Operations Management

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TECHNOLOGY & OPERATIONS MANAGEMENT (TOM)

Session 2:
Design of Product Operations and Service Operations, Process Technology & ERP

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Session Intended Learning Outcomes

At the end of this session students will be able to:

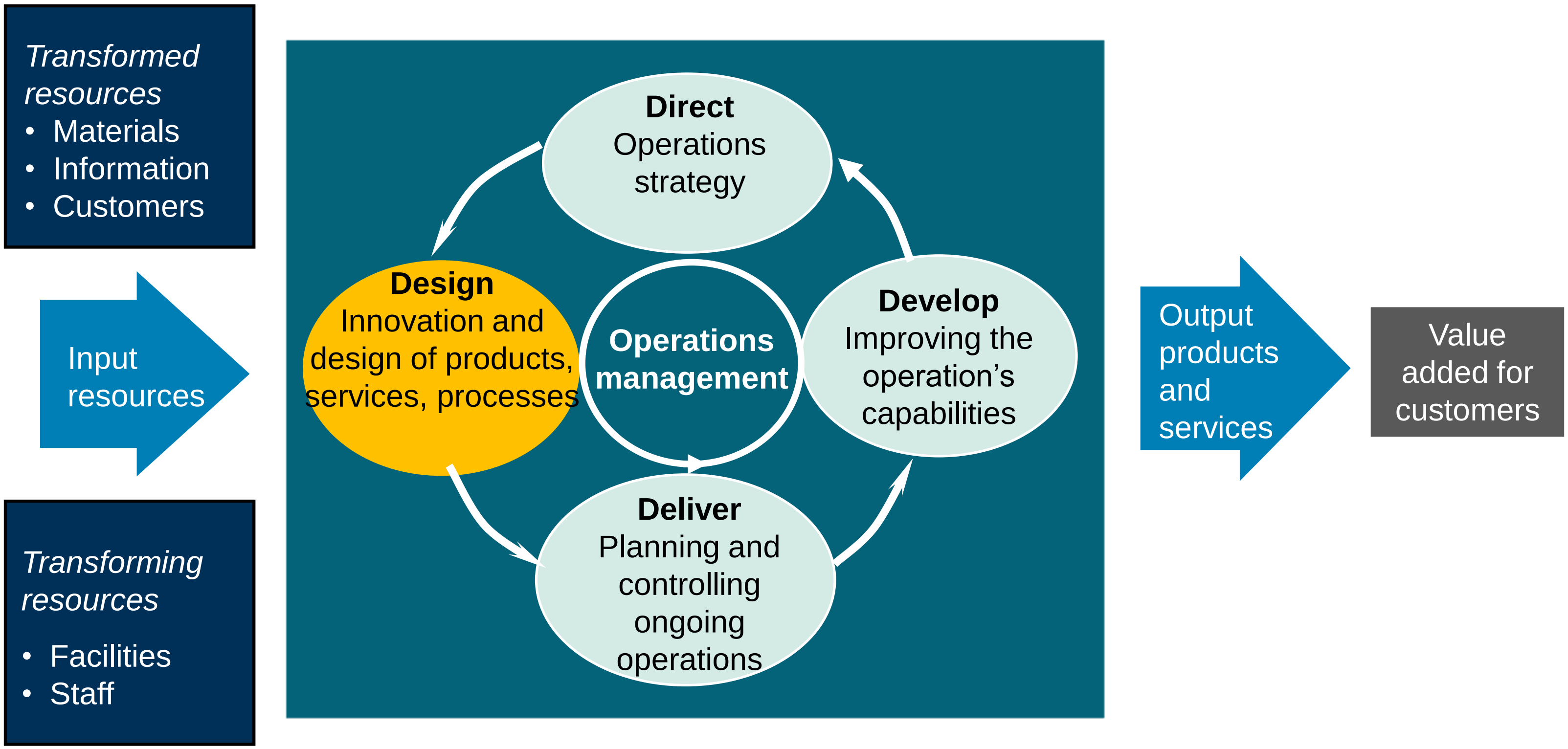
- Design and analyse various types of operations processes.
- Evaluate the key characteristics and implementation requirements of various process technologies.
- Outline the main features of ERP and the success and risk factors associated with the implementation of ERP systems.

Prescribed Readings

- Slack, N., Brandon-Jones, A., Johnston, R., Singh, H., & Phihlela, K. (2017). Chapter 4: Process design. In *Operations management: Global and Southern African perspectives* (3rd ed.) (pp. 75-97). Cape Town: Pearson South Africa.
- Slack, N., Brandon-Jones, A., Johnston, R., Singh, H., & Phihlela, K. (2017). Chapter 8: Process technology. In *Operations management: Global and Southern African perspectives* (3rd ed.) (pp. 178-200). Cape Town: Pearson South Africa.
- Slack, N., Brandon-Jones, A., Johnston, R., Singh, H., & Phihlela, K. (2017). Chapter 14: Enterprise resource planning. In *Operations management: Global and Southern African perspectives* (3rd ed.) (pp. 357-377). Cape Town: Pearson South Africa.

Outline

- **Process design / analysis**
- **Process Technology**
- ERP



<u>A general model of operations management</u>

(Source: Slack et al., 2017)

Slack *et al.* 's model of operations management

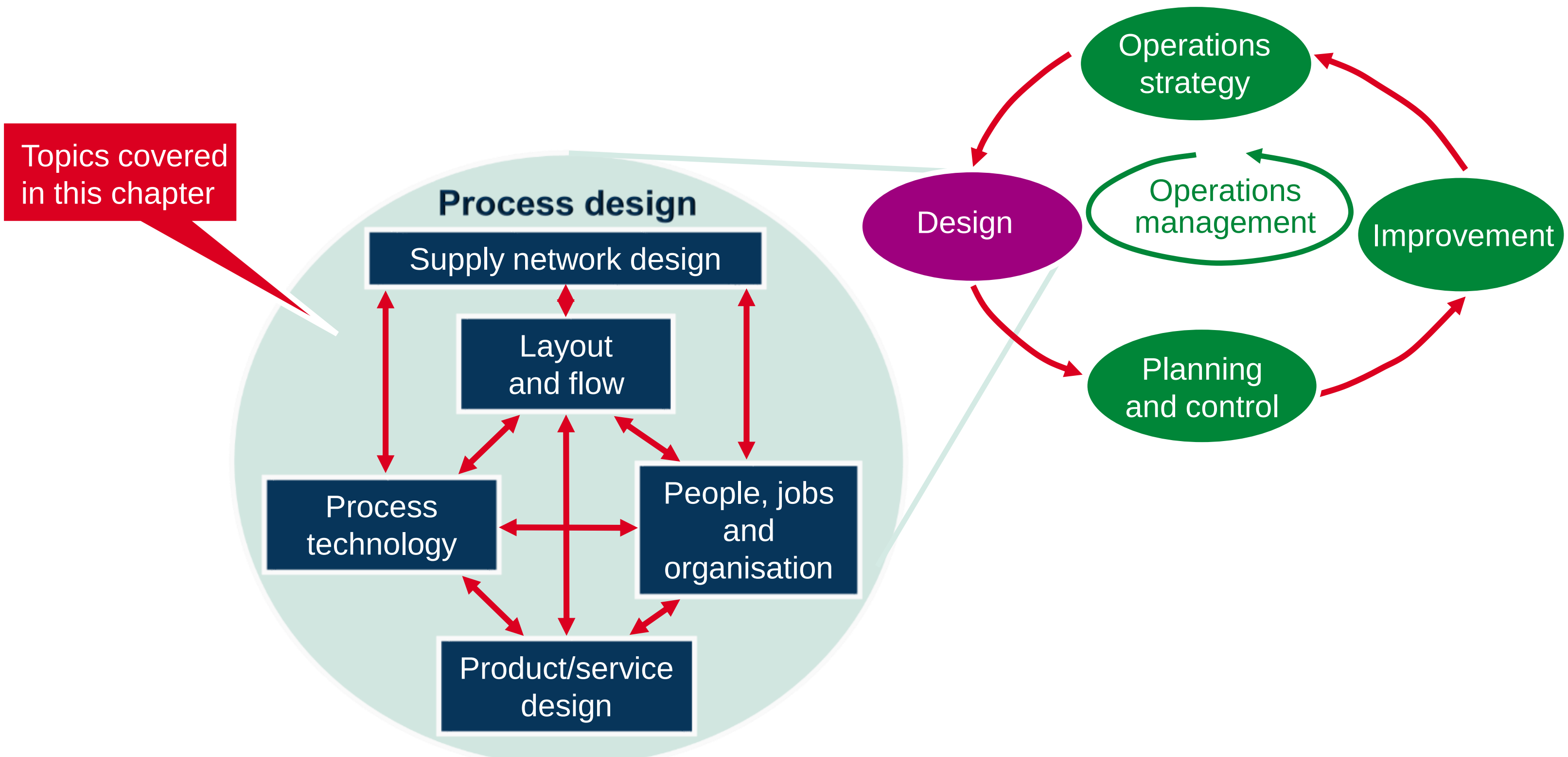


Figure 4.1 Process design activities in operations management are covered in this chapter.

Key questions

What is process design?

What objectives should process design have?

How does volume and variety affect process design?

How are processes designed in detail?

What are the effects of process variability?

What is process design?

"If you can't describe what you are doing as a **process**, you don't know what you're doing."

W. Edwards Deming

What is process design?

Nature and purpose of the design activity – operations principle

- The design of processes cannot be done independently of the services and/or products that they create.

- Decisions taken during the design of a product or service will have an impact on the decisions taken during the design of the process that produces those products or services and vice versa.

What is process design?

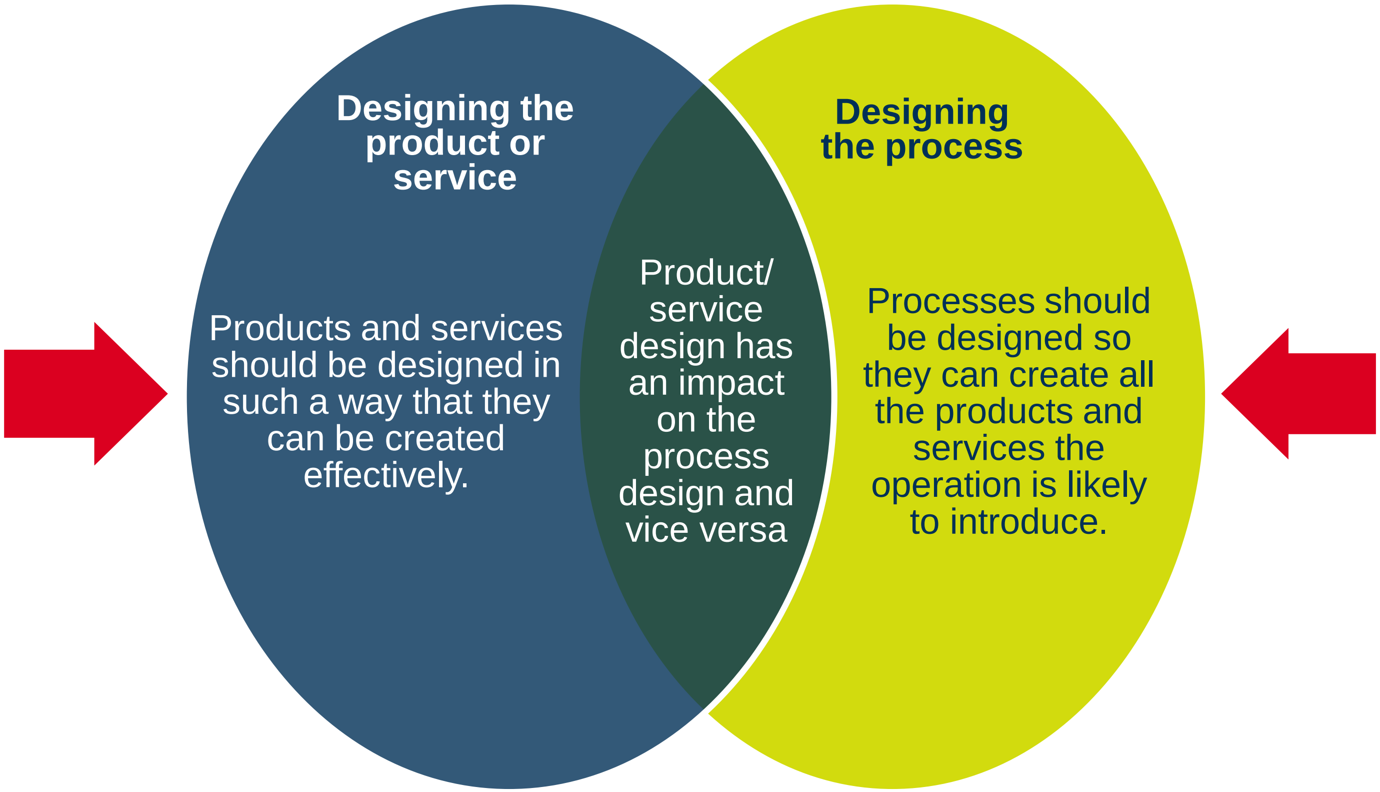


Figure 4.2 The design of products/services and processes are interrelated and should be treated together

What objectives should process design have?

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Standardisation of processes

- **Standardisation** in this context means 'doing things in the same way', or more formally, 'adopting a common sequence of activities, methods and use of equipment'.

- Standardisation is a significant issue, especially in large organisations, because very often different ways of carrying out similar or identical tasks emerge over time in the various parts of the organization.

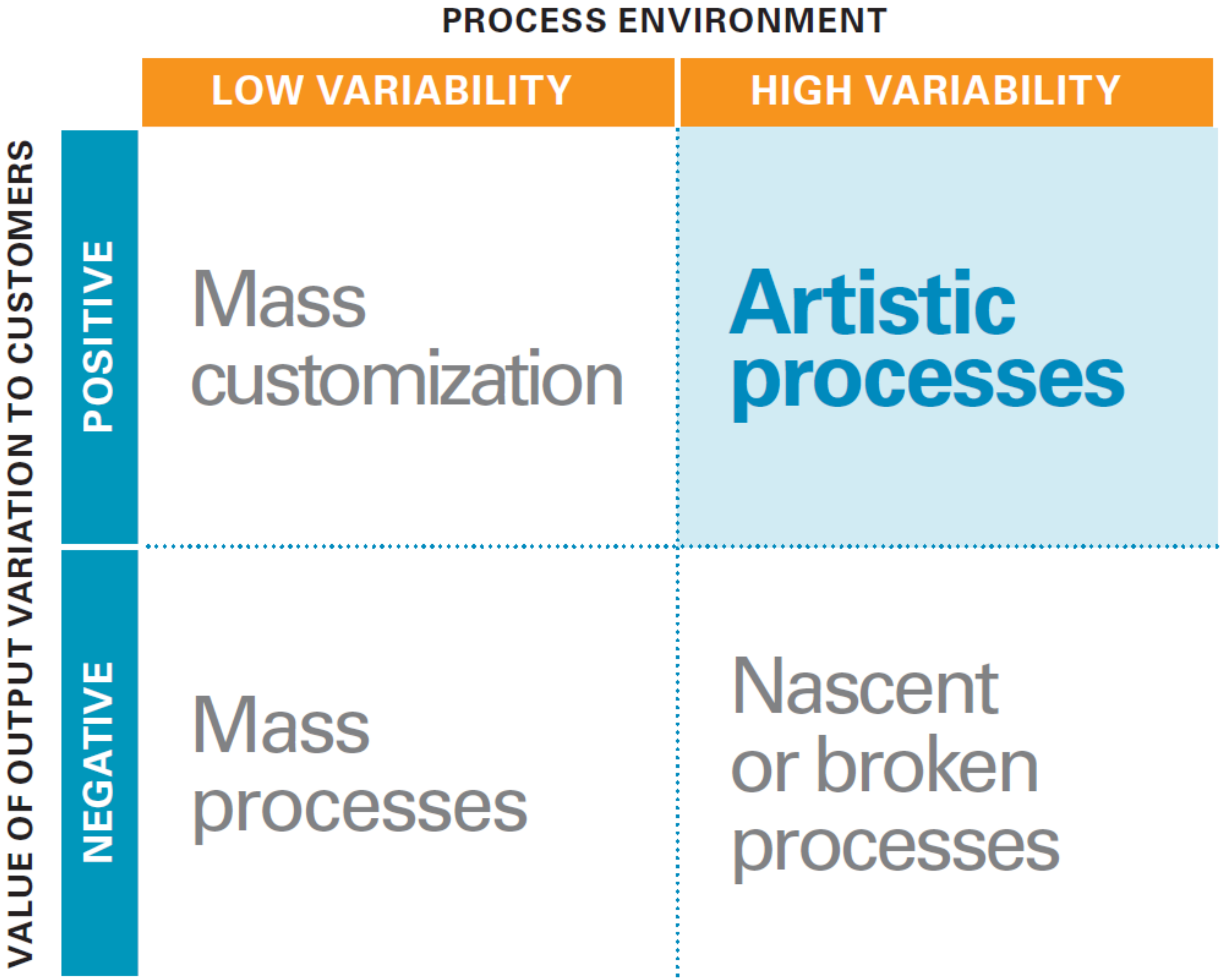
- Why not allow many different ways of doing the same thing? After all, it gives a degree of autonomy and freedom for individuals and teams to exercise their discretion. The problem is that allowing numerous ways of doing things causes confusion, misunderstandings, and eventually, inefficiency (cost penalties of high variety). In healthcare processes, it can even cause preventable deaths (see https://www.theguardian.com/society/2012/jul/27/standardised-bed-chart-hospital-deaths)

- Standardisation is also an important objective in the design of some products and services, for similar reasons.

- **The practical dilemma for most organisations is how to draw the line between processes that are required to be standardised, and those that are allowed to be different. Standardising processes can give some significant advantages, but not every process can (or should) be standardised.**

What objectives should process design have?

Standardisation of processes



The Process Matrix: This simple tool can help managers categorise processes and consider how they might or should change. *Source:* Hall, J. M., & Johnson, M. E. (2009). When should a process be art, not science*? Harvard Business Review*, 87(3), 58-65.

What objectives should process design have?

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Operations performance objective	Typical process design objectives
Quality	• Provide appropriate resources, capable of achieving the specification of product of services • Error-free processing
Speed	• Minimum throughput time • Output rate appropriate for demand
Dependability	• Provide dependable process resources • Reliable process output timing and volume
Flexibility	• Provide resources with an appropriate range of capabilities • Change easily between processing states (what, how, or how much is being processed?)
Cost	• Appropriate capacity to meet demand • Eliminate process waste in terms of: – excess capacity – excess process capability – in-process delays – in-process errors – inappropriate process inputs

Table 4.1 The impact of operations performance objectives on process design

What objectives should process design have?

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Operations performance objective	Some benefits of good process design
Quality	• Products and service produced 'on-specification' • Less recycling and wasted effort within the process
Speed	• Short customer waiting time • Low in-process inventory
Dependability	• On-time deliveries of products and services • Less disruption, confusion and rescheduling within the process
Flexibility	• Ability to process a wide range of products and services • Low cost/fast product and service change • Low cost/fast volume and timing changes • Ability to cope with unexpected events (e.g. supply or a processing failure)
Cost	• Low processing costs • Low resource costs (capital costs) • Low delay/inventory costs (working capital costs)

Table 4.1 The impact of operations performance objectives on process design (continued)

Process types – the volume-variety effect on process design

- There are different 'process types'.

- **Process types are defined by the volume and variety of 'items' they process.**

- Process types go by different names depending on whether they produce products or services.

Process types – the volume-variety effect on process design

Manufacturing process types

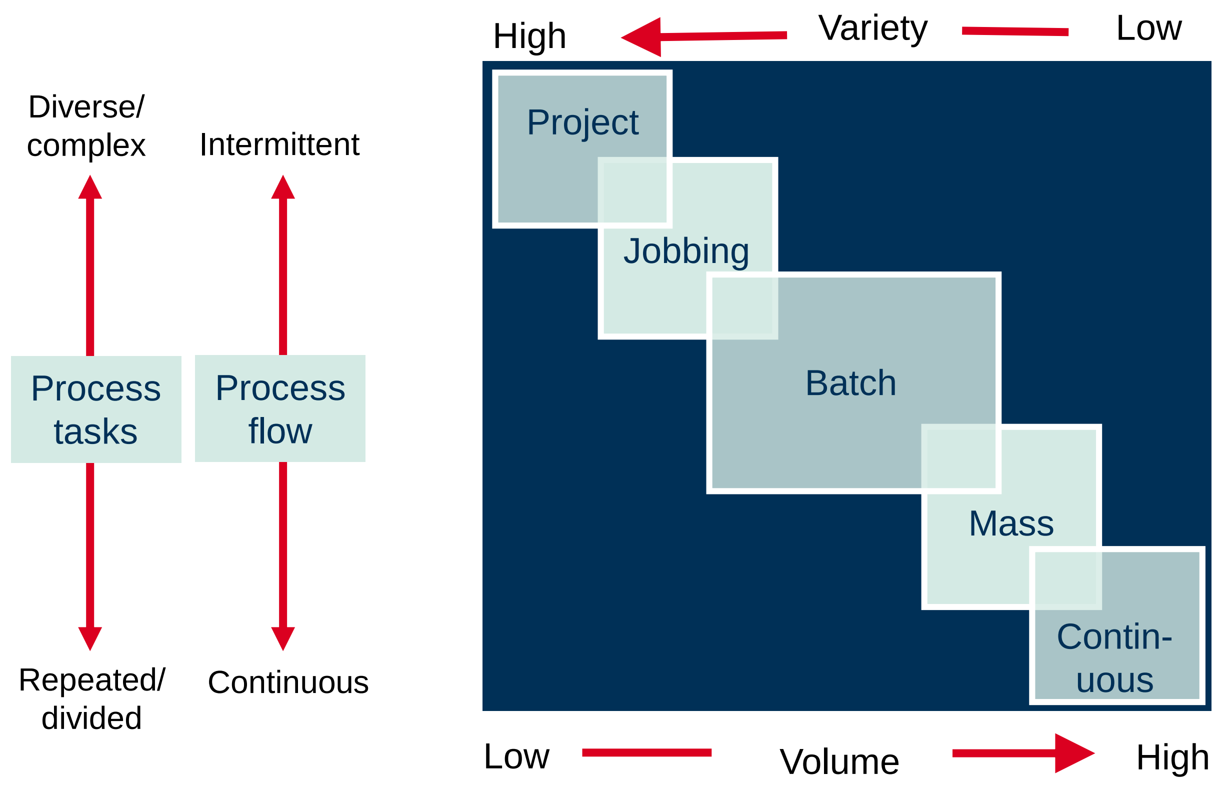

Figure 4.3 Different process types imply different volume–variety characteristics for the process

Process types – the volume-variety effect on process design

Service process types

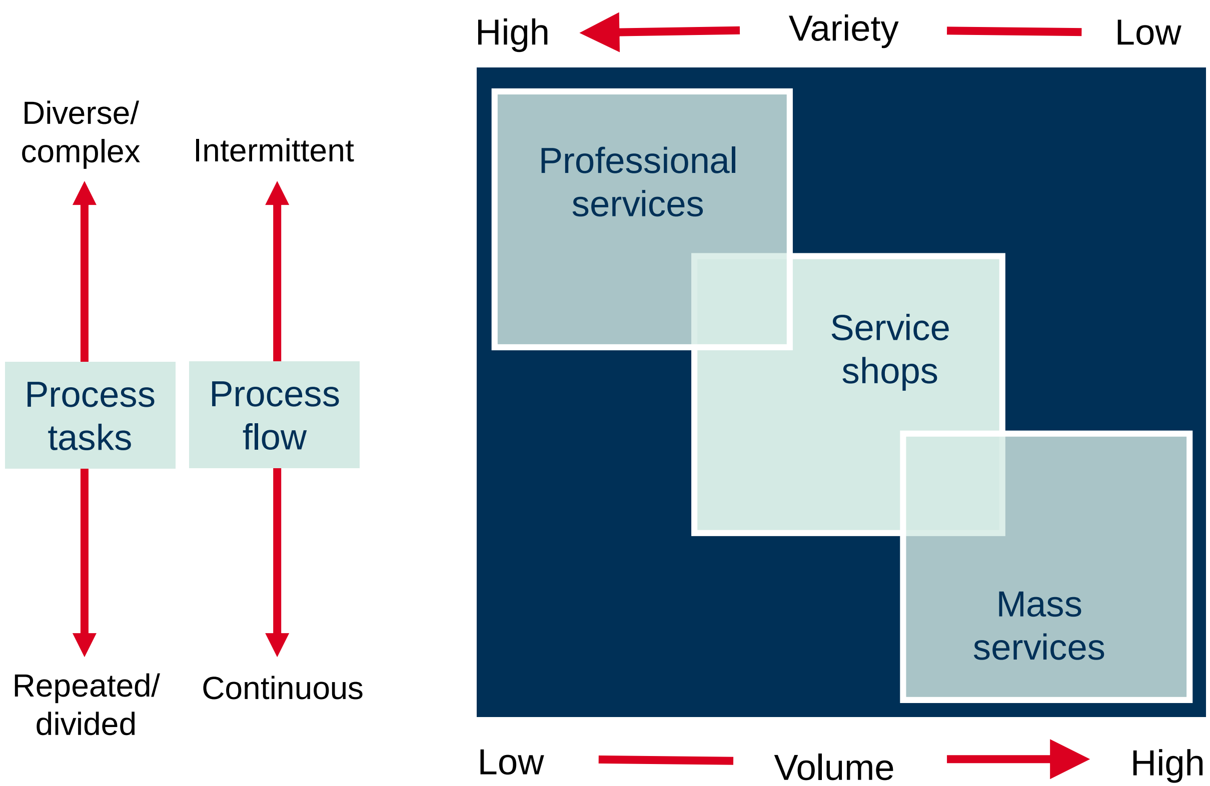

Figure 4.3 Different process types imply different volume–variety characteristics for the process.

Process types – the volume-variety effect on process design

Manufacturing process types: Project processes

- One-off, complex, large scale, high work content ‘products’.
- Specially made, ‘every one customised’.
- Defined start and finish: time, quality and cost objectives.
- Many different skills have to be coordinated.
- **Examples:** software design, movie production, construction projects, large fabrication projects (e.g. manufacturing turbo generators).

Process types – the volume-variety effect on process design

Manufacturing process types: Jobbing processes

- Very small quantities: ‘one-offs’, or only a few required.
- Specially made. High variety, low repetition.
- Skill requirements are usually very broad.
- Skilled jobber, or team, complete whole product.
- **Examples:** made-to-measure tailors, specialist toolmakers, furniture restorers, custom furniture makers, printers.

Process types – the volume-variety effect on process design

Manufacturing process types: Batch processes

- Higher volumes and lower variety than for jobbing.
- Specialised, narrower skills.
- Standard products, repeating demand. But can make specials.
- Set-ups (changeovers) at each stage of production.
- **Examples:** machine tool manufacturing, special gourmet frozen food production, bakeries, manufacturing of components for mass-produced assemblies like automobiles.

Process types – the volume-variety effect on process design

Manufacturing process types: Mass processes

- Higher volumes than batch.
- Standard, repeat products (‘runners’).
- Low and/or narrow skills.
- No set-ups or almost instantaneous ones.
- **Examples:** frozen food production, automatic packing lines, automobile plants, television factories, DVD production.

Process types – the volume-variety effect on process design

Manufacturing process types: Continuous processes

- Extremely high volumes and low variety: often single product.
- Standard, repeat products (‘runners’).
- Highly capital-intensive and automated.
- Few changeovers required.
- Difficult and expensive to start and stop the process.
- **Examples:** water treatment/processing, petrochemical refineries, electricity utilities, steel making, paper making.

Process types – the volume-variety effect on process design

Service process types: Professional services

- High levels of customer (client) contact.
- Clients spend a considerable time in the service process.
- High levels of customisation with service processes being highly adaptable.
- Contact staff are given high levels of discretion in servicing customers.
- People-based rather than equipment-based.
- **Examples:** management consultants, lawyers' practices, architects, doctors' surgeries, auditors, health and safety inspectors, IT field service operations.

Process types – the volume-variety effect on process design

Service process types: Service shops

- Medium levels of volumes of customers.
- Medium, or mixed, levels of customer contact.
- Medium, or mixed, levels of customisation.
- Medium, or mixed, levels of staff discretion.
- Service is provided via mixes of front-office and back-office activities.
- **Examples:** banks, high street shops, holiday tour operators, car rental companies, schools, gyms/fitness clubs/health clubs, most restaurants, hotels and travel agents.

Process types – the volume-variety effect on process design

Service process types: Mass services

- High levels of volumes of customers.
- Low to medium levels of customer contact.
- Low, or mixed, levels of customisation.
- Low, or mixed, levels of staff discretion (have to follow set procedures).
- Relatively defined division of labour.
- **Examples:** supermarkets, national rail networks, airports, telecommunications services, libraries, television stations, police services, enquiry desks at utilities, customer call/contact centres (very high volume of enquiries requires structuring of the communications process with customers e.g. using a carefully designed enquiry process, sometimes known as a script) .

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Process types – the volume-variety effect on process design

The underlying idea of the product–process matrix is that many of the more important elements of process design are strongly related to the volume–variety position of the process. So, for any process, the tasks that it undertakes, the flow of items through the process, the layout of its resources, the technology it uses, and the design of jobs, are all strongly influenced by its volume–variety position. This means that most processes should lie close to the diagonal of the matrix that represents the 'fit' between the process and its volume–variety position. This is called the 'natural diagonal', or the 'line of fit'.

The product–process matrix

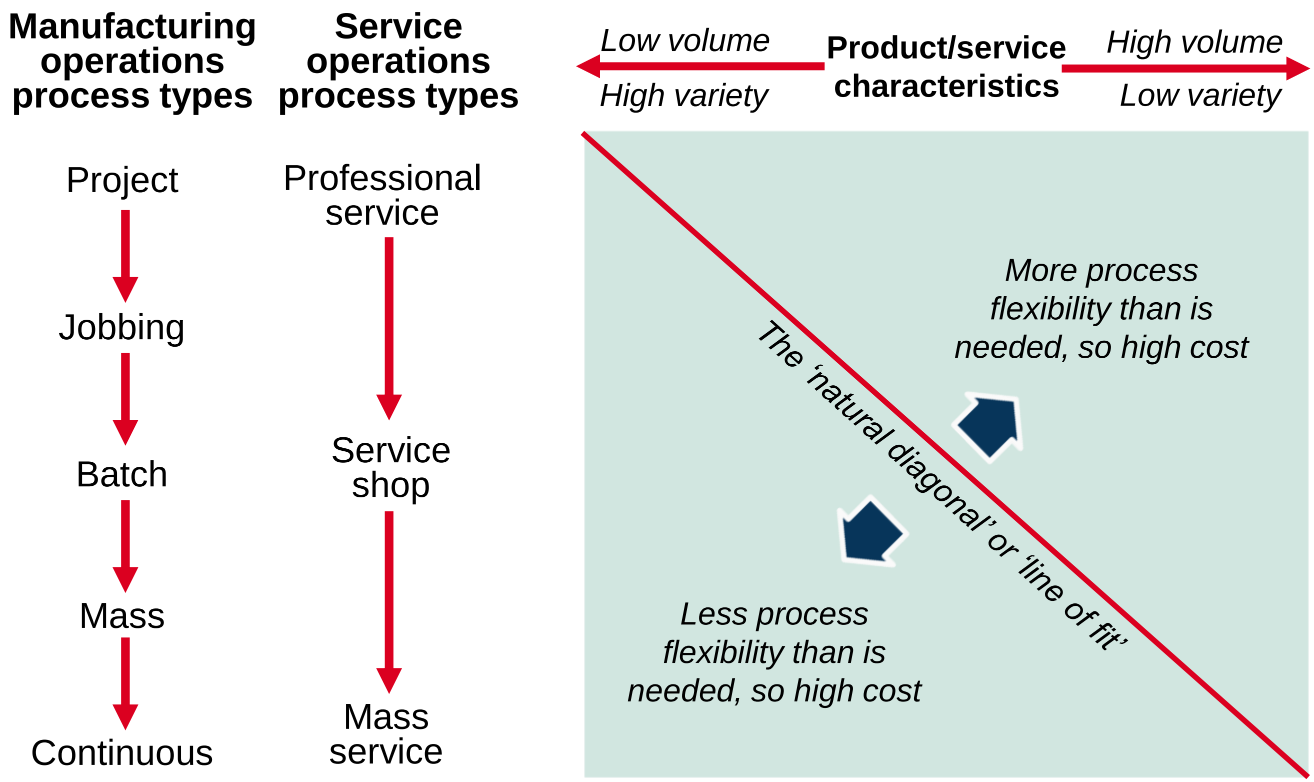


Figure 4.4 Deviating from the natural diagonal on the product–process matrix has consequences for cost and flexibility.

Process types – the volume-variety effect on process design

Product–process matrix – water meter example

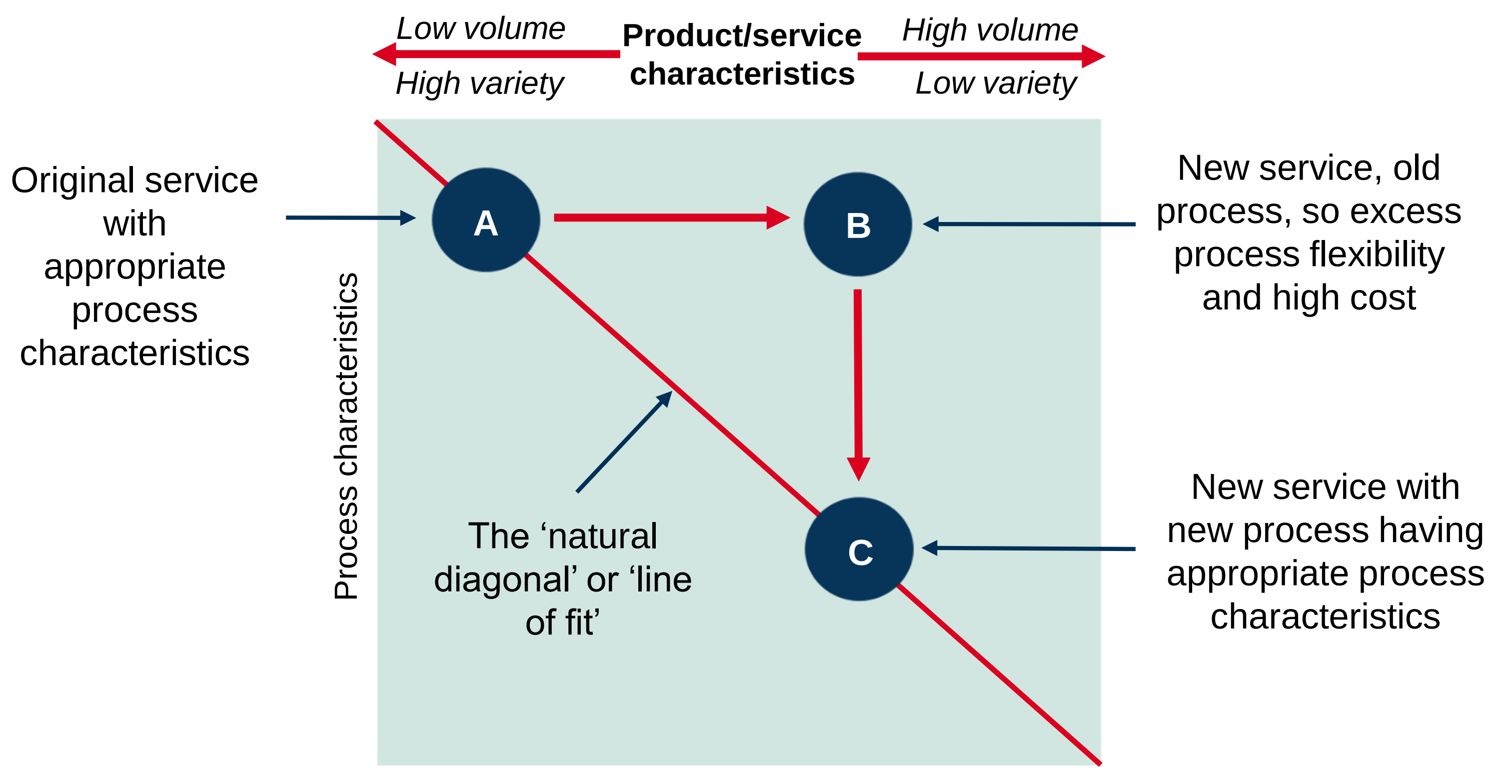


Figure 4.5 A product–process matrix with process positions from the water meter example

Detailed process design/analysis

What is a process?

A ***process*** is a series of independent tasks that transforms inputs (materials, customers, and/or information) into an output of higher value for the organisation.

Examples:

1. Toyota transforms steel, rubber, and plastic into cars.
2. McDonald's transforms meat, potatoes, and sauces into fast-food food.
3. Dell transforms customer orders into PCs.

Detailed process design/analysis

Process analysis

Why do we need to analyse the process?

- To identify ***inefficient tasks***.
- To spot ***possible effectiveness improvement tasks***.
- To understand ***where additional value can be added***.

- *Where do we start to analyse a process?*

  Draw a process map.
- *What are the relevant performance measures?*

  Requires careful thought, observation, experimentation.

Detailed process design / analysis

Process mapping symbols

Process mapping symbols derived from scientific management

- Operation (an activity that directly adds value)
- Inspection (a check of some sort)
- Transport (a movement of some thing)
- Delay (a wait, e.g. for materials)
- Storage (deliberate storage, as opposed to a delay)

Process mapping symbols derived from systems analysis

- Beginning or end of process
- Activity
- Input or output from the process
- Direction of flow
- Decision (exercising discretion)

Detailed process design / analysis

Process map – 'enquire to delivery' at stage lighting firm

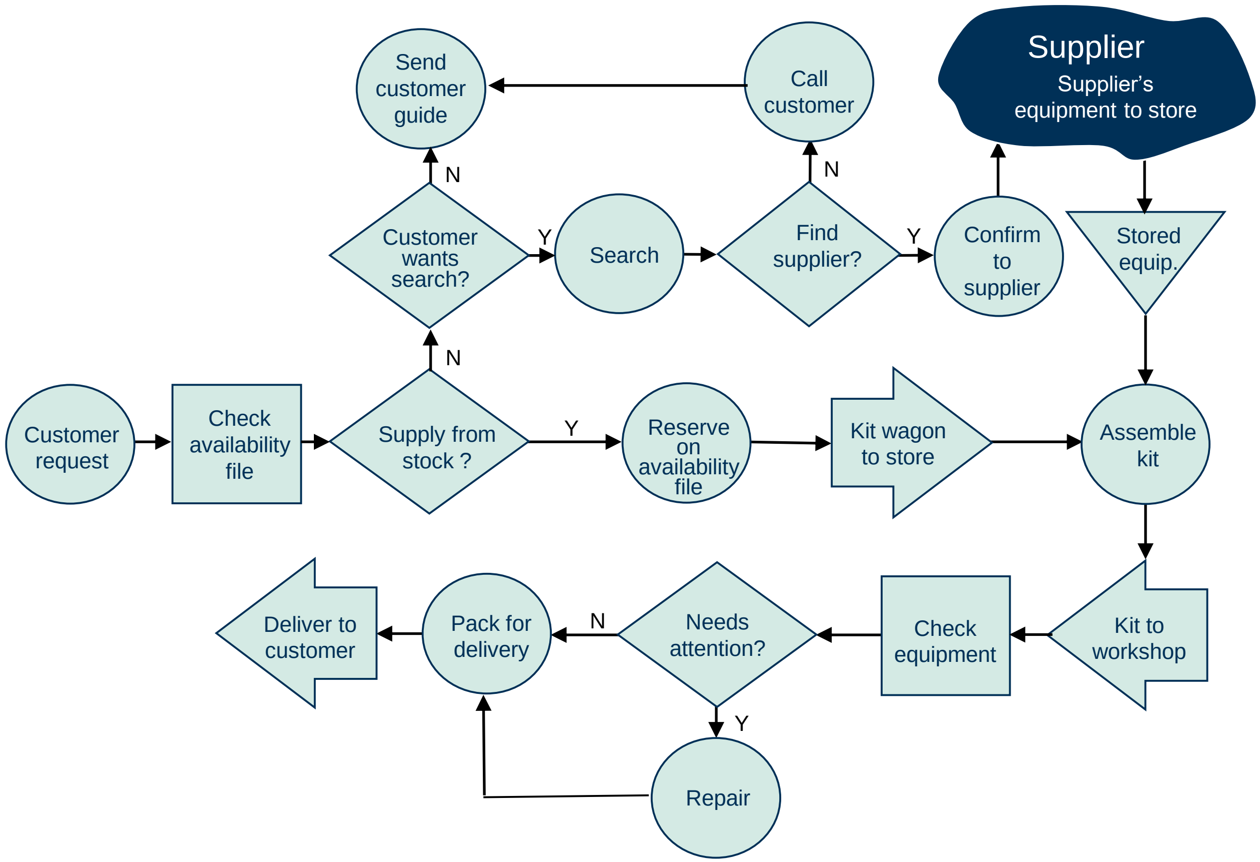


Figure 4.7 Process map for 'enquire to delivery' process at stage lighting operation

Detailed process design / analysis

‘Supply and install’ process mapped at three levels (high-level, outline, detailed)

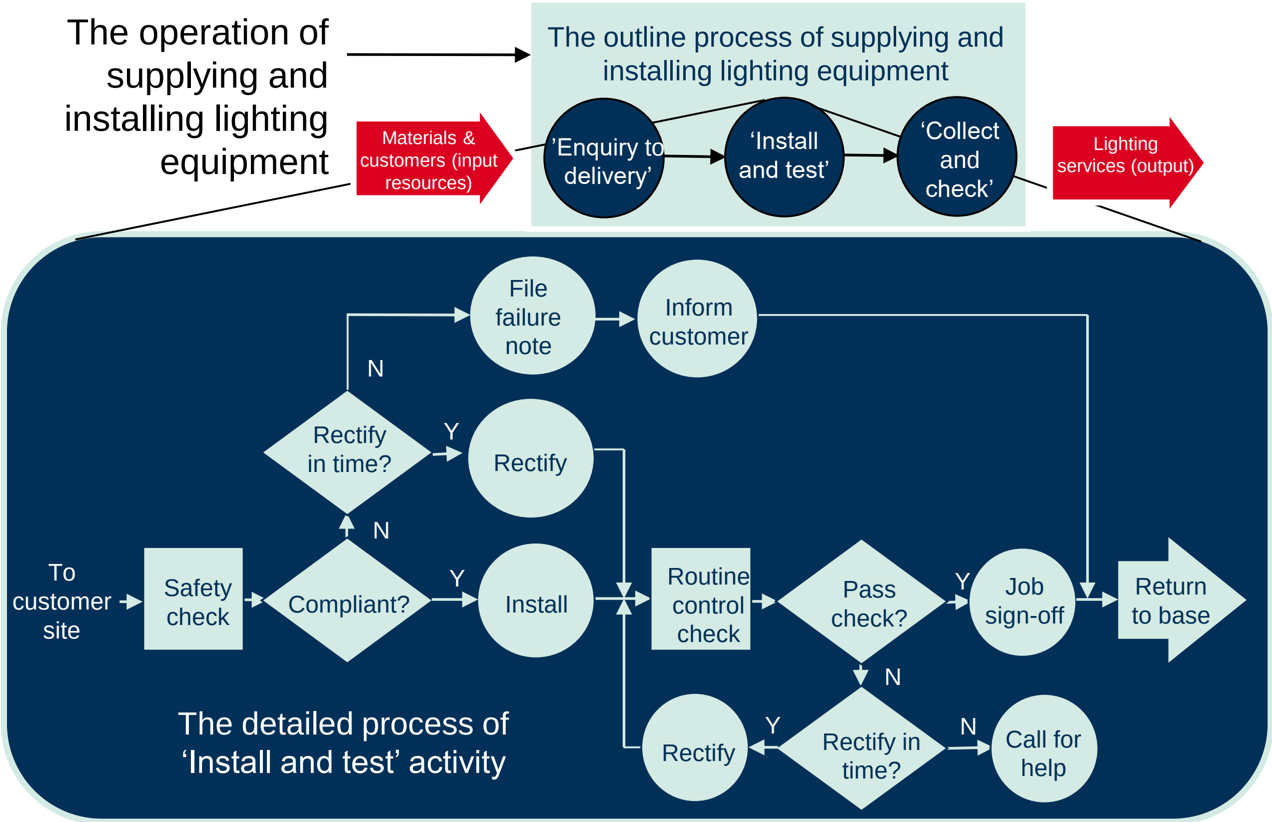


Figure 4.8 The ‘supply and install’ operations process mapped at three levels.

Detailed process design / analysis

'Collect and check' process – levels of process visibility

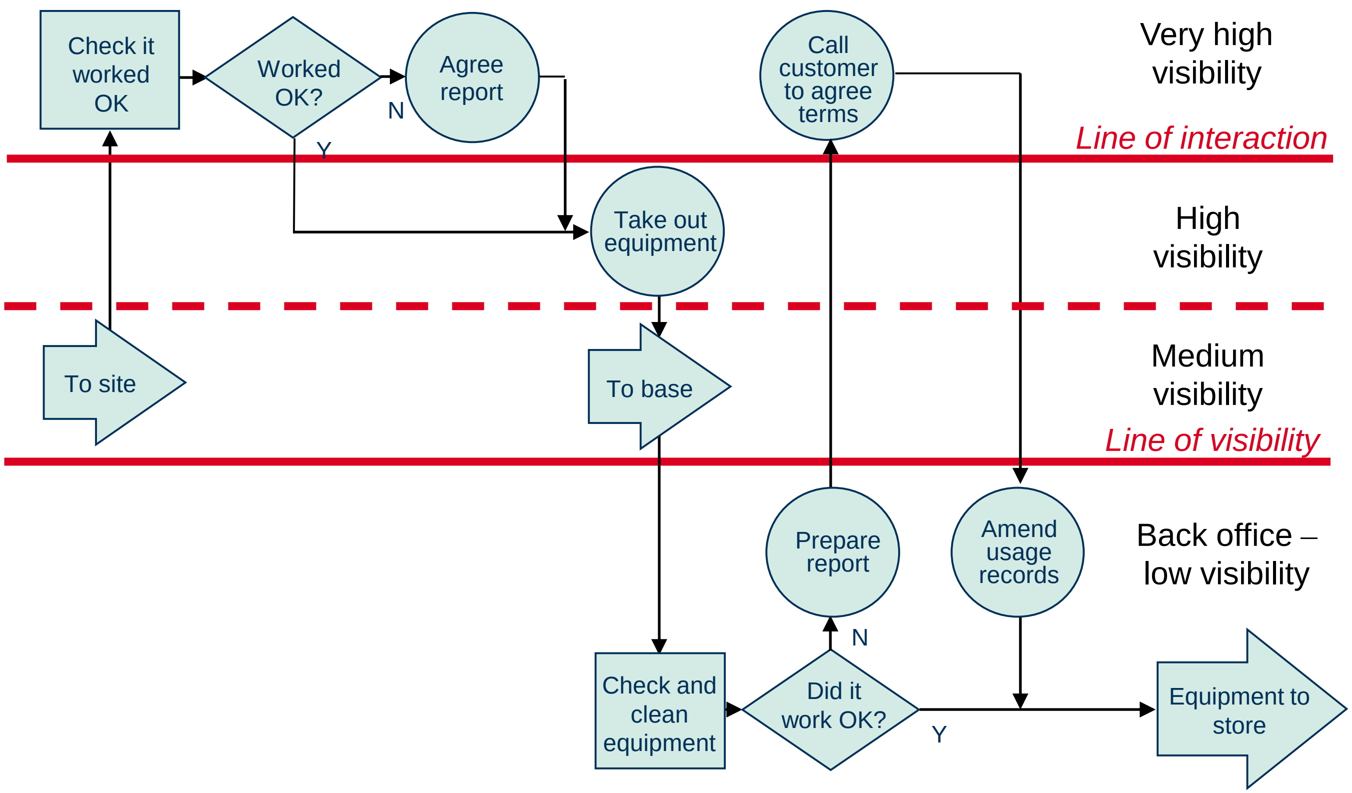


Figure 4.9 The 'collect and check' process mapped to show different levels of process visibility.

Detailed process design / analysis

Throughput time, cycle time and work in progress

- **Throughput time:** The time for a unit to move through a process (elapsed time between an item entering a process and leaving) it)
- **Cycle time:** The average time between units of output emerging from a process (average time between items being processed)
- **Work-in-process (WIP):** The number of units within a process at any point in time (also called *work-in-progress* or *in-process inventory*).

Little's Law				
Throughput time	=	work-in-process	×	cycle time
TT	=	WIP	×	CT

- **Little's Law (process analysis):**

$L = \lambda \times W$ || $W = L \times 1/\lambda$ *(equivalent to above form)*

where L is average number of items in the queuing (processing) system,
λ is average number of items arriving per unit time,
W is average waiting (processing) time in the system for an item,
and the system is stable, i.e. arrival rate = departure (exit) rate.

- **Work content:** The total amount of work (time) required to produce a unit of output.
- **Utilisation:** Proportion of available time that process resources are doing useful work.

Further reading (optional): Little, J. D. C., & Graves, S. C. (2008). "Little's Law", Chp. 5 in Chhajed, D., & Lowe, T. J. (editors), Building Intuition: Insights from Basic Operations Management Models and Principles, Springer, pp. 81-100.

Detailed process design / analysis

Worked example 1

Vusi was totally confident in his judgement. "You'll never get them back in time", he said. "They aren't just wasting time, the process won't allow them to all have their coffee and get back for 11 o'clock." Looking outside the lecture theatre, Vusi and his colleague Dirk were watching the 20 business people who were attending the seminar queuing to be served coffee and biscuits. The time was 10:45 and Dirk knew that unless they were all back in the lecture theatre at 11 o'clock there was no hope of finishing his presentation before lunch.

"I'm not sure why you're so pessimistic", said Dirk. "They seem to be interested in what I have to say and I think they will want to get back to hear how operations management will change their lives." Vusi shook his head. "I'm not questioning their motivation," he said , "I'm questioning the ability of the process out there to get through them all in time. I have been timing how long it takes to serve the coffee and biscuits. Each coffee is being made fresh and the time between the server asking each customer what they want and them walking away with their coffee and biscuits is 48 seconds. I've also observed that it takes each person about four minutes to finish their coffee and biscuits. Based on my calculations, there's simply no way they'll all be finished in time for 11 o'clock."

Is Vusi is correct in his assertion or not?

Detailed process design / analysis

Worked Example 1: Solution

Throughput time (TT)		=	? Mins
WIP		=	20 people
Cycle time (CT)		=	0.8 mins / person (48 secs / 60 secs)
Little's Law:	TT	=	WIP × CT
		=	20 × 0.8
		=	16 minutes

It would take 16 minutes for the last person in the queue to receive their coffee and biscuits, and an additional 4 minutes for that person to consume it. Therefore, the entire break would take at least 20 minutes, well beyond the remaining 15 minutes between 10:45 and 11 o'clock.

Vusi is correct in his assertion.

Detailed process design / analysis

Worked example 2

In an assemble-to-order sandwich shop, the time to assemble and sell a sandwich is two minutes and there are two people staffing the process. Each member of staff serves a customer every two minutes.

(a) Suppose you are the 10th customer to join the queue, how long will it be before you emerge from the shop?

(b) Suppose it is decided that in a new sandwich assembly and sales process, the average number of customers in the process should be limited to around ten, and that the maximum time a customer is in the process should be on average four minutes. If the time to assemble and sell a sandwich (from customer request to the customer leaving the process) in the new process has been reduced to 1.2 minutes, how many staff should be serving?

Detailed process design / analysis

Worked Example 2: Solution

(a)

Throughput time (TT)		=	? mins
Work-in-progress (WIP)		=	10 customers
Cycle time (CT)		=	2 mins / 2 customers ≡ 1 min / customer
Little's Law:	TT	=	WIP × CT
		=	10 × 1
		=	**10 minutes**

(b)

Throughput time (TT)		=	4 mins
Work-in-progress (WIP)		=	10 customers
Cycle time (CT)		=	? min / customer
Little's Law:	CT	=	TT ÷ WIP
		=	4 ÷ 10
		=	0.4 min / customer

On average, a customer emerges from the process every 0.4 minutes. Given that a single customer can be served in 1.2 minutes (the work content):

Number of servers required = 1.2 ÷ 0.4 = **3**

In other words, three (3) servers would serve three (3) customers in 1.2 minutes. Or one customer every 0.4 minutes.

Detailed process design / analysis

Worked example 3

Every year it was the same. All the workstations in the building had to be renovated. New software would have to be installed and tested and there was only one week in which to do it. The one week fell in the middle of the August vacation period when the renovation process would cause minimum disruption to normal working. Last year the company's 500 workstations had all been renovated within one working week (40 hours). Each renovation last year took on average two hours and 25 technicians had completed the process within the week. This year there would be 530 workstations to renovate but the company's IT support unit had devised a faster testing and renovation routine that would only take on average one and a half hours instead of two hours. How many technicians will be needed this year to complete the renovation processes within the week?

Detailed process design / analysis

Worked Example 3: Solution

Last year

Work-in-progress (WIP)	=	500 workstations
Time available (TT)	=	40 hours
Average time to renovate	=	2 hours per technician per workstation
Therefore throughput rate (T_r)	=	1 ÷ 2 technicians per workstation per hour
	=	0.5N workstations per hour
where N	=	number of technicians
Little's Law: WIP	=	$TT \times (\frac{1}{CT})$
WIP	=	$TT \times T_r$
500	=	40 × 0.5N
N	=	500 ÷ (40 × 0.5)
	=	25 technicians

This year

Work in progress (WIP)	=	530 workstations
Time available (TT)	=	40 hours
Average time to renovate	=	1.5 hours per technician per workstation
Throughput rate (T_r)	=	1 ÷ 1.5 technicians per workstation per hour
	=	0.67N workstations per hour
where N	=	number of technicians
Little's Law: WIP	=	$TT \times (\frac{1}{CT})$
WIP	=	$TT \times T_r$
530	=	40 × 0.67N
N	=	530 ÷ (40 × 0.67)
	=	19.77 technicians
	≈	**20 technicians (rounded up)**

Because of the faster testing and renovation routine, this year only 20 technicians will be needed.

Detailed process design / analysis

Throughput efficiency and value-added throughput efficiency

Throughput efficiency is the work content of whatever is being processed as a percentage of its throughput time.

$$\text{Throughput efficiency} = \frac{\text{Work content}}{\text{Throughput time}} \times 100$$

In Worked example 2(b), customer throughput time is restricted to 4 minutes, but the work content of the task (actually serving each customer) is only 1.2 minutes. Therefore the throughput efficiency of the process is 1.2 / 4 = 30%.

In this case the throughput efficiency is very high, relative to most processes, perhaps because the ‘items’ being processed are customers who react badly to waiting. In most material and information transforming processes, throughput efficiency is far lower, usually in single percentage figures.

The above approach to calculating throughput efficiency assumes that all the ‘work content’ is actually needed. Changing a process can significantly reduce the time that is needed to complete the task. Therefore, work content is actually dependent upon the methods and technology used to perform the task. It may be also that individual elements of a task may not be considered ‘value-added’. So, value-added throughput efficiency restricts the concept of work content to only those tasks that are literally adding value to whatever is being processed. This often eliminates activities such as movement, delays and some inspections.

$$\text{Value-added throughput efficiency} = \frac{\text{Value-added work content}}{\text{Throughput time}} \times 100$$

Detailed process design / analysis

Worked example 4

A vehicle licensing centre receives application documents, keys in details, checks the information provided on the application, classifies the application according to the type of licence required, confirms payment and then issues and mails the licence. It is currently processing an average of 5,000 licences every 8-hour day. A recent spot check found 15,000 applications that were 'in progress' or waiting to be processed. The sum of all activities that are required to process an application is 25 minutes.

(a) What is the throughput efficiency of the process?

(b) If only 20 minutes of the activities required to process an application are actually adding value, what is the value-added throughput efficiency of the process?

Detailed process design / analysis

Worked Example 4: Solution

(a) Work in progress =15,000 applications

Cycle time = Time producing

$$\frac{Time\ producing}{Number\ produced} = \frac{8\ hours}{5{,}000} = \frac{480}{5000} = 0.096\ minutes$$

From Little's law, Throughput time = WIP × Cycle time

= 15,000 × 0.096

= 1,440 minutes

= 24 hours

= 3 working days (8 hours per working day)

$$Throughput\ efficiency = \frac{Work\ content}{Throughput\ time} \times 100 = \frac{25}{1{,}440} \times 100 = 1.74\%$$

Although the process is achieving a throughput time of 3 days (which seems reasonable for this kind of process), the applications are only being worked on for 1.7% per cent of the time they are in the process.

(b) $Value - added\ throughput\ efficiency = \frac{Value\text{–}added\ work\ content}{Throughput\ time} \times 100 = \frac{20}{1{,}440} \times 100 = 1.39\%$

Detailed process design / analysis

Workflow Management

When the transformed resource in a process is information (or documents containing information), and when information technology is used to move, store and manage the information, process design is sometimes called ‘workflow’ or ‘workflow management’. Workflow management is defined as ‘the automation of procedures where documents, information or tasks are passed between participants according to a defined set of rules to achieve, or contribute to, an overall business goal’. Although workflow may be managed manually, it is almost always managed using an IT system. The term is also often associated with Business Process Re-engineering (BPR). More specifically, workflow is concerned with the following:

- Analysis, modelling, definition and subsequent operational implementation of business processes.
- The technology that supports the processes.
- The procedural (decision) rules that move information/documents through processes.
- Defining the process in terms of the sequence of work activities, the human skills needed to perform each activity, and the appropriate IT resources.

Effects of process variability

- **There are two fundamental types of variability:**

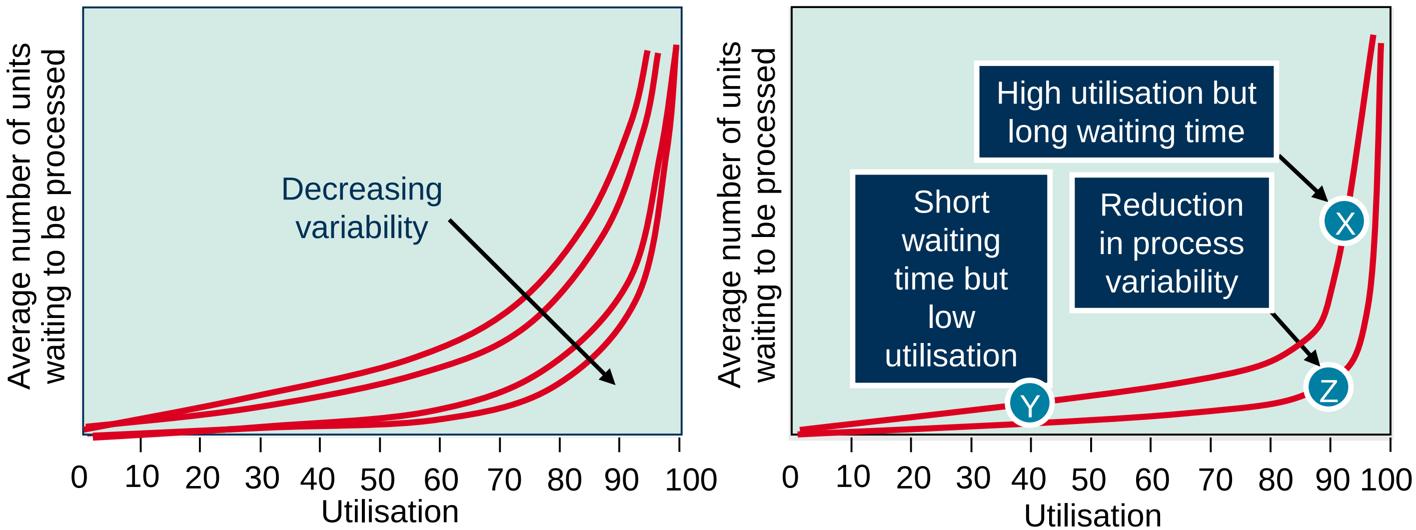
  (1) variability in the demand for processing at an individual stage of the process, usually expressed in terms of variation in the inter-arrival times of items to be processed.

  (2) variation in the time taken to perform activities (i.e. process a unit) at each stage.

- Variability in a process acts to reduce its efficiency.
- Process variability results in simultaneous waiting and resource under-utilisation.

Effects of process variability

Process utilisation, waiting time and variability



(a) Decreasing variability allows higher utilisation without long waiting times

(b) Managing process capacity and/or variability (**three options X, Y and Z for process designers**)

Figure 4.11 The relationship between process utilisation and number of items waiting to be processed for variable arrival and activity times

Effects of process variability

Trade-offs in operations management – The OM Triangle

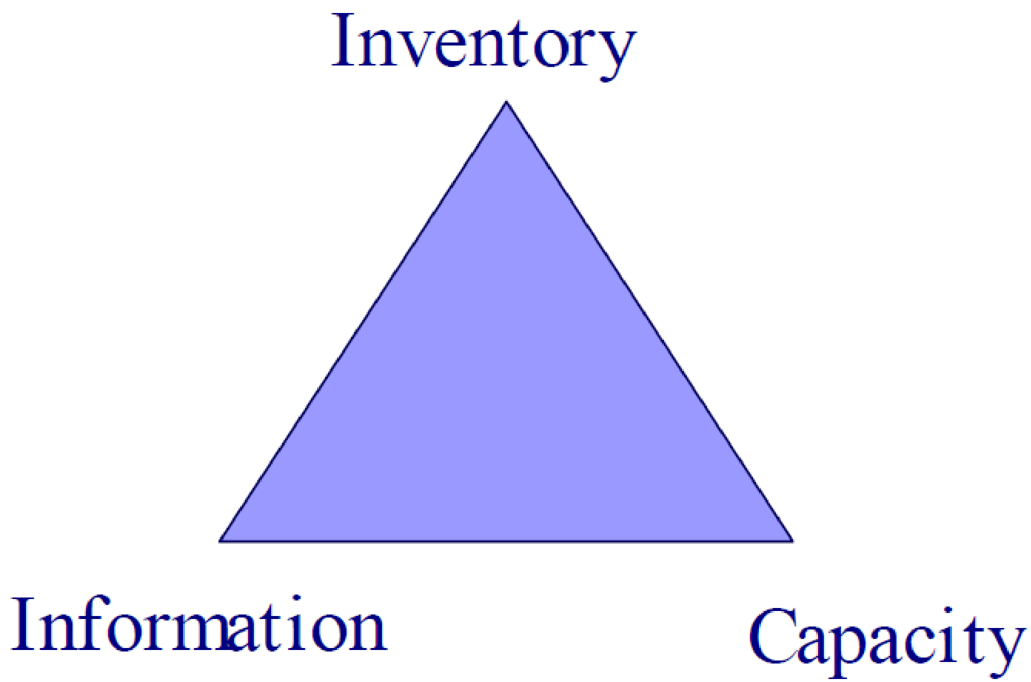


Figure 1. The OM Triangle Portrays the Substitutability of Inventory, Capacity, & Information.

Image Credit: Schmidt (2005)

Outline

Review of Sessions 1-4
Process technology
Enterprise resource planning (ERP)

Process technology

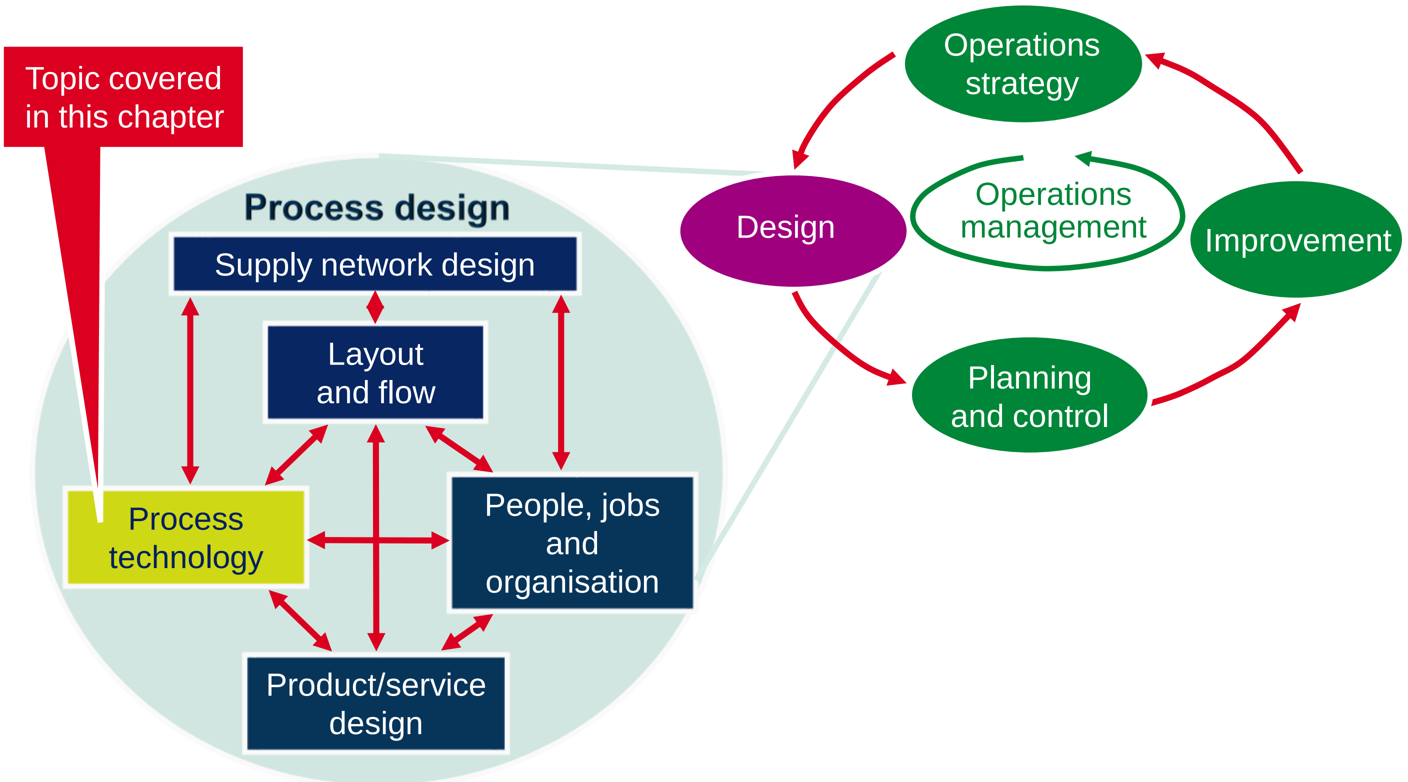
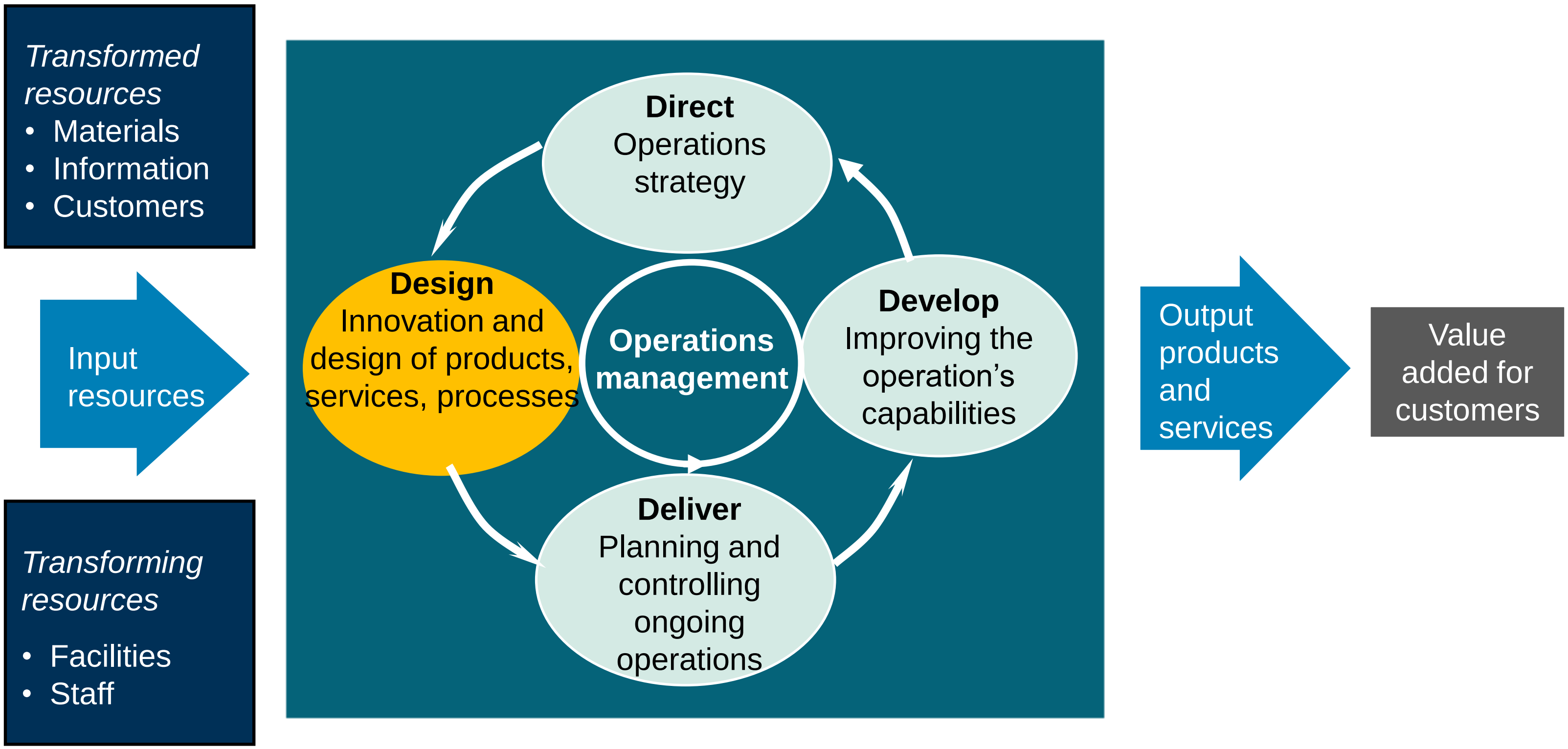


Figure 8.1 This chapter examines process technology in design activities.



<u>A general model of operations management</u>

(Source: Slack et al., 2017)

Key questions

What do operations managers need to know about process technology?

How are process technologies evaluated?

How are process technologies implemented?

The three stages of process technology management

Stage 1
Understand the process technology
→ **Question 1** – *What do operations managers need to know about process technology?*

↓

Stage 2
Evaluate the process technology
→ **Question 2** – *How does the process technology affect the operation?*

↓

Stage 3
Implement the process technology
→ **Question 3** – *How can operations managers introduce new process technology smoothly?*

Figure 8.2 The three stages of process technology management

Process technology and transformed resources: Material-processing technologies

- **Definition:** Any technology that shapes, transports, stores, or in any way changes physical materials or objects.
- **Examples:**
  - Machines and equipment used in manufacturing operations
  - Trucks, conveyors, packing machines, warehousing systems

Process technology and transformed resources: Information-processing technologies

Organisational tasks	E-business (Internet-based technology) applications and/or contributions
Design	Customer feedback on requirements, testing and information exchange in new service/product designs, data mining to understand retail consumer behaviour better
Purchasing	Ordering, fund transfer, supplier selection, supplier portals
Supplier development	Partnership, supplier development
Human resource management	E-recruiting, benefit selection and management, online and multi-media training and education
Planning and control	Production planning and control, scheduling, inventory management, quality monitoring and control, Enterprise Resource Planning (ERP)
Customer service	Online help desks, reduced cycle time, customer services, selection of distribution channels, transportation, scheduling, third-party logistics

Source: Based on E-commerce and its impact on operations management, *International Journal of Production Economics,* Vol. 75, pp. 185–97 (Gunasekaran, A., Marri, H.B., McGaughey, R.E. and Nebhwani, M.D. 2002)

Table 8.1 Some applications of e-business to operations management

Process technology and transformed resources: Customer-processing technologies

Type of interaction between the customer and the technology	Examples
Active interaction technologies (customers themselves use the technology to create the service)	Mobile phone services (voice, texts, apps) Internet bookings and purchases Fitness equipment Cash machines (ATMs)
Passive interaction technologies *(technology 'processes' and controls customers by constraining their actions in some way)*	Mass transport systems Theme park rides Automatic car wash Moving walkways and lifts
Hidden interaction technologies (technology is 'aware' of customers, but not the other way around – these 'hidden technologies' track customers' movements or transactions in an unobtrusive way)	Security cameras Retail scanners Credit card tracking

Table 8.x Three types of customer-processing technologies based on the type of interaction between the customer and the technology

Process technology and transformed resources: Integrating technologies

- **Definition:** Technologies that process more than one type of transformed resource. Many newer technologies process combinations of materials, information and customers.
- **Example:** Electronic point of sale (EPOS) technology in shops, for example, processes products, information and shoppers.

Understanding process technologies: The four key questions

Operations principle: Operations managers should understand enough about process technology to evaluate alternatives. Operations managers don't need to know the technical details of all technologies, but they do need to know the answers to four key questions

- **What** does the technology do?
- **How** does it do it?
- What **benefits** does it give?
- What **constraints** or **risks** does it impose?

Excellent example of application of the four key questions: Short case on 'Automated detection of fraudulent financial activities' (pages 183-184)

Assessing the implications of emerging technologies: Three examples (pages 182-189)

Operations principle: Emerging technologies can have a potentially significant impact on how operations are managed.

- **3D printing** (additive manufacturing) – materials-processing technology
- **Internet of Things** (IoT) – information-processing technology
- **Telemedicine** – customer-processing technology

How process technologies are evaluated: Does the process technology fit the processing task?

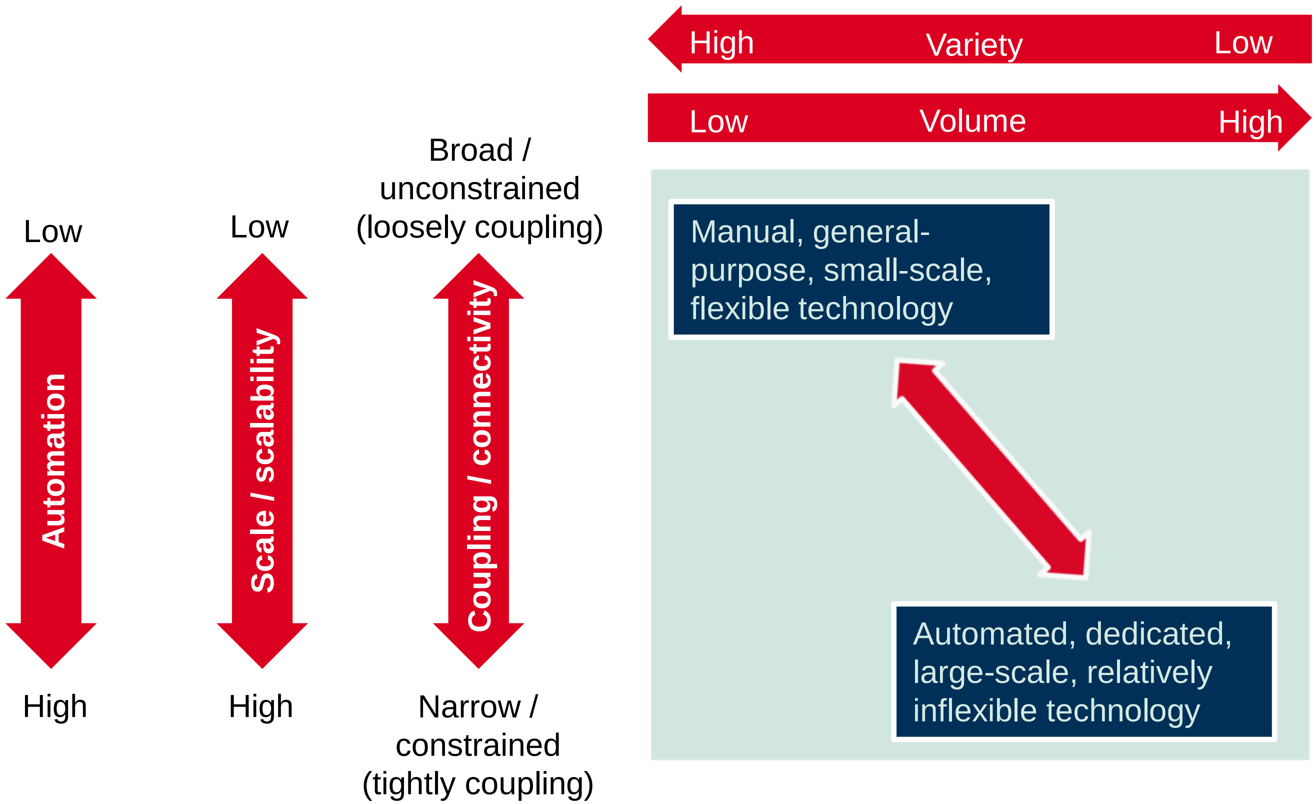


Figure 8.4 Different process technologies are important for different volume–variety combinations.

How process technologies are evaluated: How does the technology improve the operation's performance?

- Evaluate the **impact of the process technology on the five operations performance objectives**:
  - **Quality**
  - **Speed**
  - **Dependability**
  - **Flexibility** *(product / service, mix, volume, delivery)*
  - **Cost**

How process technologies are evaluated:
Does the technology give an acceptable financial return?

- **No calculations required, but ensure you understand the following reasoning / logic and its implications:**

It is important to highlight one important issue that is central to financial evaluation: while the benefits of investing in new technology can be spread over many years into the future, the costs associated with investing in the technology usually occur up front. So we have to consider **the time value of money**. Simply, this means that receiving R10,000 now is better than receiving R10,000 in a year's time. Receiving R10,000 now enables us to invest the money so that it will be worth more than the R10,000 we receive in a year's time. Alternatively, reversing the logic, we can ask ourselves how much would have to be invested now to receive R10,000 in one year's time. This amount (lower than R10,000) is called the **net present value (NPV)** of receiving R10,000 in one year's time.

- **How can we apply this reasoning / logic to non-profits and government departments/agencies?**

How are process technologies are implemented? Resource and process 'distance'

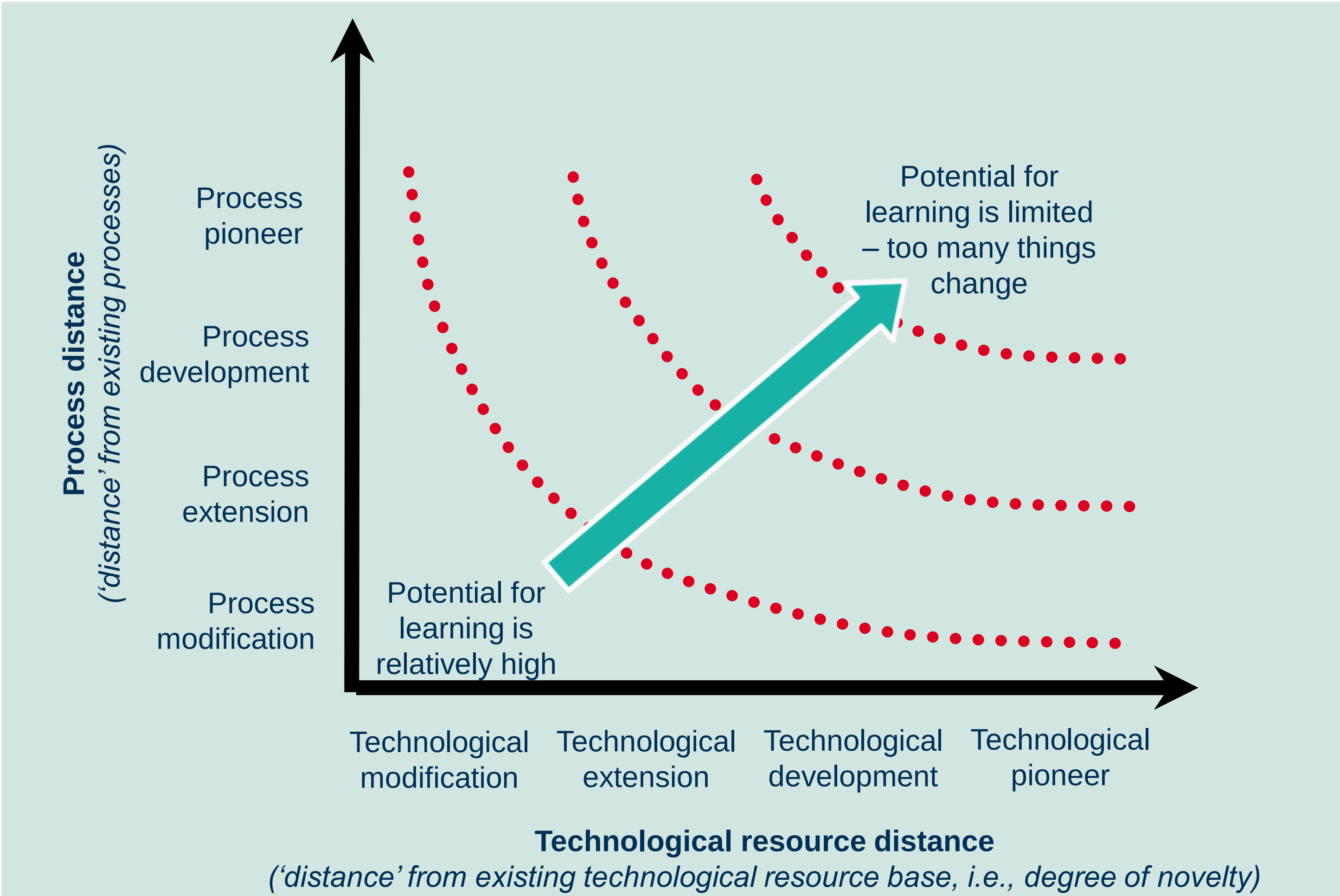


Figure 8.5 Learning potential depends on both technological resource and process 'distance'.

How are process technologies implemented? Customer acceptability

- **When an operation's customers interact with its process technology it is essential to consider the customer interaction when evaluating it. If customers are to have direct contact with technology, they must have some idea of how to operate it.** Where customers have an active interaction with technology, the limitations of their understanding of the technology can be the main constraint on its use, e.g., DVD players, Internet banking.

- **Ability of operation to train its customers in the use of its technology depends on three factors:**
  - **Complexity** – if services are complex, higher levels of 'training' may be needed, e.g., the technologies in theme parks and fast-food outlets rely on customers copying the behaviour of others.
  - **Repetition** – frequency of use is important because the payback for the 'investment' in training will be greater if the customer uses the technology frequently. Also, customers may, over time, forget how to use the technology, but regular repetition will reinforce the training.
  - **Variety of tasks performed by the customer** – training will be easier if the customer is presented with a low variety of tasks, e.g., vending machines tend to concentrate on one category of product, so that the sequence of tasks required to operate the technology remains consistent.

- **In other cases the technology may not be trusted by customers because it is technology and not a person**. Sometimes we prefer to put ourselves in the care of a person, even if their performance is inferior to a technology, e.g., fully automated/autonomous robotic surgery, pilotless aircraft.

How are process technologies implemented?
Anticipating implementation problems (adjustment costs)

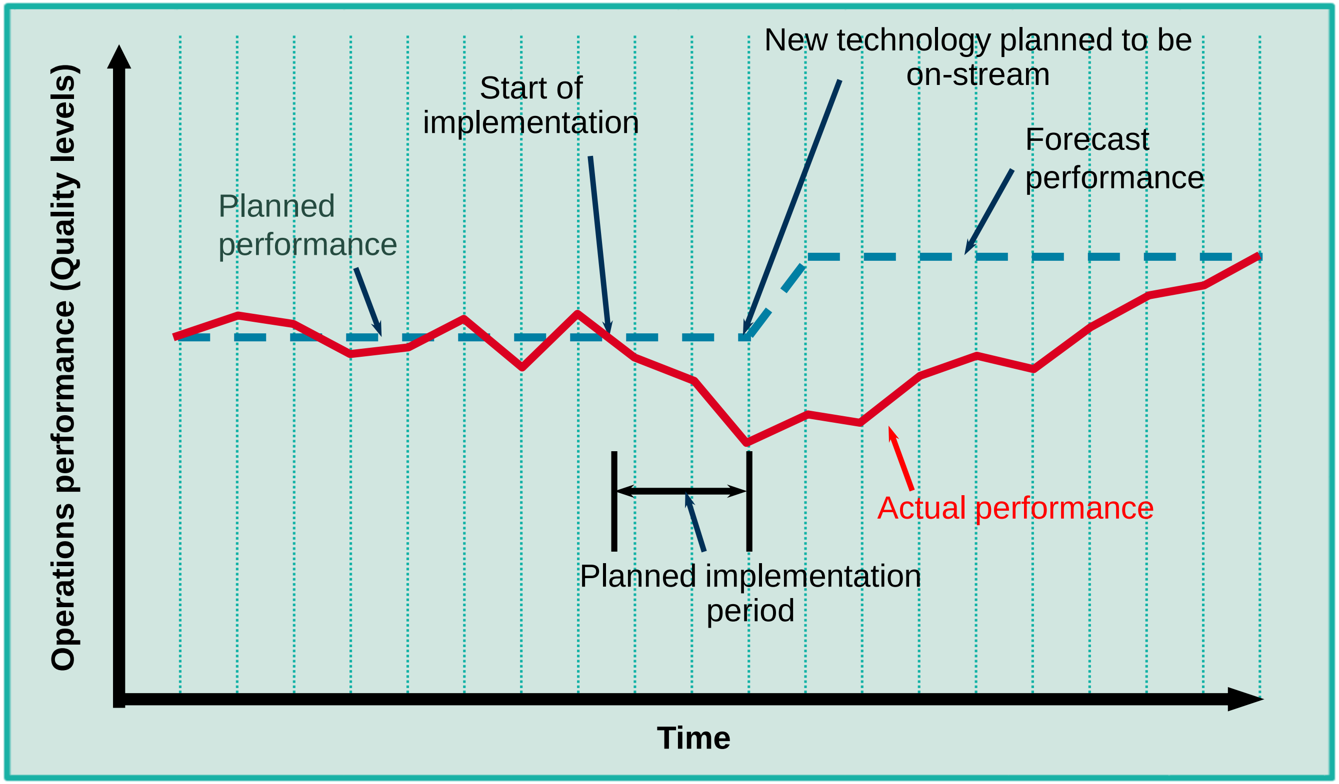


Figure 8.6 The reduction in performance during and after the implementation of a new process reflects 'adjustments costs' (dubbed a Murphy curve by Bruce Chew of MIT, after Murphy's Law)

Outline

Review of Sessions 1-4
Process technology
Enterprise resource planning (ERP)

Enterprise resource planning (ERP)

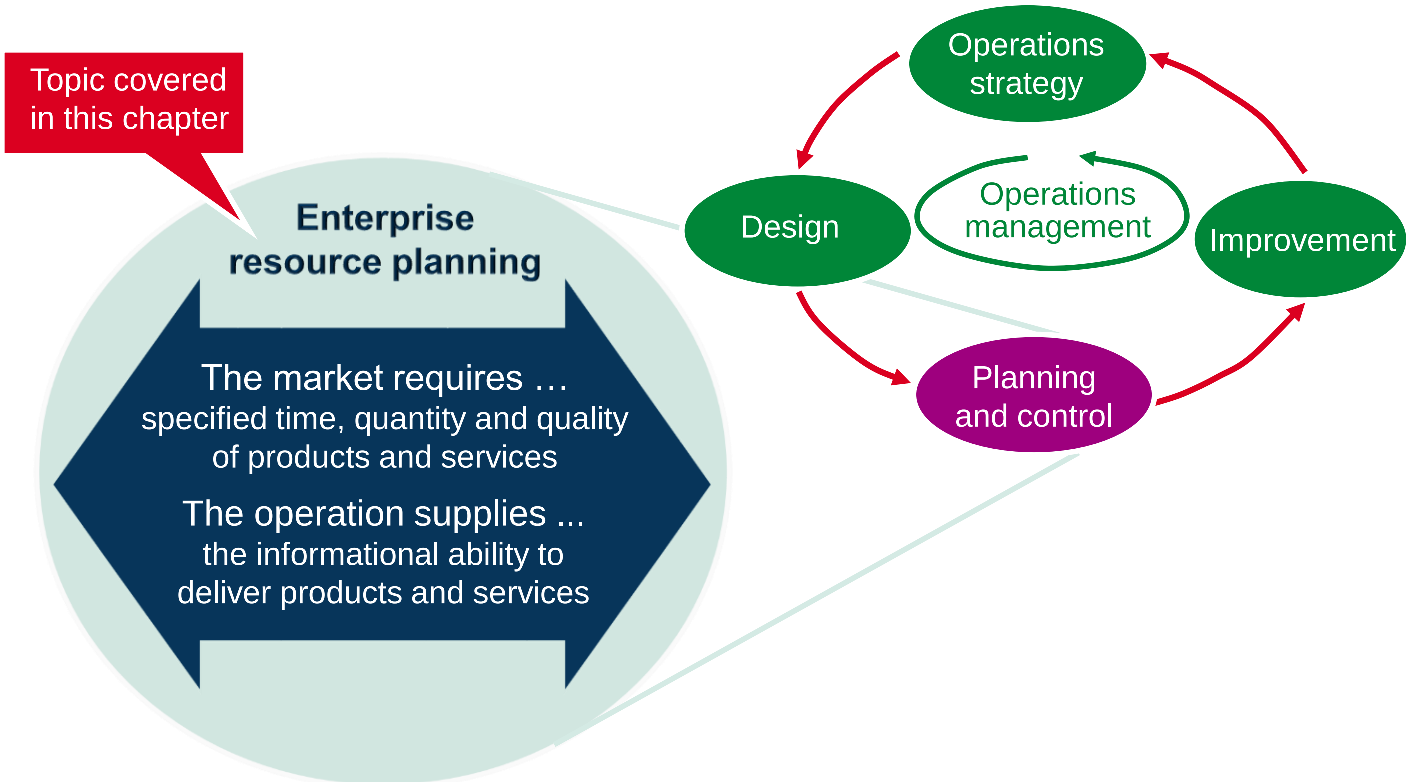


Figure 14.1 This chapter covers enterprise resource planning (ERP).

Key questions

What is ERP?

How did ERP develop?

How should ERP systems be implemented?

What is ERP?

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- An enterprise resource planning (ERP) system is an **enterprise-wide information system** that integrates all the information from many functions needed for planning and controlling operations activities. This integration around a common database allows for transparency.
- ERP often requires very considerable investment in the software itself, as well as its implementation. More significantly, it often requires a company's processes to be changed to bring them in line with the assumptions built into the ERP software.
- **Criticisms of ERP:**
  - **Zero or even negative return on investment.**
  - **Implementation is expensive** due to customisation, need to understand organisational implications, staff training, ERP ecosystem (consulting, hardware, networking, complementary applications) is estimated to be 2x spending on ERP software itself.
  - **Adverse organisational impacts** – many firms find they have to fundamentally change the way they organise their operations to fit in with ERP systems.
  - **Implementation difficulties** due to underestimation of total cost, time and effort, resourcing from both the business and IT, outside expertise required, changes required to business processes, difficulty of controlling scope of project, training required, change management (single biggest failure point for ERP implementations).
- **So why have firms invested in ERP?**
  - Attraction of turning the company's information systems into a 'smooth running and integrated machine', even if it presupposes a very simplistic model of how organisations work in practice.
  - investments were justified on the basis that, 'even if we gain no significant advantage by investing in ERP, we will be placed at a disadvantage by not investing in it because all our competitors are doing so'. There is probably some truth in this; sometimes businesses have to invest just to stand still.

What are the benefits of ERP?

- Because software communicates across all functions, **there is absolute visibility of what is happening in all parts of the business**.
- The **discipline of forcing business process-based changes** is an effective mechanism for making all parts of the business more efficient.
- There is a **better 'sense of control' of operations** that will form the basis for **continuous improvement** (albeit within the confines of the common process structures).
- It enables far more sophisticated **communication with customers, suppliers and other business partners**, often giving **more accurate and timely information**.
- It is capable of **integrating whole end-to-end supply chains**, including suppliers' suppliers and customers' customers.

How did ERP develop?

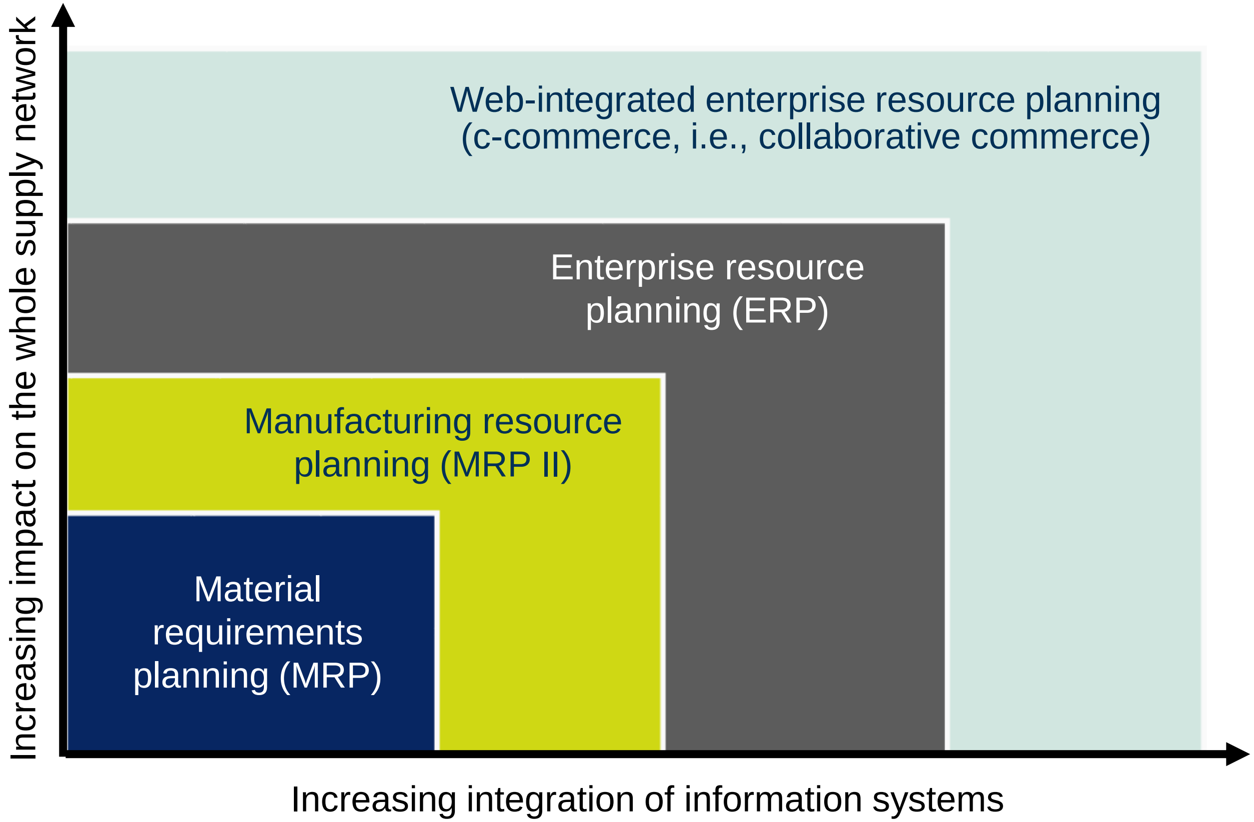
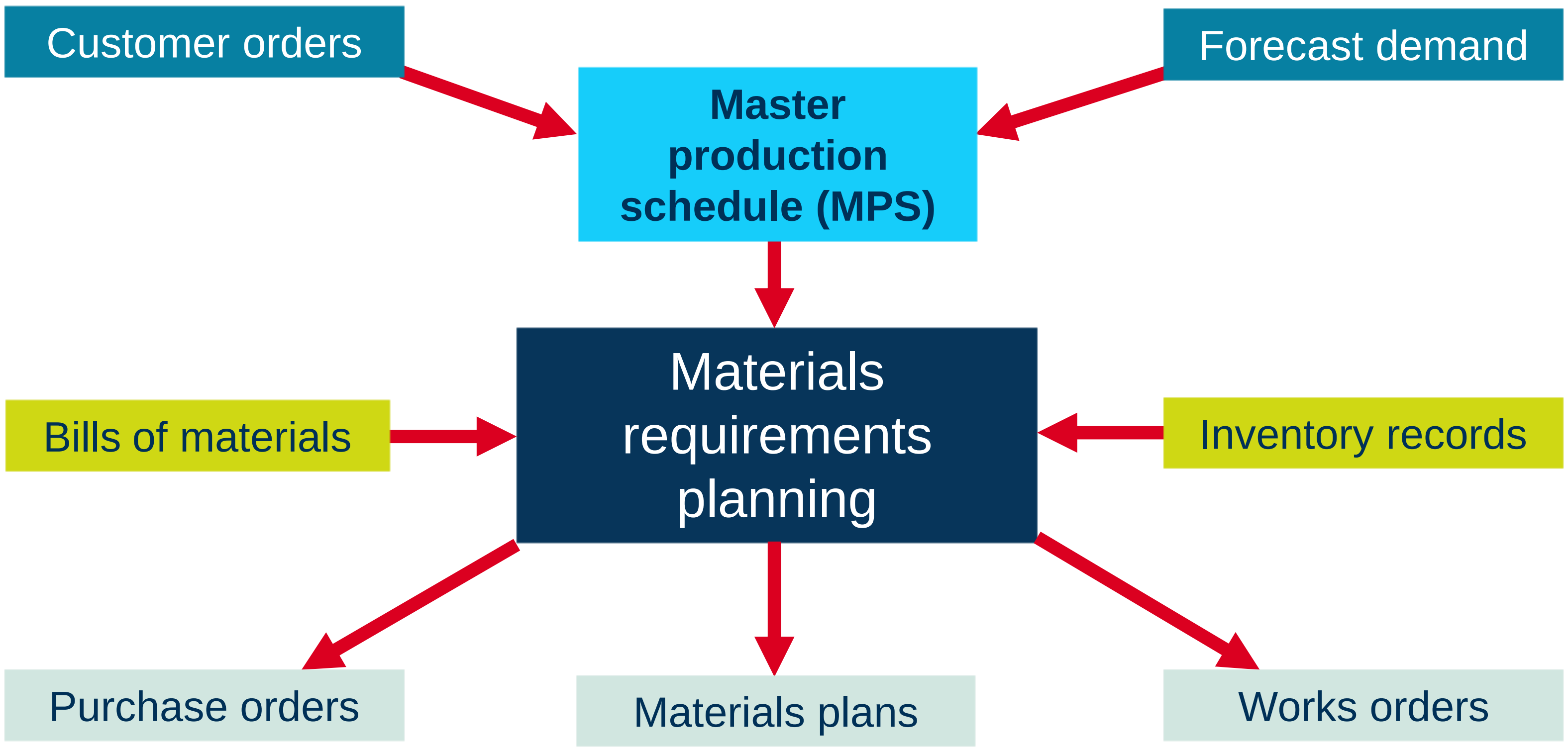


Figure 14.2 The development of ERP

Materials requirements planning (MRP) schematic



Integrative role of ERP

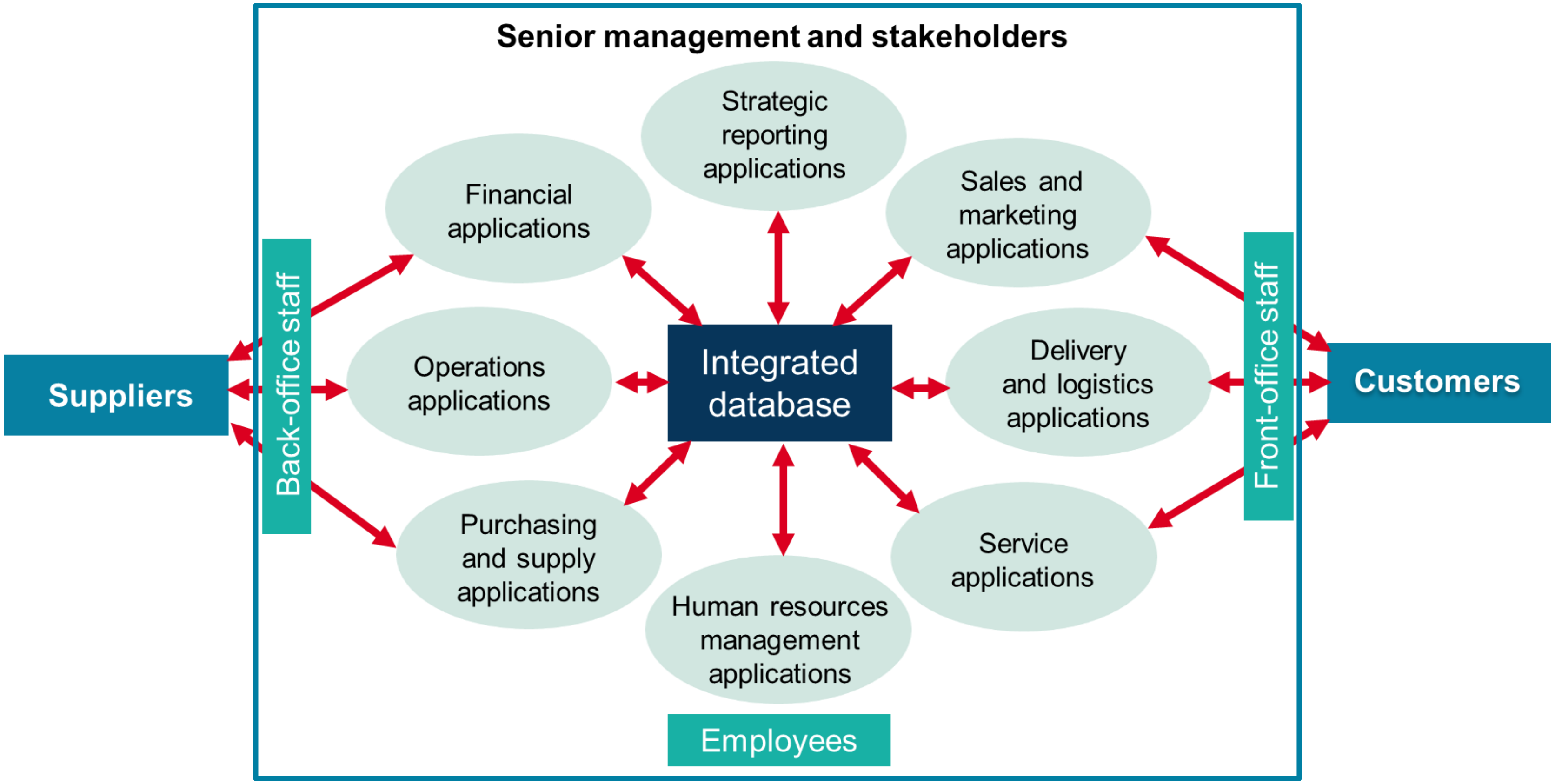


Figure 14.3 ERP integrates information from all parts of the organisation.

Implementation of ERP systems: Strategic critical success factors

- **Top-management commitment and support** – strong and committed leadership at the top-management level is essential to the success of an ERP implementation.
- **Visioning and planning** – articulating a business vision to the organisation, identifying clear goals and objectives and providing a clear link between business goals and systems strategy.
- **Project champion** – the individual should possess strong leadership skills, as well as business, technical and personal managerial competencies.
- **Implementation strategy and timeframe** – implement the ERP under a time-phased approach.
- **Project management** – the ongoing management of the implementation plan.
- **Change management** – this concept refers to the need for the implementation team to formally prepare a change management program and be conscious of the need to consider the implications of such a project. One key task is to build user acceptance of the project and a positive employee attitude. This might be accomplished through education about the benefits and need for an ERP system. Part of this building of user acceptance should also involve securing the support of opinion leaders throughout the organisation. There is also a need for the team leader to effectively negotiate between various political turfs. Some authorities also stress that in planning the ERP project, it must be looked upon as a change management initiative not an IT initiative.

Table 14.2 Strategic critical success factors (CSF) related to successful ERP implementation

Implementation of ERP systems: Tactical critical success factors

- **Balanced team** – the need for an implementation team that spans the organisation, as well as one that possesses a balance of business and IT skills.
- **Project team** – there is a critical need to put in place a solid, core implementation team that is comprised of the organisation's 'best and brightest' individuals. These individuals should have a proven reputation and there should be a commitment to 'release' these individuals to the project on a full-time basis.
- **Communication plan** – planned communication among various functions and organisational levels (specifically between business and IT personnel) is important to ensure that open communication occurs within the entire organisation, as well as with suppliers and customers.
- **Project cost planning and management** – it is important to know up front exactly what the implementation costs will be and dedicate the necessary budget.
- **IT infrastructure** – it is critical to assess the IT readiness of the organisation, including the architecture and skills. If necessary, infrastructure might need to be upgraded or revamped.
- **Selection of ERP** – the selection of an appropriate ERP package that matches the businesses processes.
- **Consultant selection and relationship** – some authorities advocate the need to include an ERP consultant as part of the implementation team.
- **Training and job redesign** – training is a critical aspect of an implementation. It is also necessary to consider the impact of the change on the nature of work and the specific job descriptions.
- **Troubleshooting/crisis management** – it is important to be flexible in ERP implementations and to learn from unforeseen circumstances, as well as be prepared to handle unexpected crises situations. The need for troubleshooting skills will be an ongoing requirement of the implementation process.

Table 14.2 Tactical critical success factors (CSF) related to successful ERP implementation