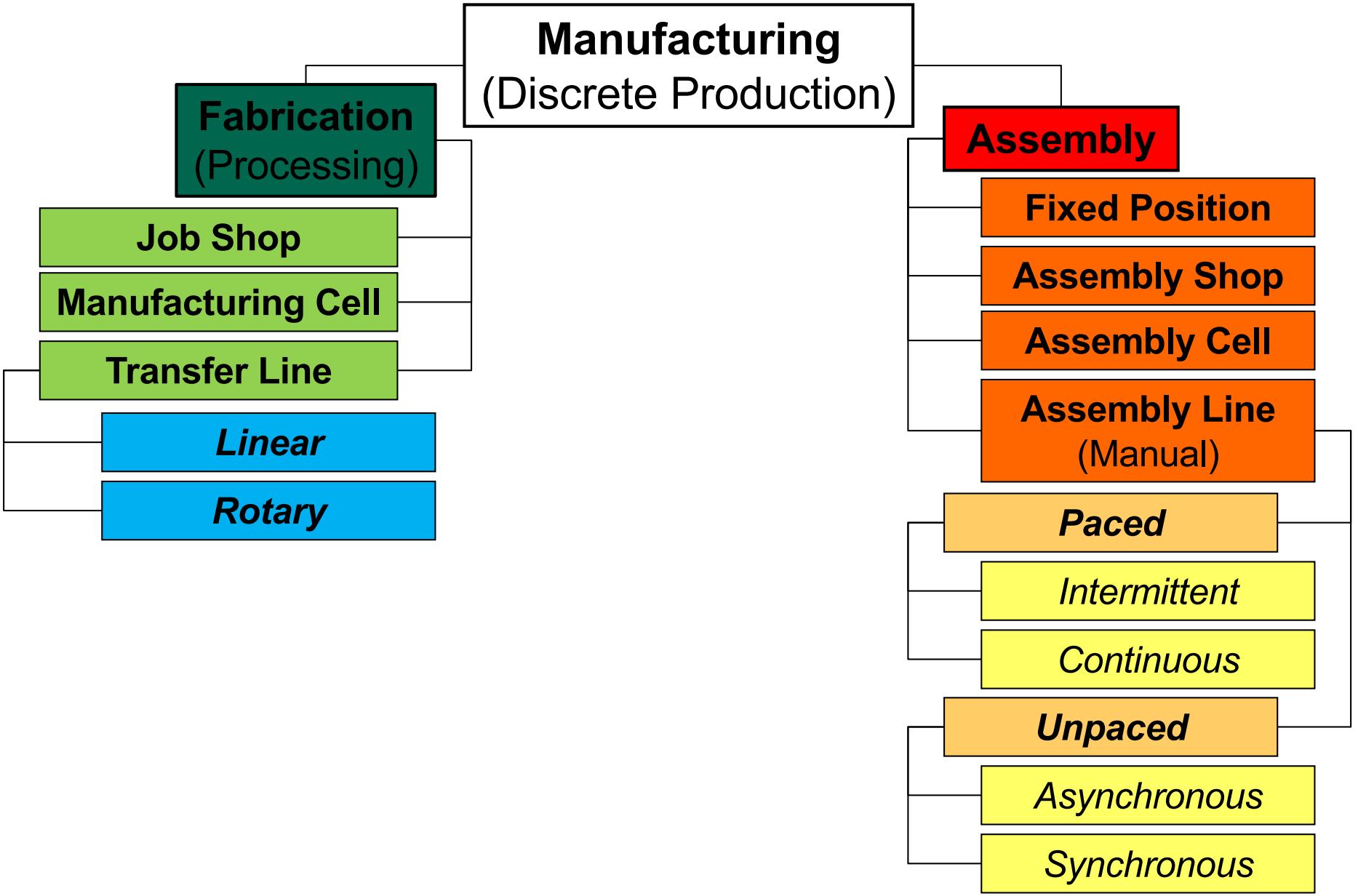

Classification by production method (volume)

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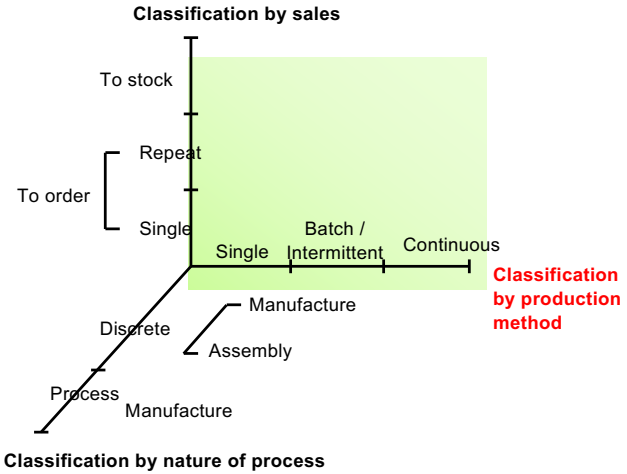
Continuous production

- Mass production
- Stable demand for commodity type products
  → producer normally does not have to store products in a planned way
- Product examples:
  - Process production products
  - low-cost mechanical parts (screws, nuts and bolts, …)



Batch / Intermittent production

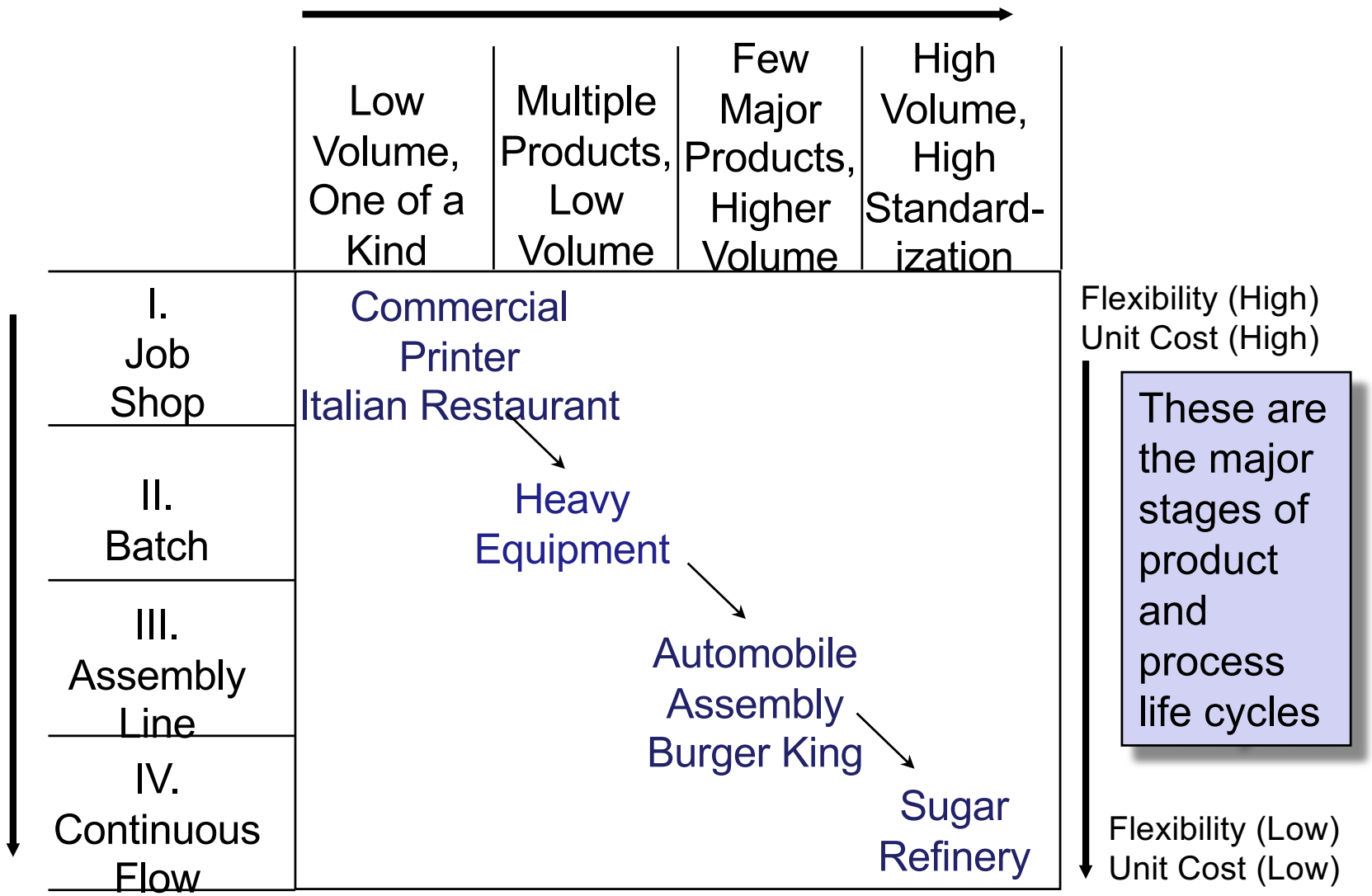
- Volume of production ranges from high to medium to low
- Trade-off between production and storage costs and demand for different types of products require production in batches (and thus set-up costs)
- Product examples:
  - Mechanical components of cars or machine tools, electrical components, cars, furniture, …

Single / Unitary production (one of a kind production (OKP) or project)

- **Borderline case**: batch production with a batch of one unit of product (set-up issues). Variability of the range of products manufactured is very high. Production performed unit by unit and the production cycle is changed from one product to the following one. Flexibility, no efficiency.

- **Project**: (particular case): product produced only once according to special design specs. Demand for a single item only. Product examples: facilities for process industry or power station, ship, custom-built car, …

Manufacturing Systems vs. variety, flexibility and volume



Classification by market interaction

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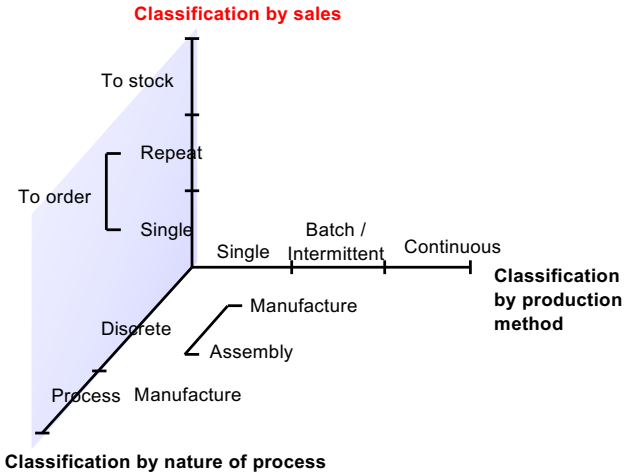

Stocked product (production to stock)

- Often produced in advance of demand (on the basis of forecasts)
- Standard specifications
- Response time lower then lead time
- Production starts in advance of order
- Relatively small range of products, standard products
- Ease of purchase for buyer
- Steady demand
- Customer demand is fulfilled by stock availability

E.g. integrated circuits, resistors, standard valves, consumer goods, PCs, automotive components, cement, paper, etc.

Classification by market interaction

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To order production:

Customised product (repeated production to order)

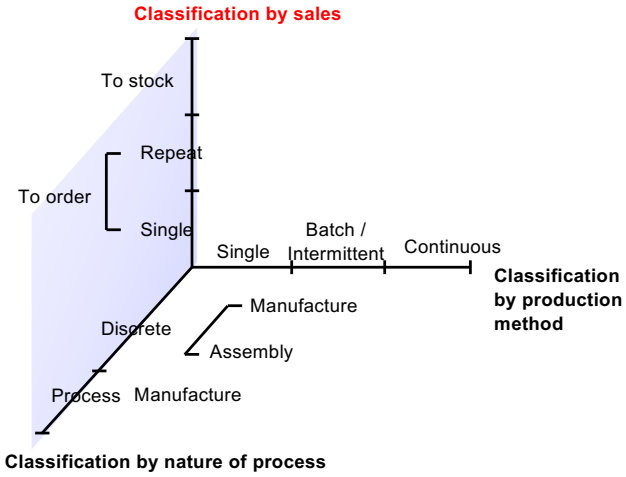
- Flexible specifications, wide range of options
- Response time higher then lead time
- Fabricated or assembled on repetitive demand
- Catalogue production

E.g. cars, equipment, PCs, machine tools, etc.

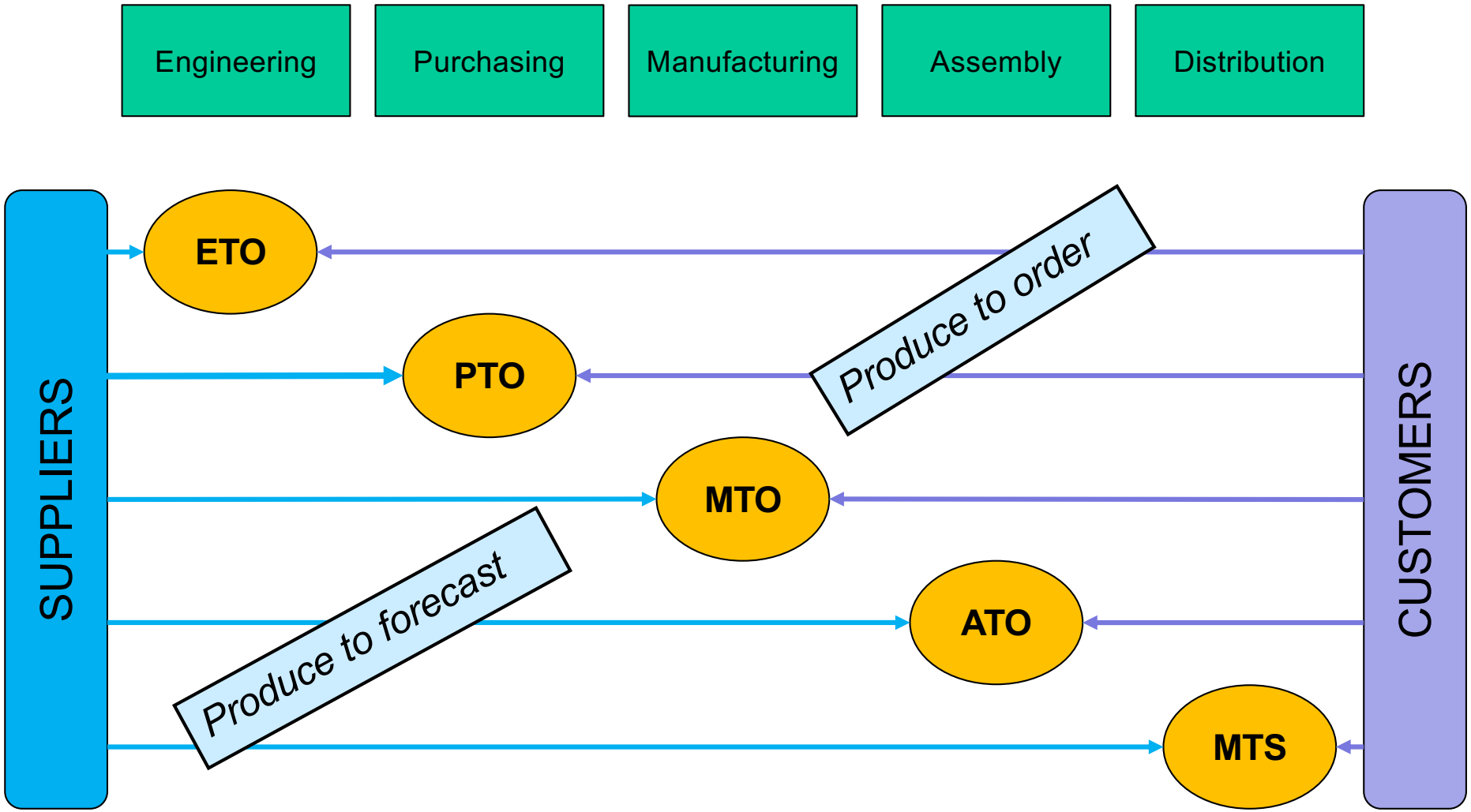
Engineered product (single production to order)

- Designed and defined only on order
- Produced exactly to customer requirements, no repetition
- High lead times, but less then response time

E.g. power station equipment, tailored clothes, special part, assembly equipment, etc.



Wortmann classification (CODP Concept)



MTS - Make to stock ***ATO - Assemble to order***
MTO - Make to order ***PTO - Purchase to order***
ETO - Engineer to order (/ Project)

Production systems classification
Correlations

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How these products production systems can be classified in the three axes?

- Single
- To order (repeat)
- Discrete fabrication

- Single
- To order (single)
- Assembly

- Continuous
- To stock
- Process

- Batch
- To stock
- Assembly

Production systems classification
Correlations

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	Single	Batch	Continuous
To stock		Commercial clothing	Water bottles replenishment
Repeat	Pizzeria	Machine tool	
Single	Tailored clothing		

Production systems classification
Correlations

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	Single	Batch	Continuous
Process manufacture		Semiconductors	Cement, paper, glass
Discrete manufacture	Customized mechanical parts	Glasses frames	Steel plastic shaping
Assembly	Shipbuilding	Electronical commodities	Car assembly

Production systems classification
Correlations

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	Process manufacture	Discrete manufacture	Assembly
To stock	Plastic	Pharmaceutical	Staples
Repeat		Pizzeria	Machine tools
Single			Shipbuilding

Production systems classification

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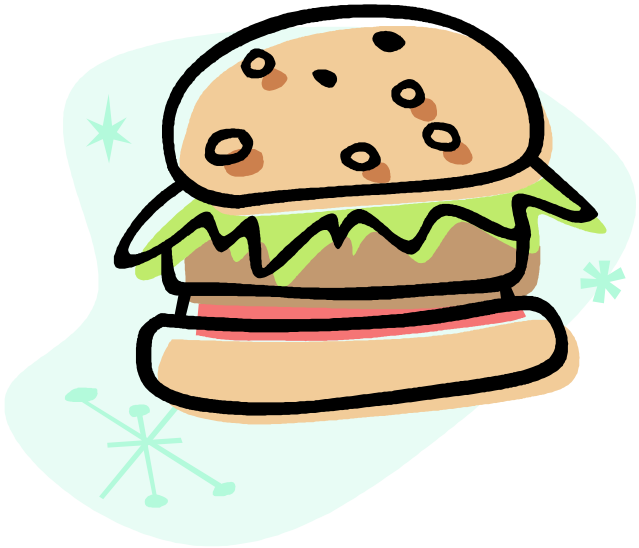
How McDonald's production system is organized?



McDonald's production process - classification

How would you classify this production process?