Chapter 6. Production Process and Factory Layout

Basic references:

- Heizer, J. & Render, B. (2009): Operations Management. New Jersey: Pearson Prentice Hall

Chapter 6. Production Process and Factory Layout

6.1.- Production strategies

6.2.- Just in time (JIT) systems

6.3.- Process design in services firms

6.4.- Analysis and design of process flow

6.5.- Layout types

6.6.- Layout distribution methods

6.7.- Layout in services firms

6.1.- Production strategies

Production strategy must allow:

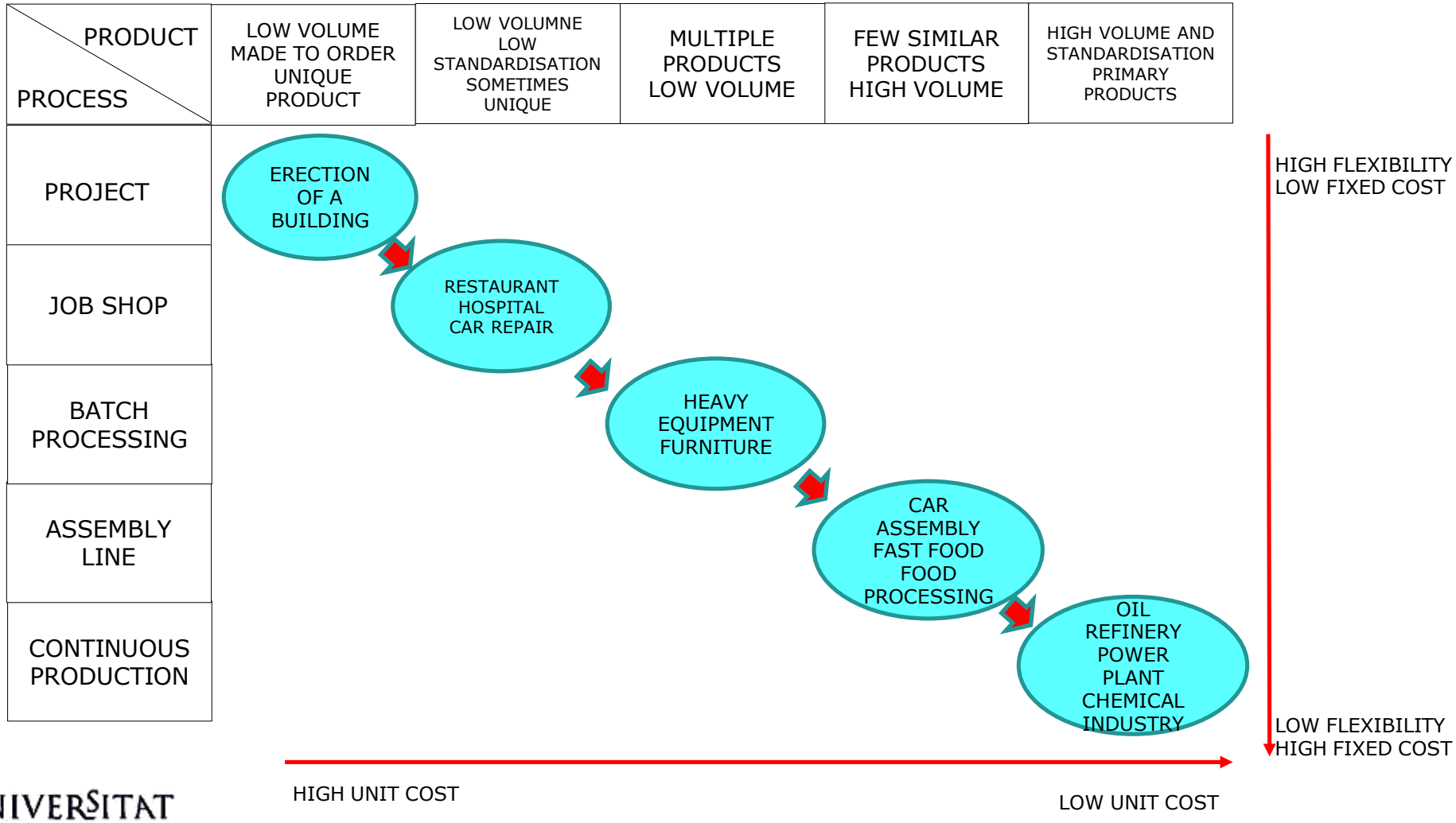
An efficient and smooth information and product flow

- Time
- Cost
- Quality

It influences

- How equipment is arranged
- Productive capacity
- Level of staffing
- Fixed assets investment

6.1.- Production strategies



6.1.- Production strategies

PROJECT PROCESSES

- Unique, exclusive product tailored to customer's specific needs.
- Operations sequence is unique for each project.
- Highly qualified and multipurpose personnel.
- Long completion time, complex.
- *Building, oil tanker, advertising campaign.*
- Project management techniques.

JOB SHOP APPROACH

- Small batch fabrication of a high variety of products.
- Variable production speed (each order or batch requires different operations)
- Flexible workforce, based on skills and knowledge of personnel.
- Low automation (specialisation in activities).
- Flexible equipment
- Low fixed costs, high unit variable costs.
- *Car repair workshops, made-to-order production, hospitals*

COMMON FEATURES :

- Fabrication to order or unique products.
- Emphasis on quality and speed vs price.
- Diverse activities.
- Flexible process.
- Multipurpose machinery and workforce.
- Variable capacity
- Decentralised structures
- Qualified and flexible human resources.

6.1.- Production strategies

Batch processing

- Stable product line
- Batches move between sections.
- Higher automation degree. Higher specialisation degree.Less variable cost than jobshop.
- *Electronics manufacturing, heavy equipment*

6.1.- Production strategies

ASSEMBLY PROCESSES

- Making standardised products.
- Product flows along assembly process, at a controlled pace and with low intermediate inventory.
- Repetitive tasks, high automation, low workforce qualification.
- Low flexibility process. A change implies re-programming equipment.
- High fixed costs and reduced variable cost.
- *Car assembly, fast food.*

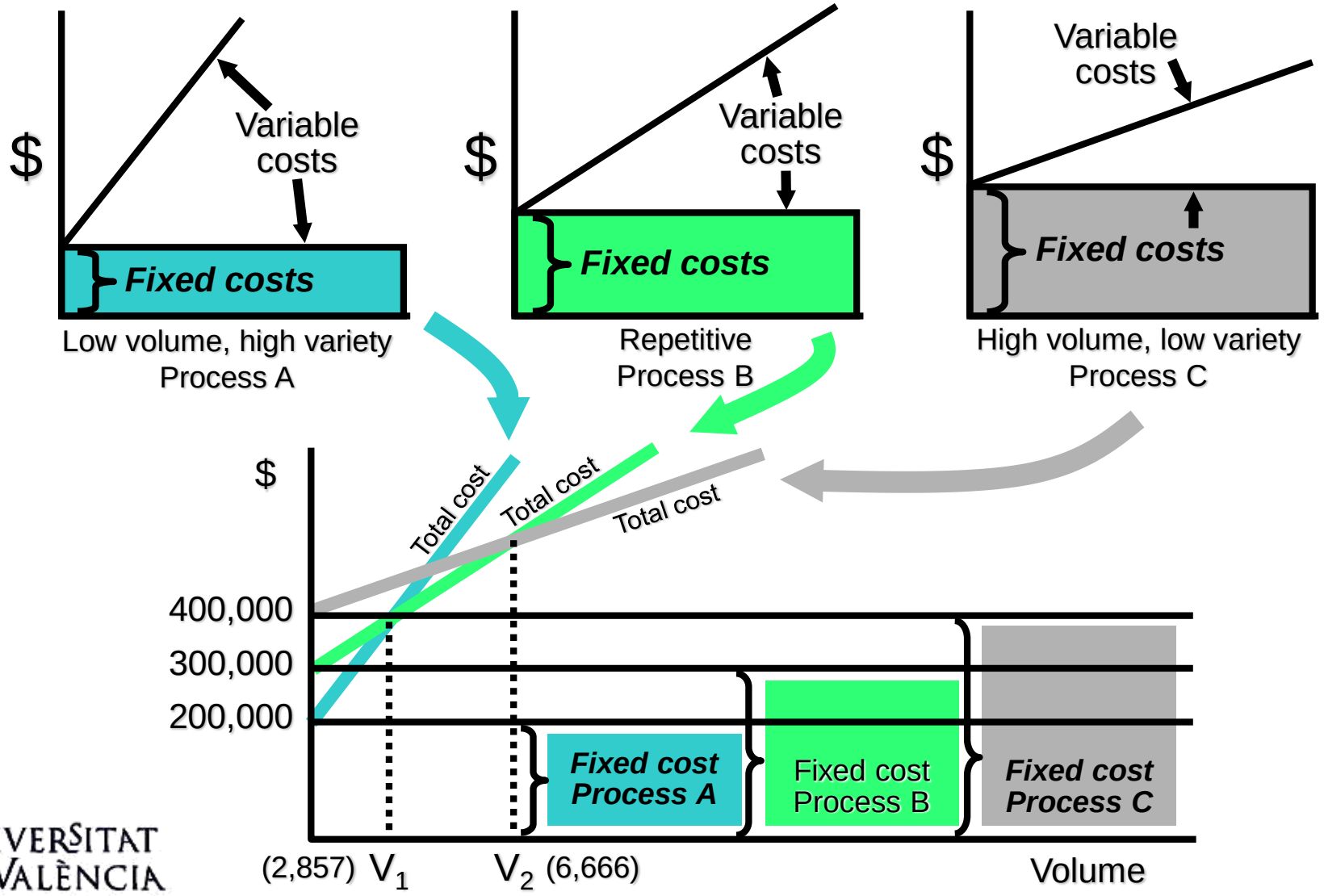
CONTINUOUS PRODUCTION

- Continuous material flow
- Stoppages and start-ups costly. Highly automated.
- High process homogeneity, repetitive operations.
- *Oil refinery, steel mill*

COMMON FEATURES :

- Fit for standardised goods and services.
- High production volumes.
- Emphasis on price as competitive variable.
- Standard processes, highly automated tasks.
- Quality assured by integration in the process.
- Centralised structure.
- Specialised human resources, but not necessarily highly qualified.

Crossover charts



6.2.- Just in time (JIT) systems

Toyota Motor Corporation

- ☑ ***Largest vehicle manufacturer in the world with annual sales of over 9 million vehicles***
- ☑ ***Continual problem solving is central to JIT***
- ☑ ***Eliminating excess inventory makes problems immediately evident***
- ☑ ***Respect for people is fundamental***
- ☑ ***Subassemblies are transferred to the assembly line on a JIT basis***
- ☑ ***High quality and low assembly time per vehicle***

Just-In-Time

- ☑ ***A 'philosophy' of continuous and forced problem solving via a focus on reduced inventory***
- ☑ ***It supplies the customer with their exact wants when the customer wants it and without waste***
- ☑ ***Emphasises employee learning and empowerment in an assembly-line environment***
- ☑ ***Emphasises understanding the customer and having a narrow connection.***
- ☑ ***Emphasises eliminating waste. Waste is anything that does not add value from the customer point of view.***

JIT and competitive advantage

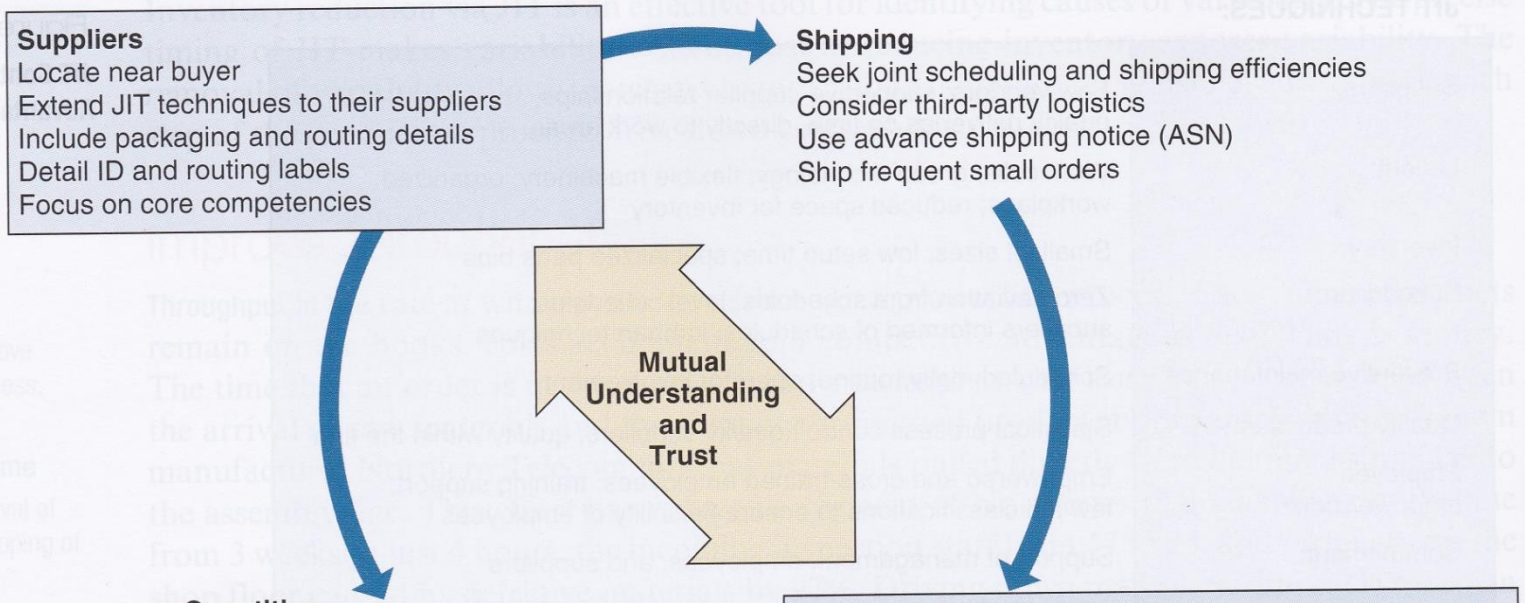
JIT TECHNIQUES:

Suppliers:	Few vendors; Supportive supplier relationships; Quality deliveries on time, directly to work areas.
Layout:	Work-cells; Group technology; Flexible machinery; Organized workplace; Reduced space for inventory.
Inventory:	Small lot sizes; Low setup time; Specialized parts bins
Scheduling:	Zero deviation from schedules; Level schedules; Suppliers informed of schedules; Kanban techniques
Preventive maintenance:	Scheduled; Daily routine; Operator involvement
Quality production:	Statistical process control; Quality suppliers; Quality within the firm
Employee empowerment:	Empowered and cross-trained employees; Training support; Few job classifications to ensure flexibility of employees
Commitment:	Support of management, employees, and suppliers

Faster response to the customer at lower cost and higher quality—

A Competitive Advantage

JIT partnerships



LO3 *Explain* JIT partnerships

Reduce waste

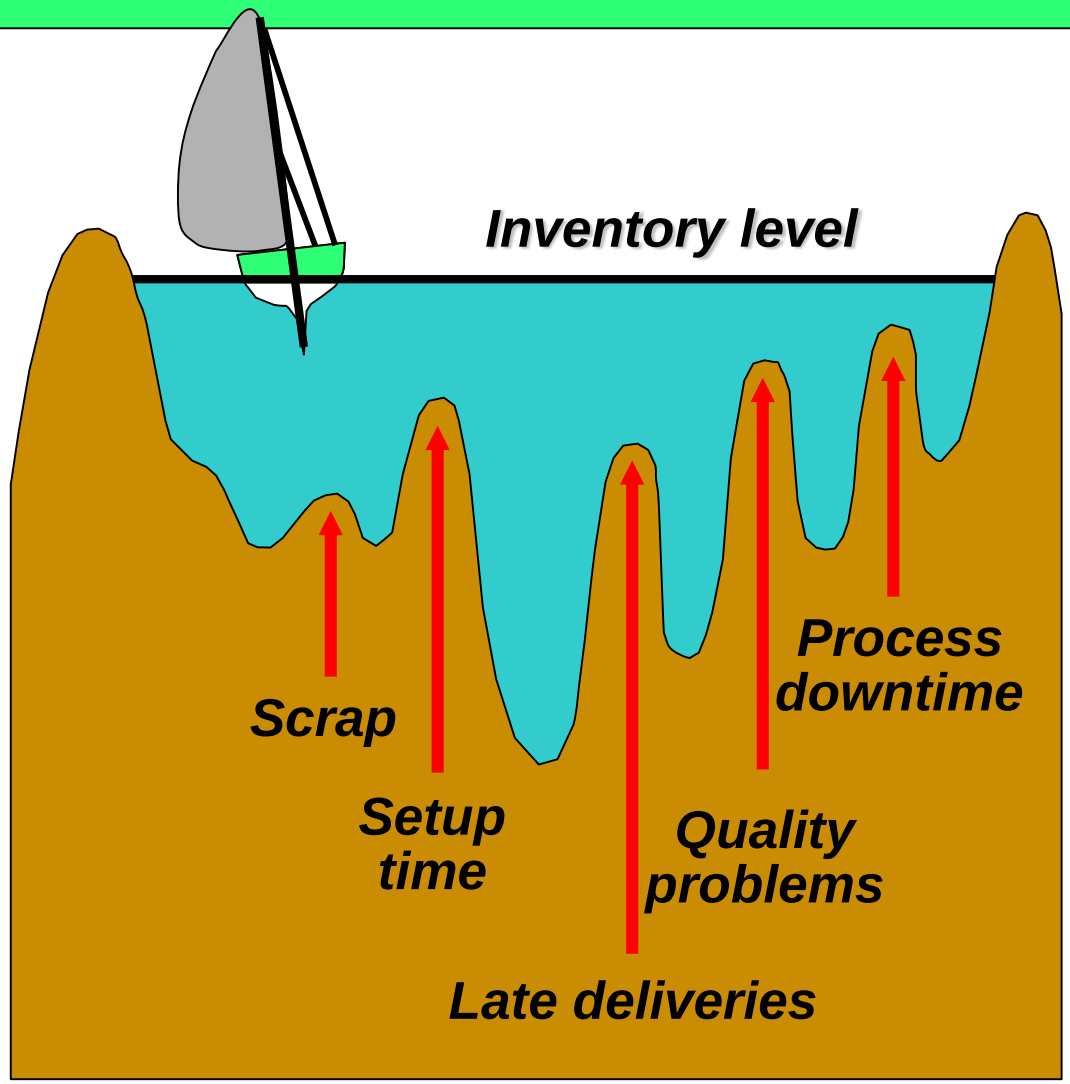


Figure 16.3

Reduce waste

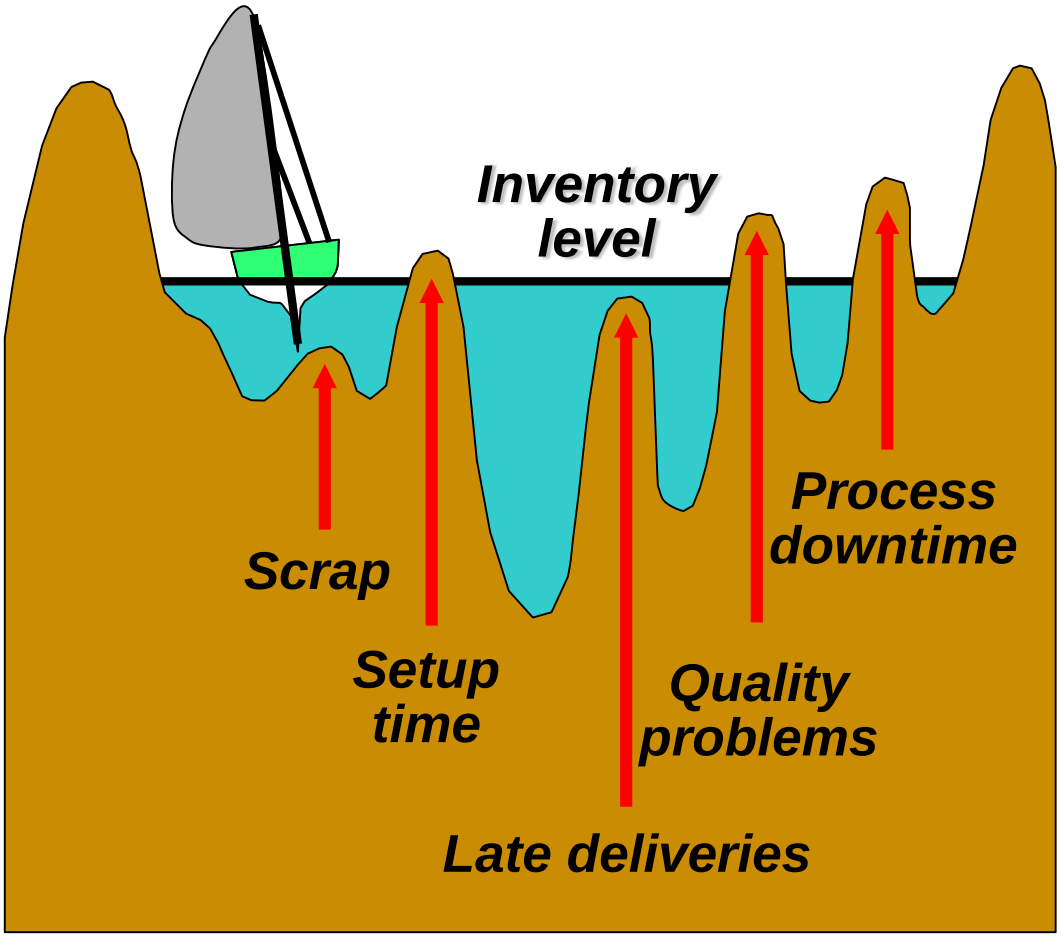
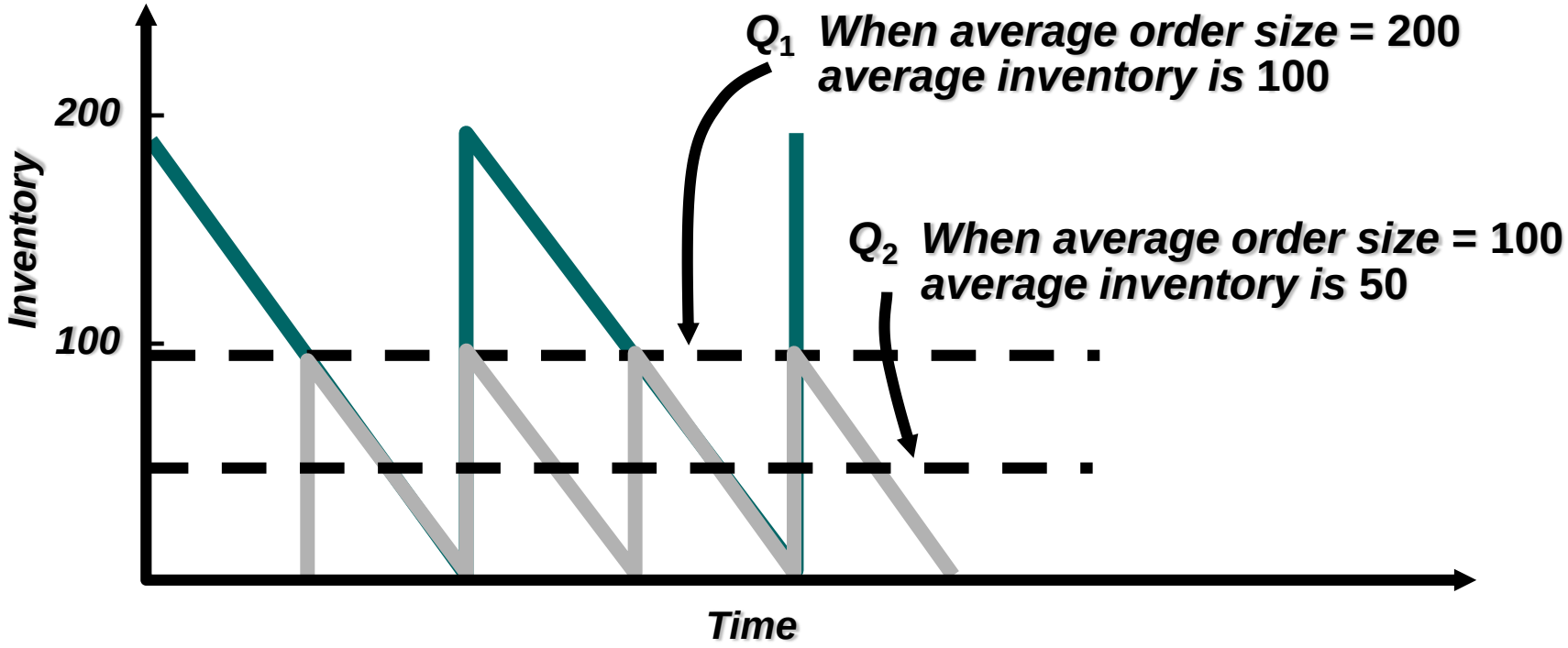


Figure 16.3

5 S

- ☑ ***Sort/segregate: keep what is needed and remove anything else from working area.***
- ☑ ***Simplify/straighten. Improve workflow***
- ☑ ***Shine: clean daily***
- ☑ ***Standardise: remove variations from production using standard operating procedures and checklists.***
- ☑ ***Sustain/self-discipline: review periodically to recognise efforts and to sustain progress.***
- ☑ ***Plus:***
- ☑ ***Safety***
- ☑ ***Support maintenance: reduce unplanned downtime.***

Reduce lot sizes



Lot size example

D = *Annual demand* = 400,000 *units*
d = *Daily demand* = 400,000/250 = 1,600 *per day*
p = *Daily production rate* = 4,000 *units*
Q = *EOQ desired* = 400
H = *Holding cost* = \$20 *per unit*
S = *Setup cost (to be determined)*

$$Q = \sqrt{\frac{2DS}{H(1 - d/p)}} \qquad Q^2 = \frac{2DS}{H(1 - d/p)}$$

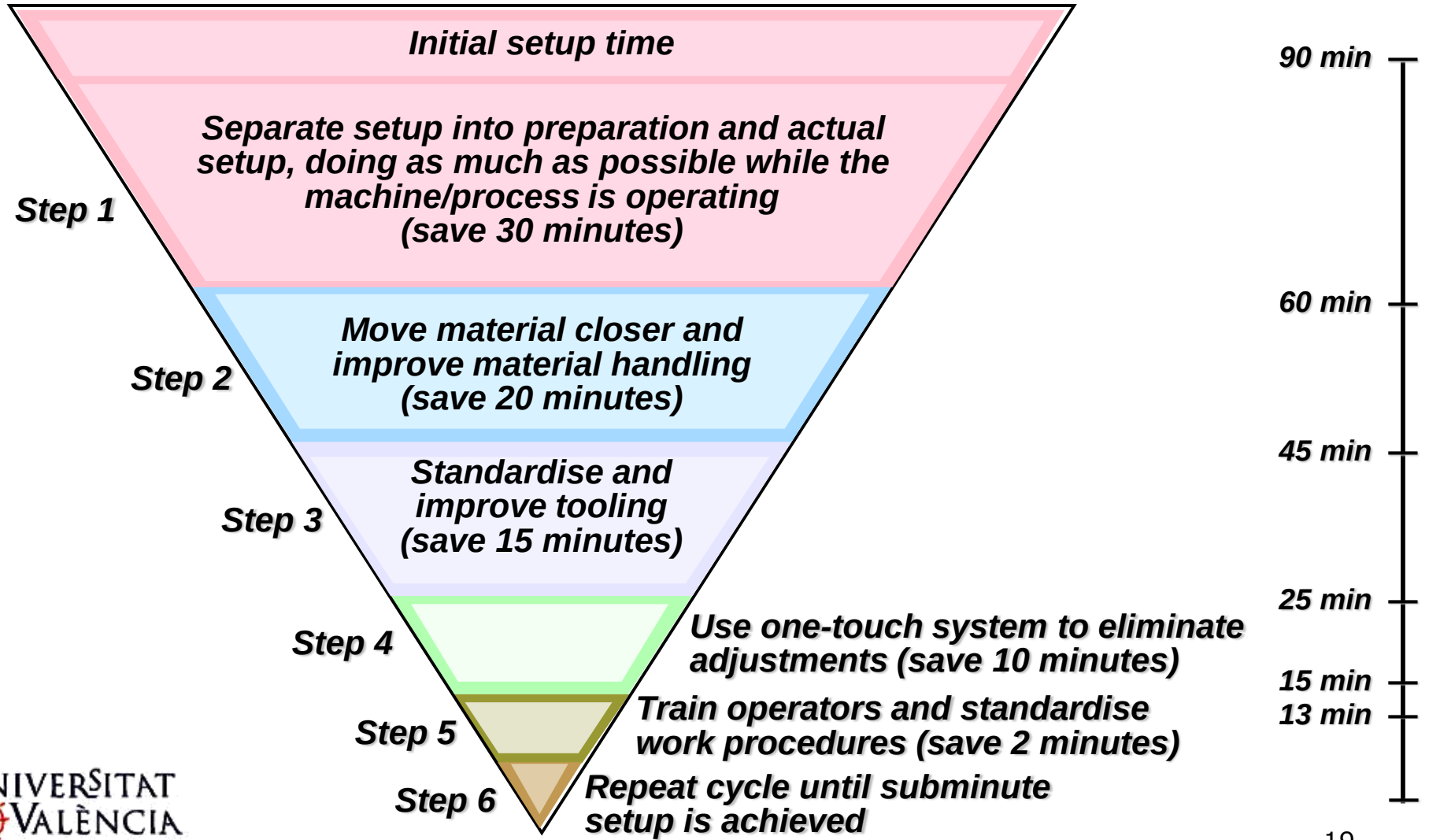
$$S = \frac{(Q^2)(H)(1 - d/p)}{2D} = \frac{(3{,}200{,}000)(0.6)}{800{,}000} = \$2.40$$

Setup time = \$2.40/(\$30/*hour*) = 0.08 *hr* = 4.8 *minutes*

Reduce setup costs

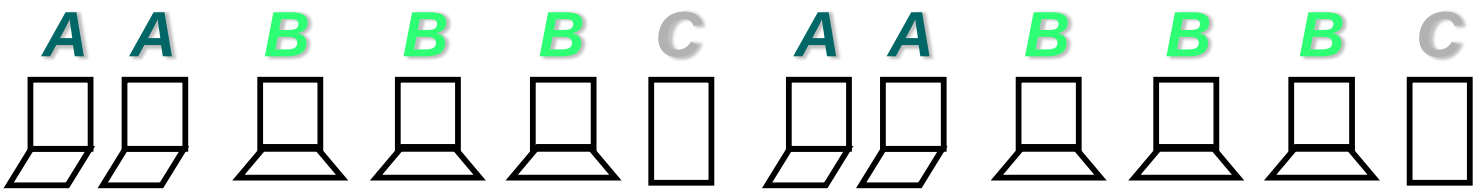
- ☑ ***High setup costs encourage large lot sizes***
- ☑ ***Reducing setup costs reduces lot size and reduces average inventory***
- ☑ ***Setup time can be reduced through preparation prior to shutdown and changeover***

Reduce setup times

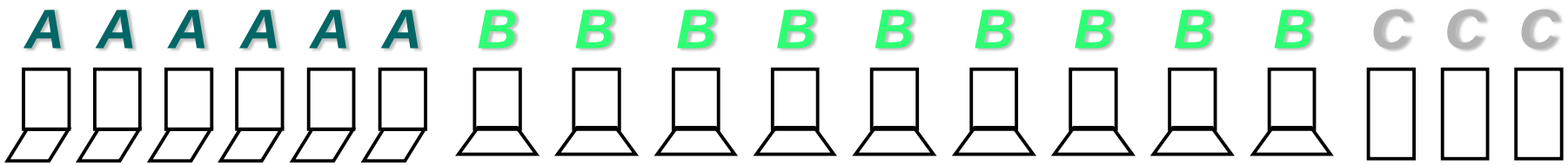


Scheduling small lots

JIT level material-use approach



Large-lot approach



Time

Kanban

- ☑ ***Kanban is the Japanese word for card***
- ☑ ***The card is an authorisation for the next container of material to be produced***
- ☑ ***A sequence of kanbans pulls material through the process***
- ☑ ***Many different sorts of signals are used, but the system is still called a kanban***

Quality

- ☑ ***JIT cuts the cost of obtaining good quality because JIT exposes poor quality***
- ☑ ***Because lead times are shorter, quality problems are exposed sooner***
- ☑ ***Better quality means fewer buffers and allows simpler JIT systems to be used***

JIT in Services

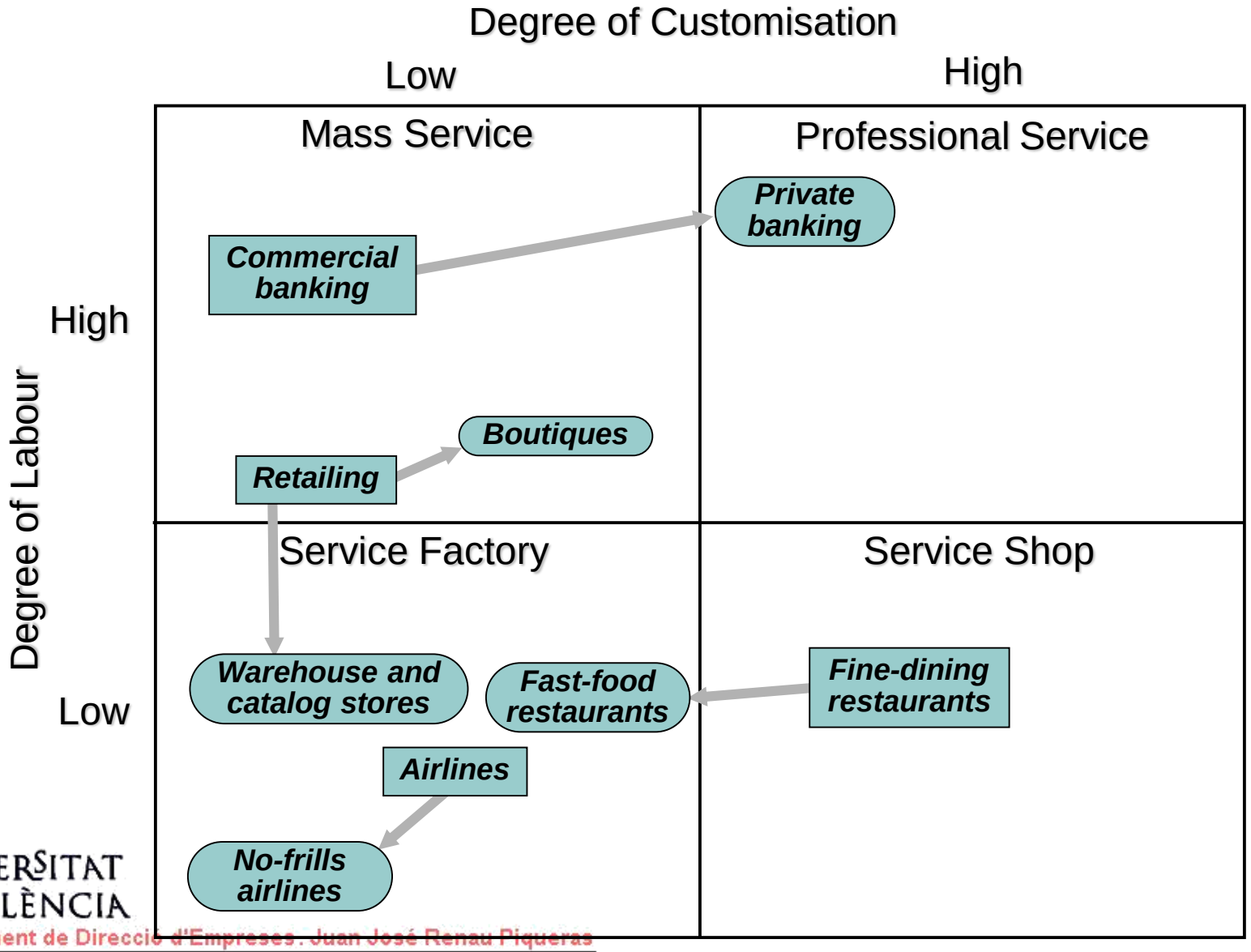
- ***The JIT techniques used in manufacturing are used in services***
  - ***Suppliers***
  - ***Layouts***
  - ***Inventory***
  - ***Scheduling***

6.3.- Process design in service firms

According to the customer involvement in the delivery process, we can classify service processes in:

Service Factory	• ALLOWS HIGH AUTOMATION DEGREE • VERY SLIGHT CUSTOMER PARTICIPATION • *FAST FOOD*
Self-Service	•CUSTOMER PARTICIPATES IN THE DELIVERY PROCESS •STANDARDISED SERVICES / SERVICES ON ORDER •*SUPERMARKETS, VENDING MACHINES*
Project Service	• SLIGHTLY STANDARDISED PROCESSES • LIMITED CUSTOMER PARTICIPATION • *MARKET RESEARCH*
Service Alliances	•PERSONAL ATTENTION TO CUSTOMER •HIGHLY SPECIALISED SERVICES WITH IMPORTANT CUSTOMER INTERACTION •*HAIR DRESSING SALOONS, RESTAURANTS*

Service process matrix



Improving service processes

- ☑ Layout
  - ☑ Product exposure, customer education, product enhancement
- ☑ Human resources
  - ☑ Recruiting and training
  - ☑ Impact of flexibility

6.4.- Analysis and design of process flow

Once the process type has been selected, we must optimise its design and adapt to the features of our firm.
We have to periodically analyse the flows (raw materials, components and finished products)

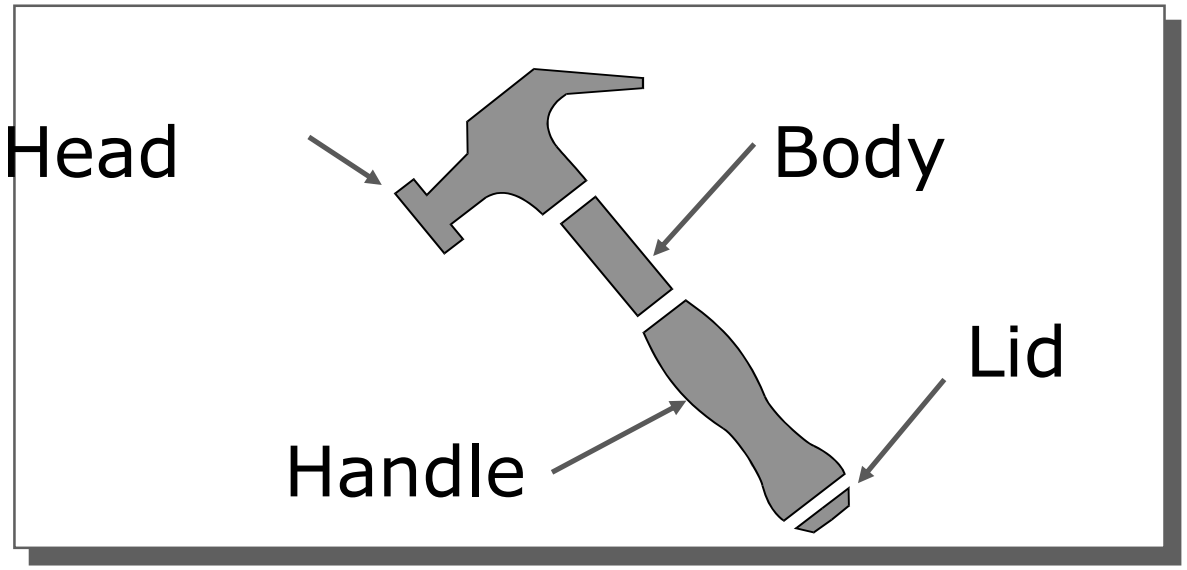
What is being made? When is each operation performed? By whom? Is this person sufficiently qualified? How is the operation made? Does everything made add value to the product, or only cost? Is the order of operations the best one? …

Tools and documents used in production

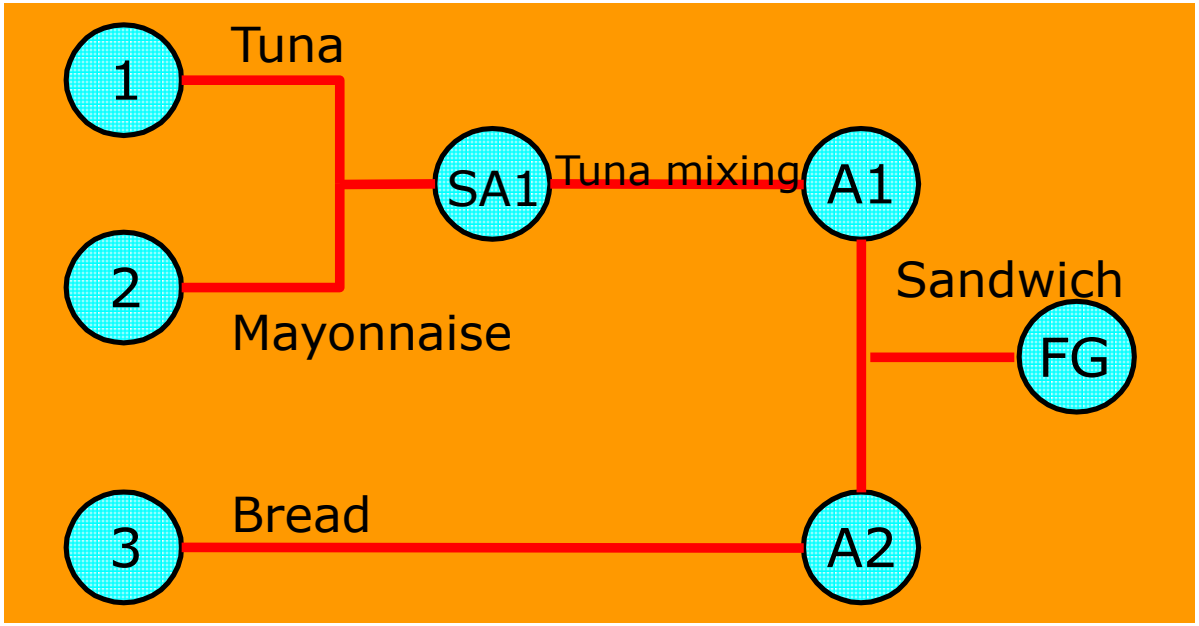
- Assembly plan
- Assembly diagram
- Process charts
- Service diagrams
- Works order

Assembly plan

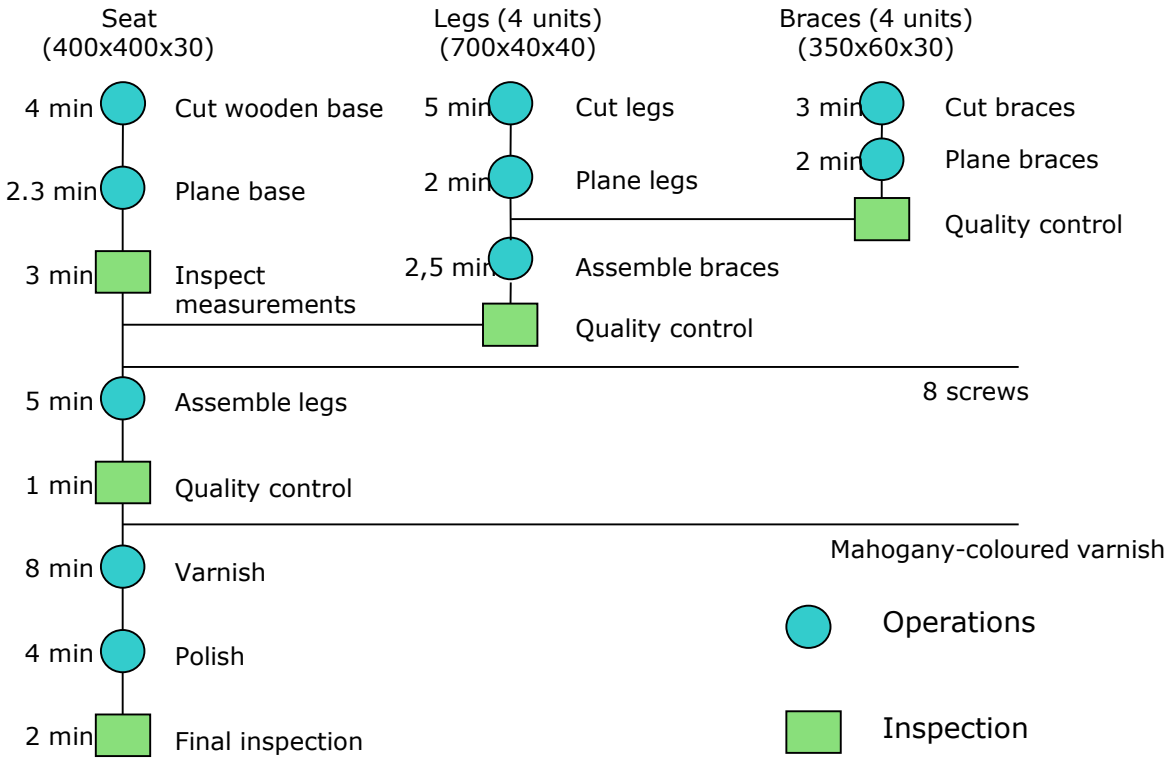
- An exploded view of product assembly.



Assembly diagram of a tuna sandwich



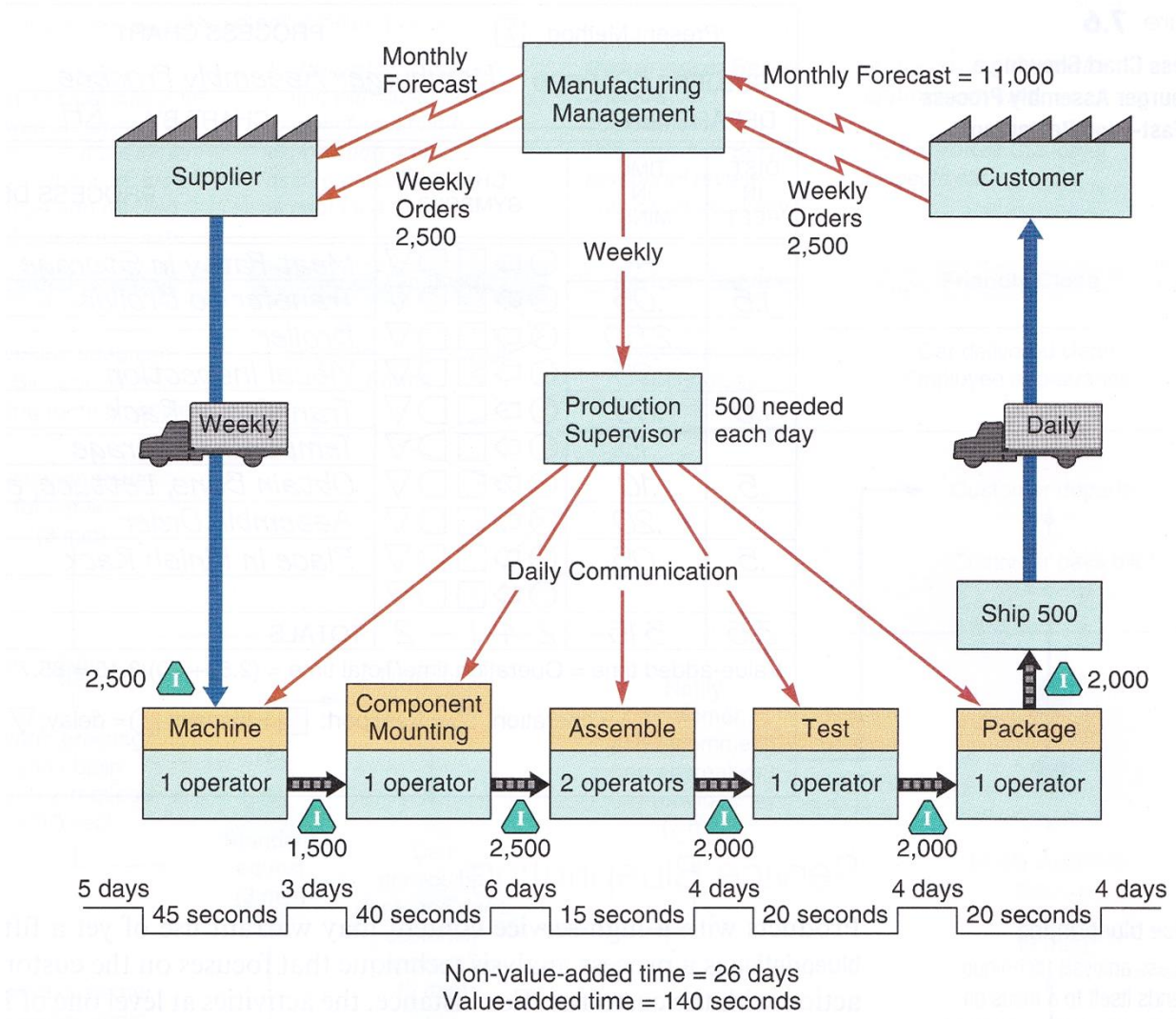
Assembly diagram of a wooden stool



Process chart of a wooden stool

ACTIVITY	SYMBOLS	Time minutes	Distance metres	Comments
Send to the cutting section		2	50	
Cut base		4		
Wait for the worker at next section		1		
Plane wooden parts		2.3		
Wait for transport vehicle		1		
Carry to the inspection area		3.5	150	
Inspect dimensions and finish		3		
Transport to the warehouse		4	250	
Warehousing		5		

Process diagramming: value stream mapping (VSM)



Process reengineering

Business process reengineering (BPR)
Hammer and Champy, the developers, define it as a fundamental review and radical redesign of processes, with the aim of achieving radical improvements in performance (cost, quality, service, speed). In other words, to re-invent the firm.

PHASES

- Analyse deeeply the current process.
- Search for new processes that enhance efficiency
- Design and document new processes.
- Implement the new processes, controlling the start-up and adding the necessary corrective measures.

6.5.-Layout types

Innovations at McDonald's

- ☑ ***Indoor seating (1950s)***
- ☑ ***Drive-through window (1970s)***
- ☑ ***Adding breakfast to the menu (1980s)***
- ☑ ***Adding play areas (late 1980s)***
- ☑ ***Redesign of the kitchens (1990s)***
- ☑ ***Self-service kiosk (2004)***
- ☑ ***Now three separate dining sections***

McDonald's new layout

- Three separate dining areas
  - Linger zone with comfortable chairs and wifi connections
  - Grab and go zone with tall counters
  - Flexible zone for kids and families
- Facility layout is a source of competitive advantage
- McDonald's in Norway vs. Spain (Coke)

Strategic importance of layout decisions

The objective of layout strategy is to develop a cost-effective layout that will meet a firm's competitive needs

Layout design considerations

- ☑ ***Higher utilisation of space, equipment, and people***
- ☑ ***Improved flow of information, materials, or people***
- ☑ ***Improved employee morale and safer working conditions***
- ☑ ***Improved customer/client interaction***
- ☑ ***Flexibility***

☑example: lay-out at university

Good layouts consider:

1. ***Material handling equipment***
2. ***Capacity and space requirements***
3. ***Environment and aesthetics***
4. ***Information flows***
5. ***Cost of moving between various work areas***

Fixed-position layout

- ☑ ***Product remains in one place***
- ☑ ***Workers and equipment come to site***
- ☑ ***Complicating factors***
  - ☑ ***Limited space at site***
  - ☑ ***Different materials required at different stages of the project***
  - ☑ ***Volume of materials needed is dynamic***

Process-oriented layout

- ☑ ***Similar machines and equipment are grouped together***
- ☑ ***Flexible and capable of handling a wide variety of products or services***
- ☑ ***Scheduling can be difficult and setup, material handling, and labour costs can be high***

Process-oriented layout

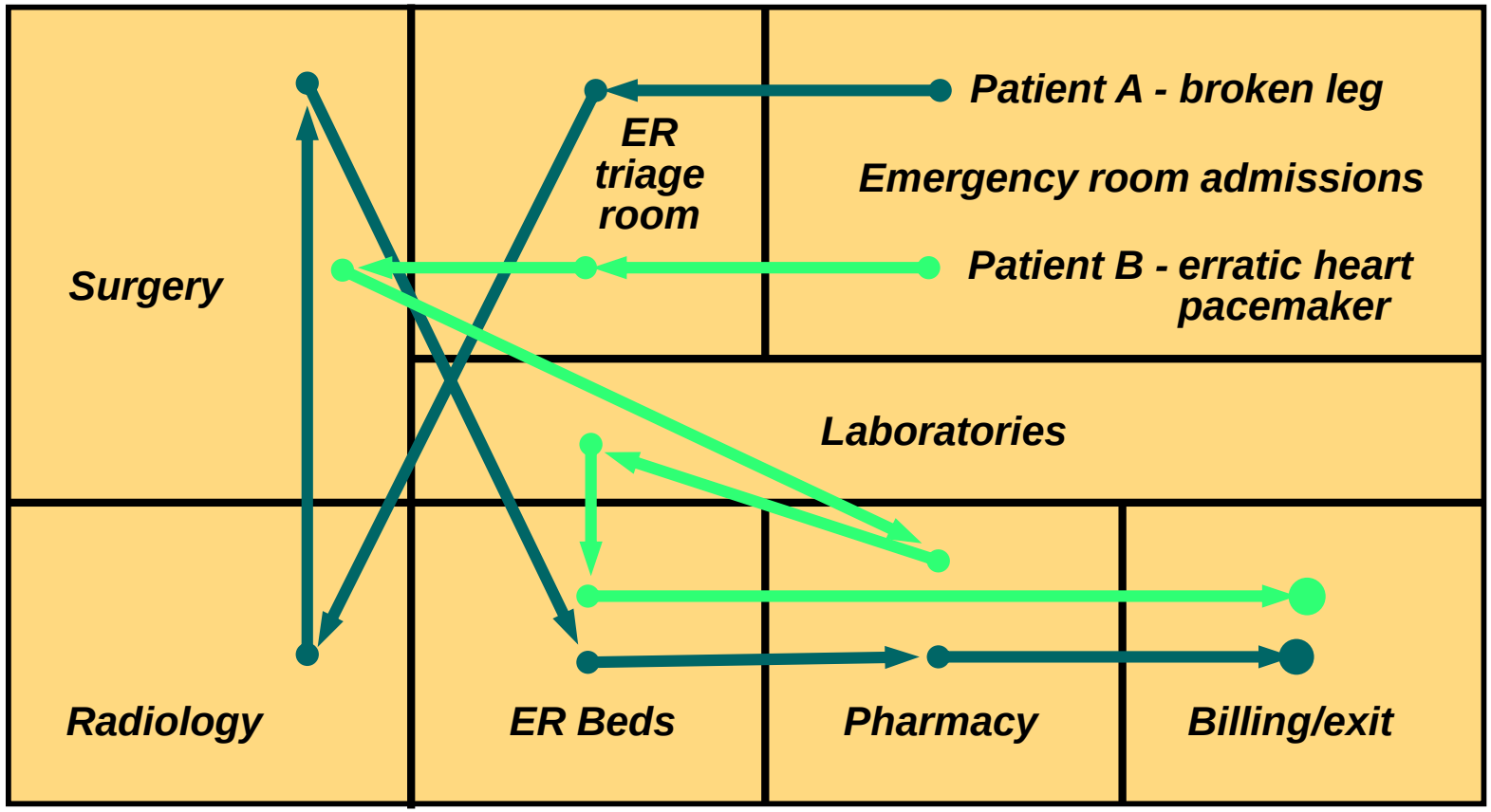


Figure 9.3

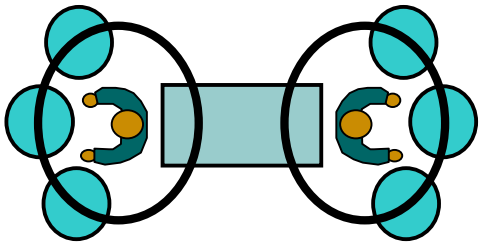
Work cells

- ☑ ***Reorganises people and machines into groups to focus on single products or product groups***
- ☑ ***Group technology identifies products that have similar characteristics for particular cells***
- ☑ ***Volume must justify cells***
- ☑ ***Cells can be reconfigured as designs or volume changes***

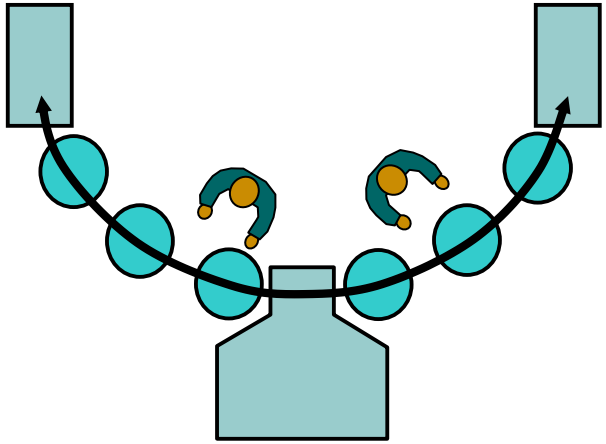
Advantages of work cells

1. Reduced work-in-process inventory
2. Less floor space required
3. Reduced raw material and finished goods inventory
4. Reduced direct labour
5. Heightened sense of employee participation
6. Increased use of equipment and machinery
7. Reduced investment in machinery and equipment

Improving layouts using work cells



Current layout - workers in small closed areas. Cannot increase output without a third worker and third set of equipment.

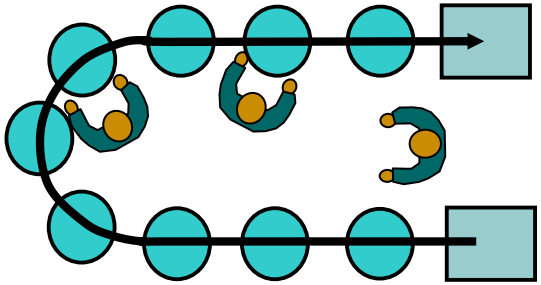


Improved layout -- cross-trained workers can assist each other. May be able to add a third worker as additional output is needed.

Figure 9.10 (a)

Improving layouts using work cells

Current layout - straight lines make it hard to balance tasks because work may not be divided evenly



Improved layout - in U shape, workers have better access. Fewer cross-trained workers needed.

U-shaped line may reduce employee movement and space requirements while enhancing communication, reducing the number of workers, and facilitating inspection

Figure 9.10 (b)

Repetitive and product-oriented layout

Organised around products or families of similar high-volume, low-variety products

1. ***Volume is adequate for high equipment utilisation***
2. ***Product demand is stable enough to justify high investment in specialised equipment***
3. ***Product is standardised or approaching a phase of life cycle that justifies investment***
4. ***Supplies of raw materials and components are adequate and of uniform quality***

Product-oriented layouts

- ***Assembly line***
  - ***Puts fabricated parts together at a series of workstations***
  - ***Paced by work tasks***
  - ***Balanced by moving tasks***

- ***Fabrication line. Builds components***

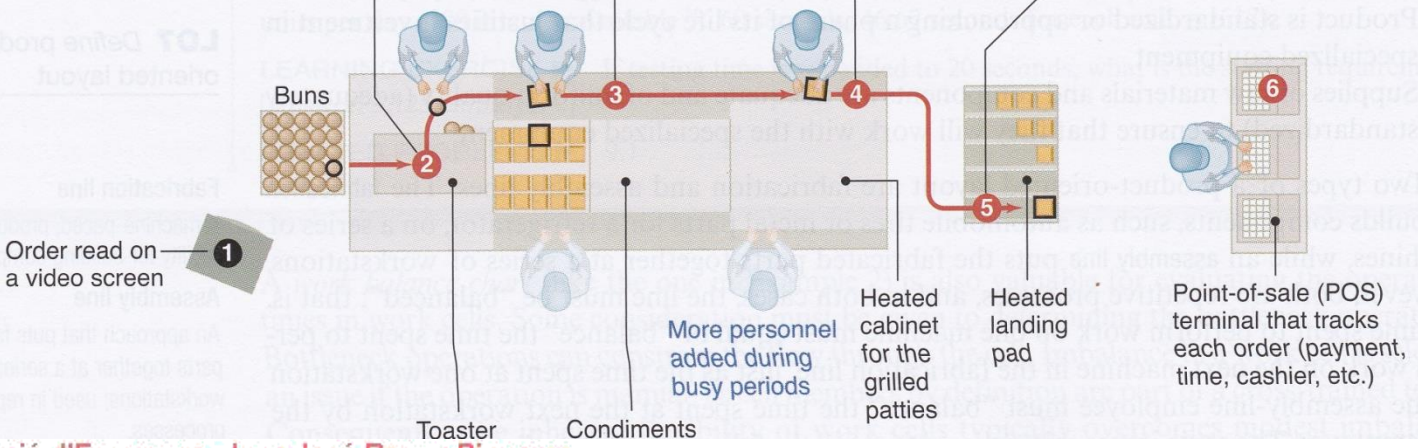
Product-oriented layouts

Assembly-Line Balancing

LO8 *Explain* how to balance production flow in a repetitive or product-oriented facility

Line balancing is usually undertaken to minimize imbalance between machines or personnel while meeting a required output from the line. To produce at a specified rate, management must know the tools, equipment, and work methods used. Then the time requirements for each assembly task (e.g., drilling a hole, tightening a nut, or spray-painting a part) must be determined. Management also needs to know the *precedence relationship* among the activities—that is, the sequence in which various tasks must be performed. Example 3 shows how to turn these task data into a precedence diagram.

Elapsed time	0:00	0:11	0:31	0:45		1:30
Task time (seconds)		11	20	14	0	45
Task	1. Order	2. Bun toasting	3. Assembly with condiments	4. Wrapping of patty with bun	5. Order picked up immediately to keep it fresh	6. Customer service (order and payment)



Product-oriented layouts

Advantages

1. ***Low variable cost per unit***
2. ***Low material handling costs***
3. ***Reduced work-in-process inventories***
4. ***Easier training and supervision***
5. ***Rapid performance***

Disadvantages

1. ***High volume is required***
2. ***Work stoppage at any point ties up the whole operation***
3. ***Lack of flexibility in product or production rates***

6.6.- Layout distribution methods

Techniques for process redesign

- Analysis of operations sequence
- Analysis of block diagrams
- Analysis of transport movements

Techniques for product distribution

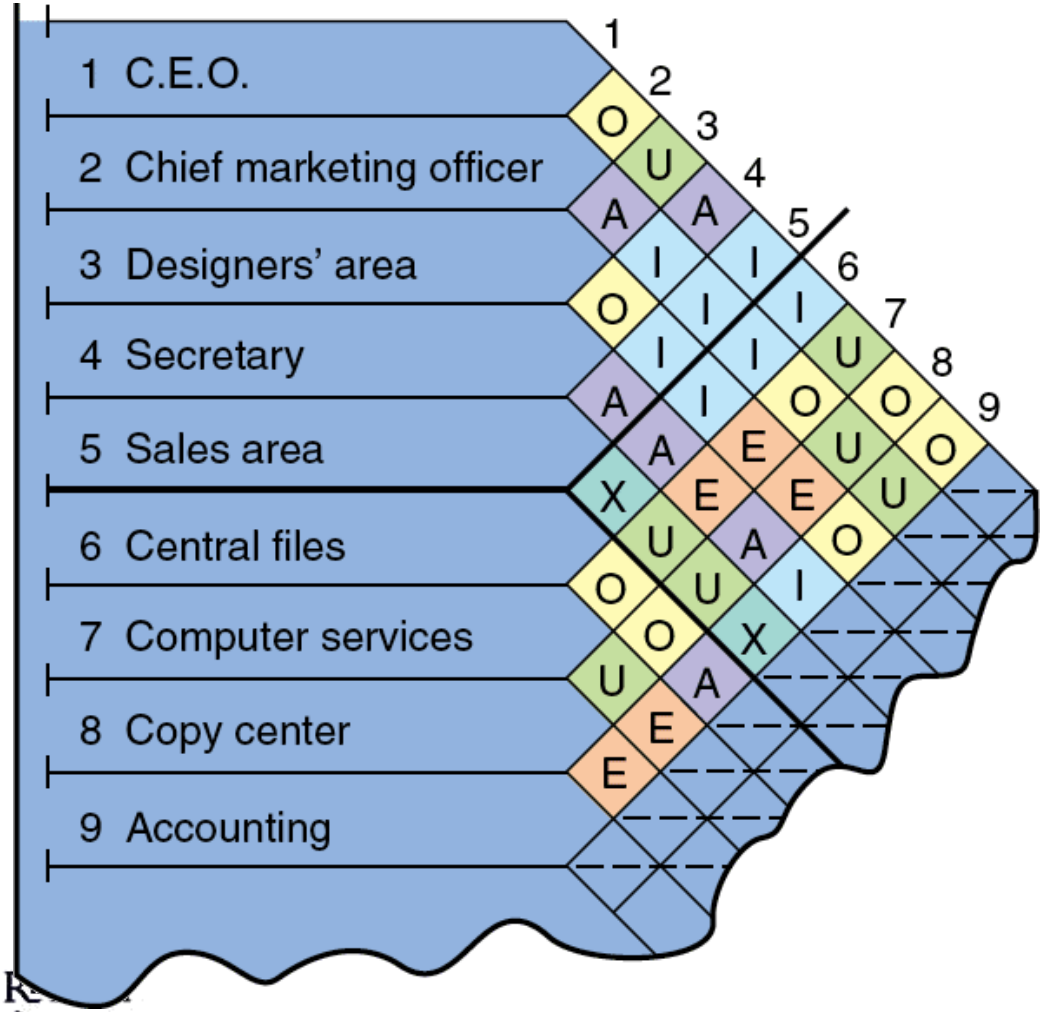
- Assembly line balancing.

6.7.- Layout in services firms

Office layout

- ☑ ***Grouping of workers, their equipment, and spaces to provide comfort, safety, and movement of information***
- ☑ ***Movement of information is main feature***
- ☑ ***Typically in state of flux due to frequent technological changes***

Relationship chart

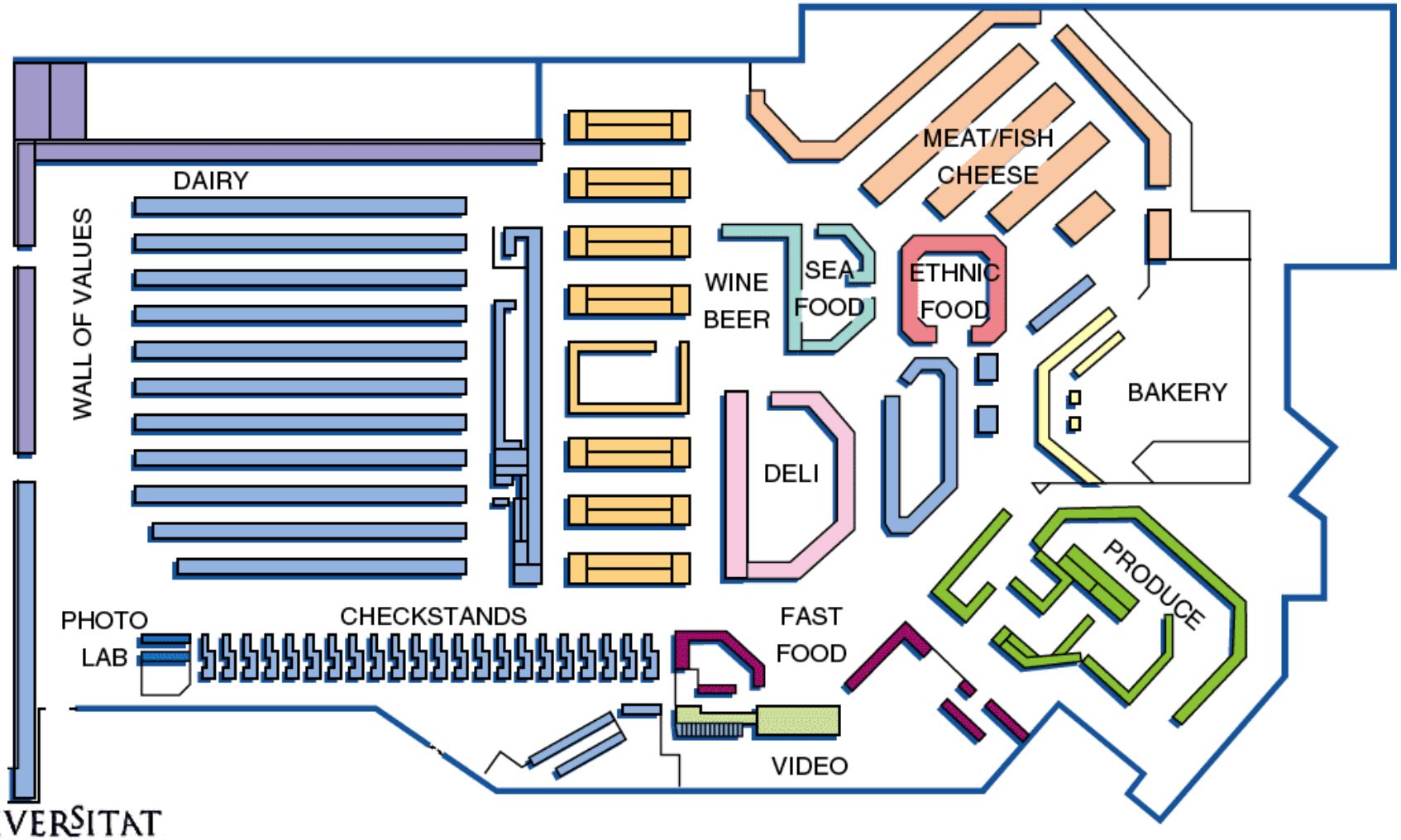


Value	CLOSENESS
A	Absolutely necessary
E	Especially important
I	Important
O	Ordinary OK
U	Unimportant
X	Not desirable

Supermarket retail layout

- ☑ ***Objective is to maximise profitability per square foot of floor space***
- ☑ ***Sales and profitability vary directly with customer exposure***

Store layout

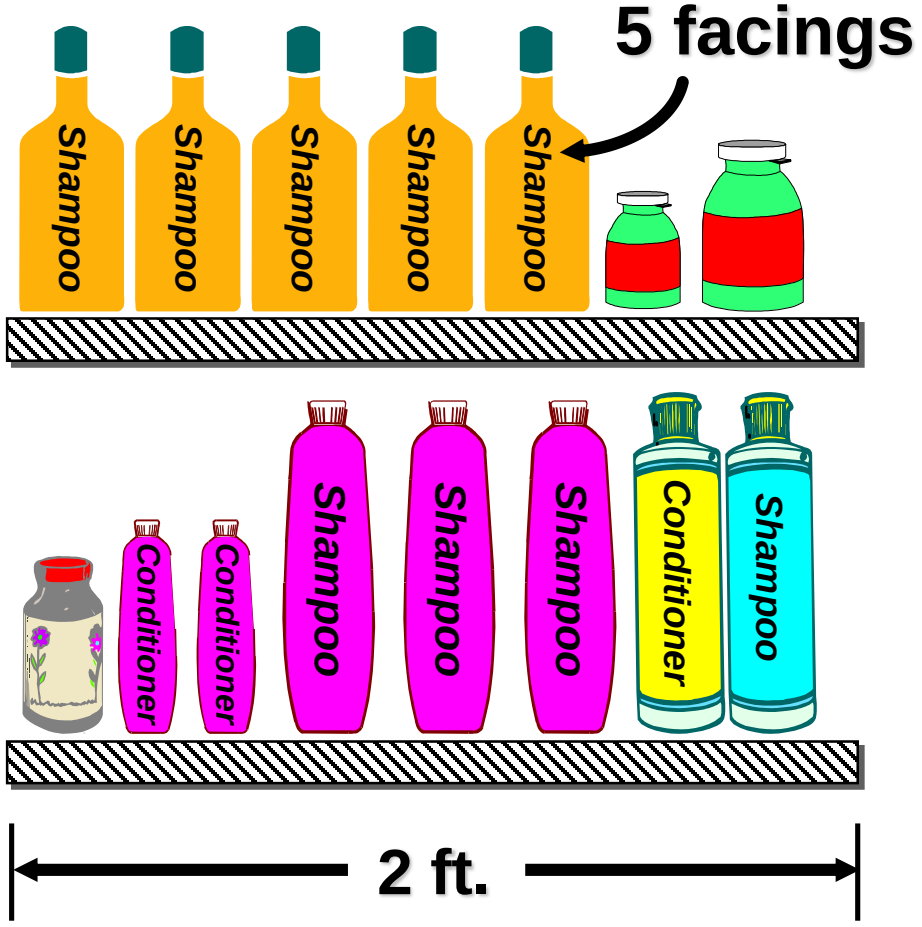


Retail slotting

- ***Manufacturers pay fees to retailers to get the retailers to display (slot) their product***
- ***Contributing factors***
  - ***Limited shelf space***
  - ***Increasing number of new products***
  - ***Better information about sales through POS data collection***
  - ***Closer control of inventory***

Retail store shelf space planogram

- ☑ Computerised tool for shelf-space management
- ☑ Generated from store's scanner data on sales
- ☑ Often supplied by manufacturer



Warehousing and storage layouts

- ☑ ***Objective is to optimise trade-offs between handling costs and costs associated with warehouse space***
- ☑ ***Maximize the total 'cube' of the warehouse – utilise its full volume while maintaining low material handling costs***

Warehouse layout

Traditional layout