Ministry of Foreign Affairs, Singapore –
Chartered Institute of Logistics & Transport Singapore

Executive Programme in Logistics and Distribution Management

Business Logistics Management

9 October 2008, 9am~5pm

Business Logistics Management

- Trends and Strategies in Business Logistics
- Strategic Supply Chain and Inventory Positioning
- Supply Chain Network Design
- Best Practices in Supply Chain Management
- Resource Planning and Optimisation
- Forecasting and Just-in-Time (JIT)

Topic 1 – Trends and Strategies in Business Logistics

Understand the importance on business logistics and its impact on the supply chain

- define business logistics
- know the key activities in logistics management
- understand the importance of logistics/supply chain
- the value added role of logistics

1.1 Defining Business Logistics

Logistics is the part of the supply chain process that plans, implements and controls the efficient, effective flows and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements.

The 3 key points to note are:

- Product flows are to be managed from the point where they exist as raw materials to the point where they are finally discarded.
- Logistics is also concerned with the flow of services as well as physical goods, an area of growing opportunity for improvement.
- Logistics is a process that includes all the activities that have an impact on making goods and services available to customers as and when they wish to acquire them.

1.2 Key Activities of Logistics Management

The key activities of a typical logistics system are:

- Alliance between Customer Service and Marketing
- Transportation
- Inventory Management
- Information flows and order processing

1.2 Key Activities of Logistics Management

Alliance between Customer Service and Marketing:

- To determine customer needs and wants for logistics services
- To determine customer responses to service
- To set customer service levels

1.2 Key Activities of Logistics Management

Transportation:

- Mode and transport service selection
- Freight consolidation
- Carrier routing
- Vehicle scheduling
- Equipment selection
- Claims processing
- Rate auditing

1.2 Key Activities of Logistics Management

Inventory Management:

- Raw materials and finished goods stocking policies
- Short-term sales forecasting
- Product mix at stocking points
- Number, size and location of stocking points
- Just-in-time, push and pull strategies

1.2 Key Activities of Logistics Management

Information flows and order processing:

- Sales order-inventory interface procedures
- Order information transmittal methods
- Order rules (e.g. EOQ, Lot for Lot etc)

1.3 The Importance of Logistics/Supply Chain

The emphasis of logistics in organisations has changed over time:

Then (1980s and 1990s)

Improving customer service in supply chain management was important because:

Customer service contributed directly to revenue increase and market share

• Business logistics management was considered to be equally important with sales and marketing to produce development

There was therefore a continued need for firms to reduce supply chain costs and assets as well as improve customer service for long term growth

1.3 The Importance of Logistics/Supply Chain

The emphasis of logistics in organisations has changed over time:

Now

The emerging view of the new century is that supply chain management can both drive and enable the business strategy of many firms.

Aligning supply chain strategy with business strategy will enable value enhancement throughout the firm.

1.3 The Importance of Logistics/Supply Chain

The emphasis of logistics in organisations has changed over time:

Now

Example:

Dell Computer's "Retail Direct" involves processing orders direct from their customers, building the system to the customer's order and delivering then within 5 days. To support this logistical approach, Dell requires its suppliers to maintain inventories within 15 minutes of its manufacturing plants. By unleashing the strategic power of the supply chain, Dell Computer easily outperformed its competitors in terms of shareholder value growth by over 3000 percent (taken from Stern Stewart EVA 1000 database)

1.3 The Importance of Logistics/Supply Chain

Value

According to studies conducted for the US economy, logistics costs rank second only to the cost of goods sold.

Value is added by minimising these costs and passing the benefits to the customer and the firm’s shareholders.

Impact on cash earnings

Shareholder Value is represented by Profitability (which is a relation of Revenue and Cost) and Invested Capital (represented by Working Capital and Fixed Capital).

Revenue – Greater customer service

Greater product availability

Cost – Lower cost of goods sold, transportation, warehousing, material handling, and distribution management costs

Working Capital – Lower raw materials and finished goods inventory

Shorter ‘order to cash’ cycles

Fixed Capital – Fewer physical assets (e.g. trucks, warehouses, material handling equipment)

Worked Example

J. Mitchell currently has sales of $10 million a year, with a stock level of 25% of sales.
Annual holding cost for the stock is 20% of value.
Operating costs (excluding the cost of stocks) are $7.5 million a year and other assets are valued at $20 million.

- What is the current return on assets?
- How does this change if stock levels are reduced to 20% of sales?

Worked Example - Solution

Taking costs over a year, the current position is:

Cost of stock	= amount of stock x holding cost	
	= 10 million x 0.25 x 0.2	= \$0.5 million a year
Total costs	= operating cost + cost of stock	
	= 7.5 million + 0.5 million	= \$8 million a year
Profit	= sales - total costs	
	= 10 million - 8 million	= \$2 million a year
Total assets	= other assets + stock	
	= 20 million + (10 million x 0.25)	= \$22.5 million
Return on assets	= profit / total assets	
	= 2 million / 22.5 million	= 0.089 or 8.9%

Worked Example - Solution

The new position with stock reduced to 20% of sales is:

Cost of stock	= amount of stock x holding cost	
	= 10 million x 0.20 x 0.2	= $0.4 million a year
Total costs	= operating cost + cost of stock	
	= 7.5 million + 0.4 million	= $7.9 million a year
Profit	= sales - total costs	
	= 10 million – 7.9 million	= $2.1 million a year
Total assets	= other assets + stock	
	= 20 million + (10 million x 0.20)	= $22 million
Return on assets	= profit / total assets	
	= 2.1 million / 22 million	= 0.095 or 9.5%

Reducing stocks gives lower operating costs, higher profit and a significant increase in ROA.

1.3 The Importance of Logistics/Supply Chain

Key Capabilities

In the 1996 study (by Morash, Drage and Vickery) on the highly competitive US furniture industry, they identified and quantified the impact of the supply chain in profitability and growth.

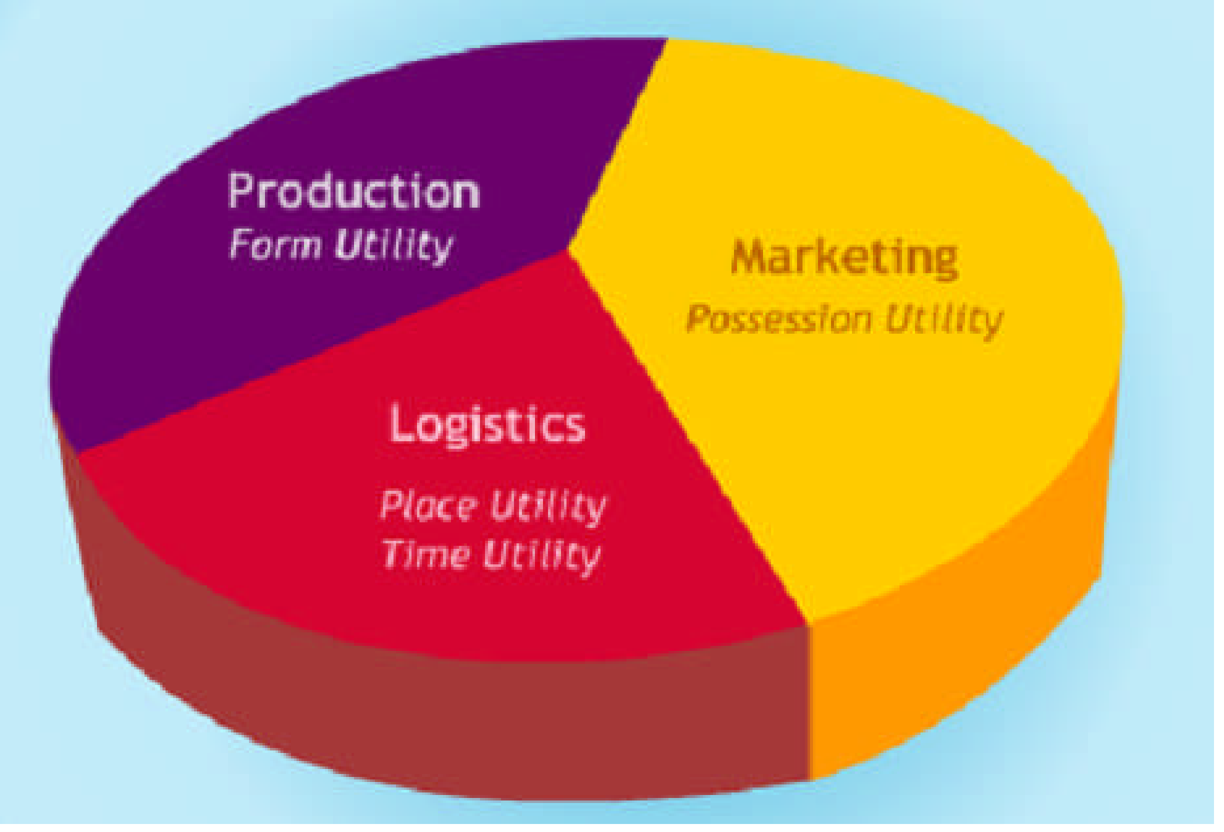
Analysis of the survey results identified 4 key supply chain capabilities that contribute directly to financial performance.

They are:

1. Delivery speed
2. Reliability
3. Responsiveness to target markets
4. Low cost total distribution

1.4 Value-Added Role of Logistics

There are 4 principal types of economic utility that add value to a product or service, i.e. form utility, possession utility, place utility and time utility



1.4 Value-Added Role of Logistics

Remember the *What*, *Where*, *When* and *Why* of the economic utilities

<u>What – Form Utility</u>

Refers to the value added to goods through a manufacturing , production or assembly process. For example, breaking bulk and product mixing changes a product's form by changing its <u>shipment size packaging characteristics</u>

<u>Where – Place Utility</u>

Logistics <u>extends the physical boundaries</u> of the market area, thus adding economic value to the goods. This addition is known as place utility

<u>When – Time Utility</u>

Goods and services must be available when customers demand them. By having goods and services available <u>when it is needed</u> creates time utility

<u>Why – Possession Utility</u>

Possession Utility is primarily created by the marketing activities related to the promotion of goods and services. It <u>increases the desire</u> in a customer to possess a good or to benefit from a service

Topic 2 – Strategic Supply Chain and Inventory Positioning

Understand the key concepts in supply chain inventory modelling and its components

- understand the Economic Order Quantity (EOQ)
- know how to determine the Reorder Point (ROP)
- explain the use of the Newsboy Model in inventory replenishment
- understand Pipeline Inventory and its components

2.1 Economic Order Quantity

EOQ is an accounting formula that determines the point at which the combination of order costs and inventory carrying costs are the least. The result is the most cost effective quantity to order.

Assumptions used for Economic Order Quantity:

- Demand occurs at a known and reasonably constant rate
- The item has a sufficiently long shelf life
- The item is monitored under a continuous review system
- All the cost parameters remain constant forever (over an infinite time horizon
- A complete order is received in one batch

2.1 Economic Order Quantity

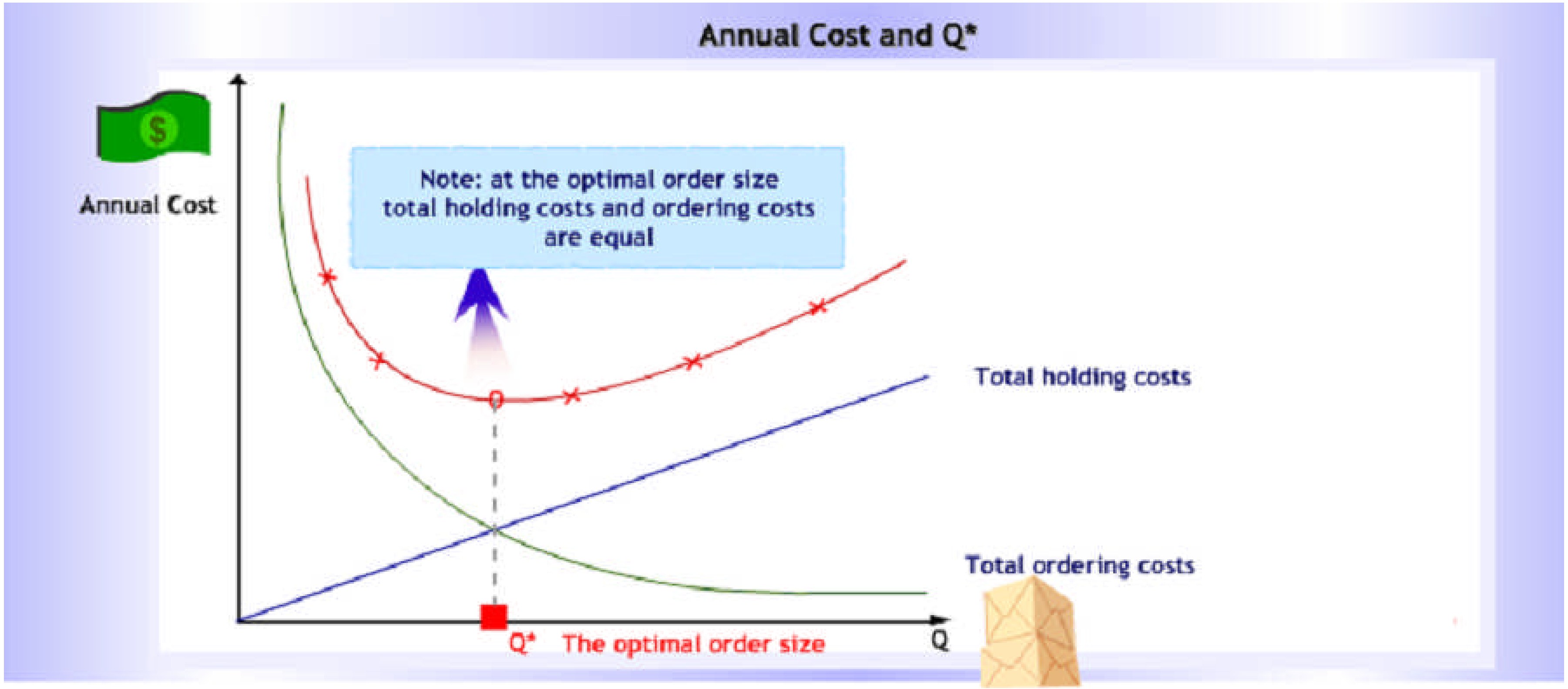
Cost Equation for the Economic Order Quantity (EOQ) Model:

$$Q^* = \sqrt{\frac{2DC_o}{C_h}}$$

where Q^* = Optimal order size
C_h = Annual holding cost per unit
D = Annual usage in units
C_o = Order cost

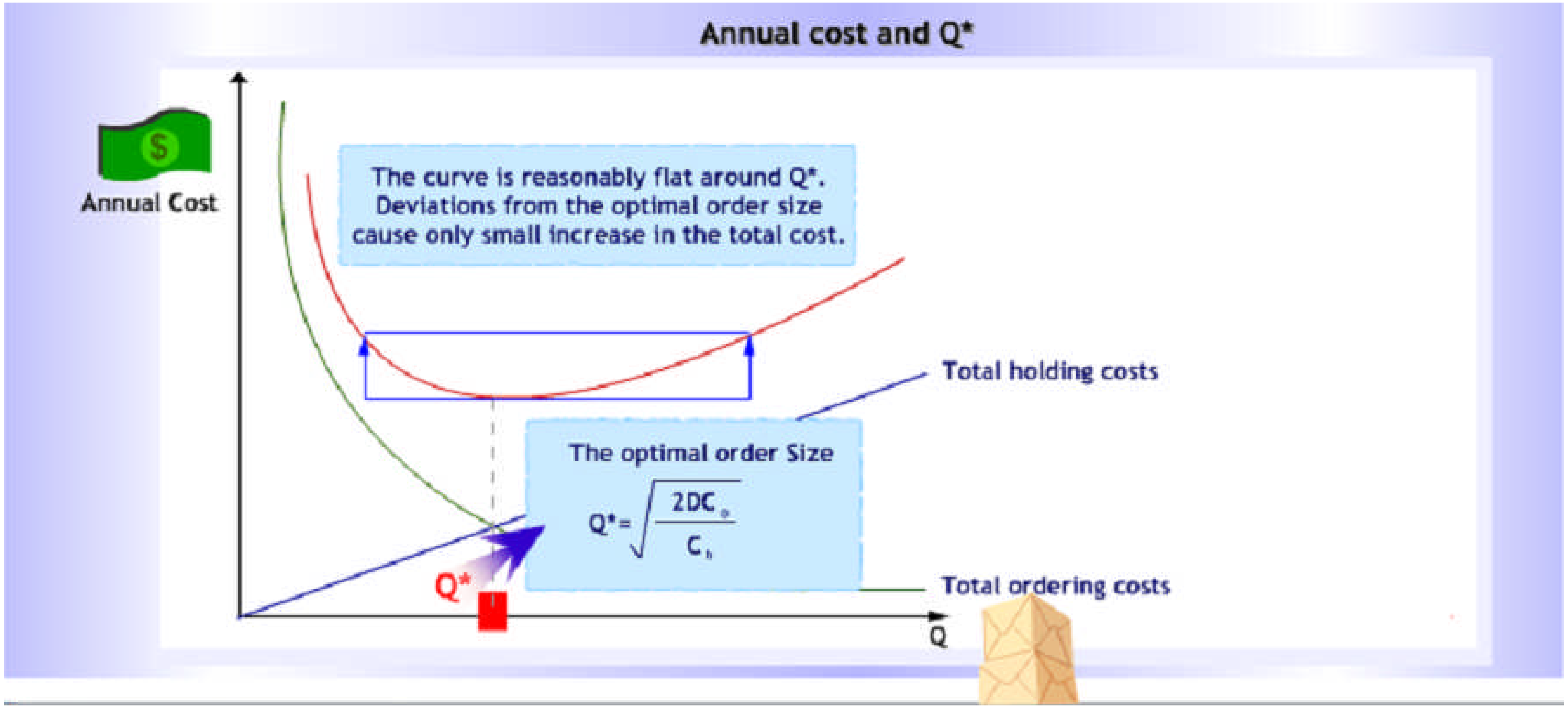
2.1 Economic Order Quantity

A graphical representation



2.1 Economic Order Quantity

Sensitivity



2.1 Economic Order Quantity

Worked Example

1) Economic Order Quantity (EOQ)

$$Q^* = \sqrt{\frac{2DC_o}{C_h}}$$

where Q^* = Optimal order size; D = Annual usage in units; C_h = Annual holding cost per unit; C_o = Order cost

2) Total Annual Inventory Costs = Total Annual Holding Costs + Total Annual Ordering Costs + Total Annual Procurement Costs

or $TC(Q) = (Q/2)C_h + (D/Q)C_o + DC$

With Safety Stock, the Total Annual Inventory Costs changes to:

$$TC(Q) = (Q/2)C_h + (D/Q)C_o + DC + C_hSS$$

With C_hSS being the Safety Stock Holding Costs.

2.1 Economic Order Quantity

Worked Example

3) Cycle Time (T)

• The cycle time, T, represents the time that elapses between the placement of orders.
• Note, if the cycle time is greater than the shelf life, items will go bad, and the model must be modified.

T = Q/D

4) Number of Orders per Year (N)

• To find the number of orders per years take the reciprocal of the cycle time

N = D/Q

2.1 Economic Order Quantity

Worked Example

ALLEN APPLIANCE COMPANY (AAC)
AAC wholesales small appliances.
AAC currently orders 600 units of the Citron brand juicer each time inventory drops to 205 units.
Management wishes to determine an optimal ordering policy for the Citron brand juicer

Available Data

- Co = $12 ($8 for placing an order) + (20 min. to check)($12 per hr)
- Ch = $1.40 [HC = (14%)($10)]
- C = $10.
- H = 14% (10% ann. interest rate) + (4% miscellaneous)
- D = demand information of the last 10 weeks was collected:
- The constant demand rate seems to be a good assumption.
- Annual demand = (120/week) x (52weeks) = 6240 juicers.

Calculate the EOQ and Total Variable Cost.

Solution:

<u>EOQ and Total Variable Cost:</u>

Current ordering policy calls for Q = 600 juicers.

TV(600) = (600/ 2)($1.40) + (6240 / 600)($12) = $544.80

The EOQ policy calls for orders of size
Q* = = 327.065 = 327
TV(327) = (327 / 2)($1.40) + (6240 / 327) ($12) = $457.89

Under the current ordering policy AAC holds 13 units safety stock.
AAC is open 5 day a week.

- The average daily demand = 120/week)/5 = 24 juicers.
- Lead time is 8 days. Lead time demand is (8)(24) = 192 juicers.
- Reorder point without Safety stock = LD = 192.
- Current policy: R = 205.
- Safety stock = 205 – 192 = 13.

For safety stock of 13 juicers the total cost is

TC(327) = 457.89 + 6240($10) + (13)($1.40) = $62,876.09

2.1 Economic Order Quantity

Worked Example

Sensitivity of the EOQ Results:

Changing the order size

- Suppose juicers must be ordered in increments of 100 (order 300 or 400)
- AAC will order Q = 300 juicers in each order.
- There will be a total variable cost increase of $1.71.
- This is less than 0.5% increase in variable costs.

Changes in input parameters

- Suppose there is a 20% increase in demand. D=7500 juicers.
- The new optimal order quantity is Q* = 359.
- The new variable total cost = TV(359) **=** $502
- If AAC still orders Q = 327, its total variable costs becomes $504

2.1 Economic Order Quantity

Worked Example

Cycle Time

For an order size of 327 juicers we have:

$T = (327/6240) = 0.0524$ year.

$= 0.0524(52)(5) = 14$ days.

This is useful information because:

- Shelf life may be a problem.
- Coordinating orders with other items might be desirable.

2.2 Determining the Reorder Point (ROP)

The following scenarios will be modelled:

Continuous Review – Constant Demand and constant Lead Time

Continuous Review – Variable Demand and constant Lead Time

Fixed Period Review

2.2 Determining the Reorder Point (ROP)

Continuous Review – Constant Demand and constant Lead Time

In reality lead time (**LT**) always exists, and must be accounted for when deciding at which point in time to place an order

The reorder point, **ROP**, is the inventory position when placing an order

The formula to calculate the Reorder point when there is a Constant daily demand (**D**) and lead-time (**LT**) is:

$$\mathbf{ROP} = \mathbf{LT} \times \mathbf{D}$$

Note: LT and D must be expressed in the same time unit (e.g. per month)

2.2 Determining the Reorder Point (ROP)

Continuous Review – Variable Demand and constant Lead Time

The formula to calculate the Reorder point when there is a Variable daily demand with mean **đ** and standard deviation σ_d and lead-time (**LT**) is:

$$\mathbf{ROP} = \mathbf{đ} \times \mathbf{LT} + \mathbf{z} \times \sigma_d \times \sqrt{\mathbf{LT}}$$

Note: z represents the service level. It is assumed that the variability in Lead Time follows a Normal Distribution.

The second term on the right represents the Safety Stock. Safety Stock acts as a buffer to handle higher than average lead time demand and longer than expected lead times.

2.2 Determining the Reorder Point (ROP)

Fixed Period Review

Definition of Order up-to-level point (I_{max})

I_{max} = Expected demand during (OI + LT) + safety stock

i.e. $$I_{max} = \bar{d} \times (OI + LT) + z \times \sigma_d \times \sqrt{OI + LT}$$

The Order Quantity is simply the difference between Imax and the quantity on hand during the review

i.e. **Order Quantity** = I_{max} – **Quantity on Hand**

Reorder Point (ROP) Worked Example:

1) Continuous Review (Constant Demand, Constant Lead Time)

Reorder Point **R** = **D** x **LT**

2) Continuous Review (Variable Demand, Constant Lead Time)

Reorder Point $\mathbf{R} = \mathbf{đ} \times \mathbf{LT} + \mathbf{z} \times \sigma_{\mathbf{d}} \times \sqrt{\mathbf{LT}}$

3) Periodic Review (Order up to level or Imax)

I_{max} is defined as expected demand during order interval (OI) , lead time (LT) and safety stock

i.e. $\mathbf{I_{max}} = \mathbf{đ} \times (\mathbf{OI} + \mathbf{LT}) + \mathbf{z} \times \sigma_{\mathbf{d}} \times \sqrt{\mathbf{OI} + \mathbf{LT}}$

Order Quantity = Imax – Quantity on Hand

Reorder Point (ROP) Worked Example:

1) Continuous Review (Constant Demand, Constant Lead Time)

A Carpet manufacturer has the following:
Daily usage **D** = 30 yards/day
Lead Time **LT** = 10 days

Reorder Point **R** = **D** x **LT**

= 30 x 10 = 300 yards

2) Continuous Review (Variable Demand, Constant Lead Time)

Additionally, the following is known:

Mean of daily usage **đ** = 30 yards/day
Variance in demand σ_d = 5 yards/day
Service Level of reordering, **z** = 95% (corresponding to normal variate of 1.65)

Reorder Point **R** = **đ** x **LT** + **z** x σ_d x $\sqrt{LT}$

= 30 x 10 + 1.65 x 5 x $\sqrt{10}$ = 326.1 yards

Reorder Point (ROP) Worked Example:

3) Periodic Review (Order up to level or Imax)

Using the following information:

Lead Time **LT** = 10 days
Mean of daily usage **đ** = 30 yards/day
Variance in demand σ_d = 5 yards/day
Service Level of reordering, **z** = 95%
Fixed time between orders **OI** = 60 days

First compute Imax (defined as expected demand during order interval (OI) , lead time (LT) and safety stock)

i.e. $I_{max} = đ \times (OI + LT) + z \times \sigma_d \times \sqrt{OI + LT}$

$= 30 \times (60 + 10) + 1.65 \times 5 \times \sqrt{(60+10)} = 2169$ yards

Based on that value of Imax, and at the point of placing the order, the quantity to be ordered will be the difference of Imax and the quantity on hand i.e.
If Quantity on hand = 450 units,

Order Quantity = I_{max} – **Quantity on Hand**

= 2169 – 450 = 1719 yards

2.3 Newsboy Model

The Newsboy Model mimics a person who buys newspapers at the beginning of the day, sells a random amount and discards any leftovers.

Here the 2 main issues are:

- Single Replenishment
- The need to determine the appropriate order quantity in the face of uncertain demand

2.3 Newsboy Model

Insights to the Newsboy Model

- In an environment of uncertain demand, the appropriate production/order quantity depends on both the distribution of demand and the relative costs of overproducing versus underproducing.

- In general, increasing the variability (i.e. standard deviation) of demand will increase the production/order quantity and will therefore increase the likelihood that the actual demand is far from what is produced/ordered. This implies that mean and variance of total cost will increase with variability of demand.

2.3 Newsboy Model

$$G(Q^*) = \left(\frac{C_s}{C_o + C_s} \right)$$

G(Q*) – The probability function of the optimum quantity Q*

C_o - The **unit overage cost** is the amount lost per excess set

C_s - The **unit shortage cost** is the lost profit from a sale

Newsboy Model Worked Example:

Consider the following:

A manufacturer of Christmas lights faces a problem each year. Demand is somewhat unpredictable and occurs in such a short burst just prior to Christmas that if the inventory is not on the shelves, the demand will be lost.

Therefore the decision of how many sets of lights to produce must be made prior to the holiday season. Additionally, the cost of collecting unsold inventory and holding it until next year is too high to make year-to-year storage an attractive option. Instead, any unsold sets of lights are sold after Christmas at a steep discount.

Suppose that a set of lights costs $1 to make and distribute and is selling for $2. Any sets not sold by Christmas will be discounted to $0.50. Suppose further that demand has been forecast to be 10,000 units with a standard deviation of 1,000 units and that the normal distribution is a reasonable representation of demand.

How many sets should the manufacturer produce?

Newsboy Model Worked Example:

Preliminary Analysis:

A set of lights costs $1 to make and distribute and is selling for $2.
Any sets not sold by Christmas will be discounted to $0.50.

In terms of the above modeling notation, this means that the unit **overage cost** is the amount lost per excess set or Co = $(1 - 0.50) = $0.50.
The unit **shortage cost** is the lost profit from a sale or Cs = $(2 - 1) = $1.00

The firm could choose to produce 10,000 sets of lights. But, the symmetry (i.e., bell shape) of the normal distribution implies that it is equally likely for demand to be above or below 10,000 units.

If demand is below 10,000 units, the firm will lose Co = $0.5 per unit of overproduction.

If demand is above 10,000 units, the firm will lose Cs = $1 per unit of underproduction.

Clearly, shortages are worse than overages.

This suggests that perhaps the firm should produce more than 10,000 units. But, how much more?

Newsboy Model Worked Example:

Original Selling Price, OP = \$2.00
Cost of Production, C = \$1.00
Discounted Selling Price, DP = \$0.50

Assuming the firm could choose to produce 10,000 sets of lights,

The **unit overage cost** is the amount lost per excess set or C_o = \$(1.00 - 0.50) = \$0.50
This means that if demand is below 10,000 units, the firm will lose \$0.5 per unit of overproduction

The **unit shortage cost** is the lost profit from a sale or C_s = \$(2.00 – 1.00) = \$1.00
This implies that if demand is above 10,000 units, the firm will lose \$1.00 per unit of underproduction. Clearly, shortages are worse than overages

Solving for the Probability function, we have:

$$G(Q^*) = \left(\frac{C_s}{C_o + C_s} \right)$$

$$= \frac{1}{1 + 0.5} = 0.67$$

Answer: (cont'd)

As its demand is normally distributed,

$$G(Q^*) = \Phi\left(\frac{Q^* - 10{,}000}{1{,}000}\right)$$

$$= \frac{1}{1+0.5} = 0.67$$

Where Φ represents the cumulative distribution function of the standard normal distribution.
From a standard normal table, we find that $\Phi(0.44) = 0.67$.
Hence, we have:

$$G(0.44) = 0.67$$

$$\Rightarrow \frac{Q^* - 10{,}000}{1{,}000} = 0.44$$

$$or \quad Q^* = 10{,}440$$

Note: The Newsboy analysis is only applicable when the goods are **time-perishable** i.e.

OP > C > DP

Newsboy Model Worked Example:

In which of the following situations, can the Newsboy Model be used?

Scenario 1:
Croissants are sold at $1.60 each.
Cost of production is $1.20 each
Unsold units are discounted to $0.80 each

Scenario 2:
Newspapers are sold at $0.80 each.
Cost of production is $0.40 each
Unsold units are discarded i.e. $0 value

Scenario 3:
Cookies are sold at $2.80 per packet.
Cost of production is $1.20
Unsold units are discounted to $2.20

2.4 Pipeline Inventory

The formula below describes the formula to calculate the average demand during the lead time.

ĎL = đ x LT

Where ĎL is the average demand during the lead time

Example:

đ = 20 units per week

LT = 3 weeks

ĎL = 20 x 3 = 60 units in the pipeline

Topic 3 – Supply Chain Network Design

Appreciate the importance of supply chain network design and its impact on managing demand

- learn how to cope with Demand Uncertainty

- learn the different types of inventory management:
  Centralisation vs Decentralisation

- understand the use of Risk Pooling

3.1 Coping with Demand Uncertainty

The effect of Demand Uncertainty

Most companies treat the world as if it were predictable:

1. Production and inventory planning are based on forecasts of demand made far in advance of the selling season
2. Companies are aware of demand uncertainty when they create a forecast, but they design their planning process as if the forecast truly represents reality

3.1 Coping with Demand Uncertainty

Unfortunately for these companies, there are three principles that hold true for all forecasting techniques.

Principle 1 :

Forecasting is always wrong

Principle 2 :

The longer the forecast horizon, the worse the forecast

Principle 3 :

Aggregate forecasts are more accurate

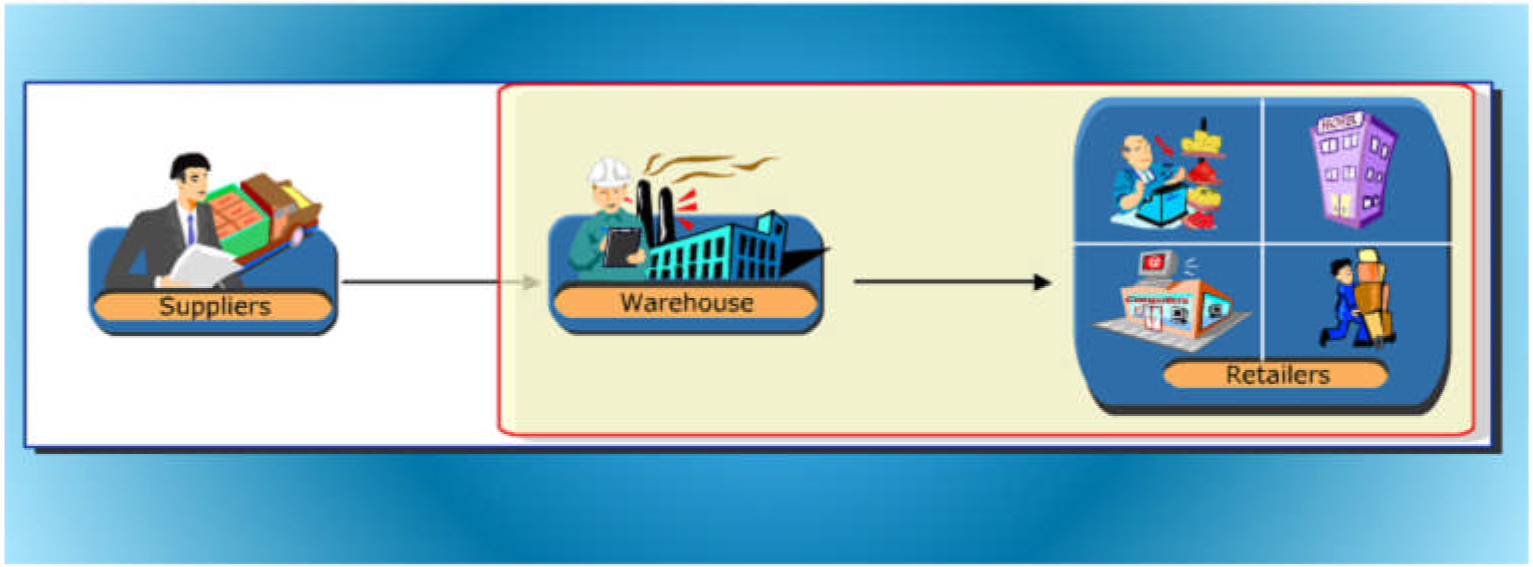
3.1 Coping with Demand Uncertainty

Key Insights are:

1. The optimal order quantity is not necessarily equal to average forecast demand.
2. The optimal order depends on the relationship between marginal profit and marginal cost
3. As order quantity increases, average profit first increases then decreases
4. As production quantity increases, risk increases. In other words, the probability of large gains and of large losses increases.

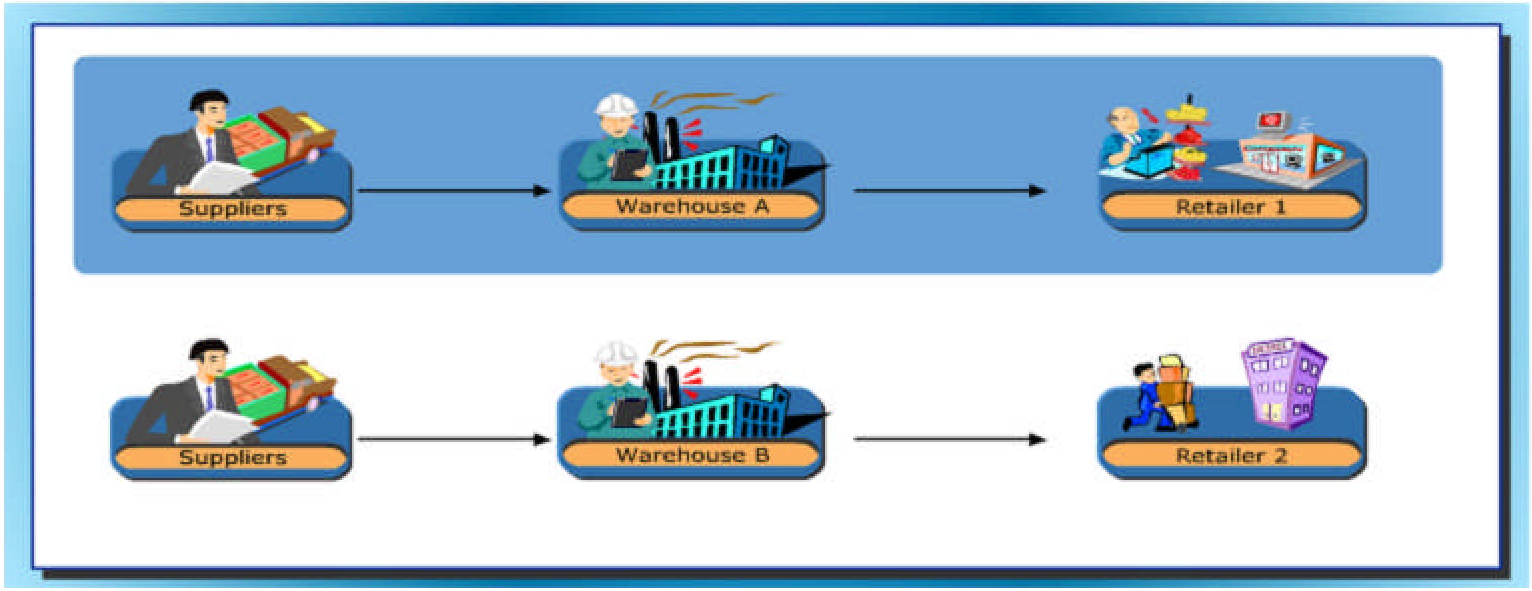
3.2 Inventory Centralisation/Decentralisation

A Centralised Distribution System is an inventory model that has a single warehouse serving all customers



3.2 Inventory Centralisation/Decentralisation

A Decentralised Distribution System is an inventory model that has a several warehouse serving customers with different needs (e.g. location/product/market)



3.2 Inventory Centralisation/Decentralisation

Whether to centralise or decentralise, depends on the following factors:

Safety Stock
Generally the amount of safety stock decreases when a firm moves from a decentralised to a centralised system

Service Level
When both centralised and decentralised systems contain the same level of safety stock, the service level provided by the centralised system is higher

Overhead Costs
These costs are typically higher in a decentralised system because these system enjoys fewer economies of scale

Customer Lead Time
In decentralised distribution systems, the response time to retailers is shorter because the warehouses are located much closer to the retailers

Transportation Costs
The net impact of this point is unclear due to the fact that the cost of the outbound deliveries to retailers decreases for decentralised systems, but at the same time, the costs of delivering the products to said warehouses increase.

3.2 Inventory Centralisation/Decentralisation

Inventory Management: Best Practices

After a company has decided on which distribution system to adopt, it will need to continually reevaluate its inventory levels due to changing demands

Some of the best practices used by most companies include:

- **Periodic inventory reviews**
- **Tight management of usage rates, lead times and safety stock**
- **ABC approach**
- **Reduced safety stock levels**
- **Shift more inventory or inventory ownership, to suppliers**
- **Quantitative approaches**

3.2 Inventory Centralisation/Decentralisation

Changes in Inventory Turnover

With recent developments in information and communication technologies, the trend in most companies is to increase inventory turnover

This allows companies to increase service levels while keeping inventory costs low

Inventory turnover ratio = annual sales / average inventory level

The following is an indication of Inventory Turnover Ratios used by major players in the industry:

Industry	Upper Quartile	Median	Lower Quartile
Dairy Products	34.4	19.3	9.2
Electronic Component	9.8	5.7	3.7
Electronic Computers	9.4	5.3	3.5
Books: publishing	9.8	2.4	1.3
Household audio & video equipment	6.2	3.4	2.3
Household electrical appliances	8.0	5.0	3.8
Industrial chemical	10.3	6.6	4.4

3.3 Risk Pooling

Understanding the concept of Risk Pooling

Risk Pooling is an important concept in supply chain management

- **It suggests that demand variability is reduced if one aggregates demand across locations**
- **This means that generally, high demand from one customer will be offset by low demand from another**
- **This reduction in variability allows a decrease in safety stock and therefore reduces average inventory**

3.3 Risk Pooling

Consider the 2 different systems shown below:

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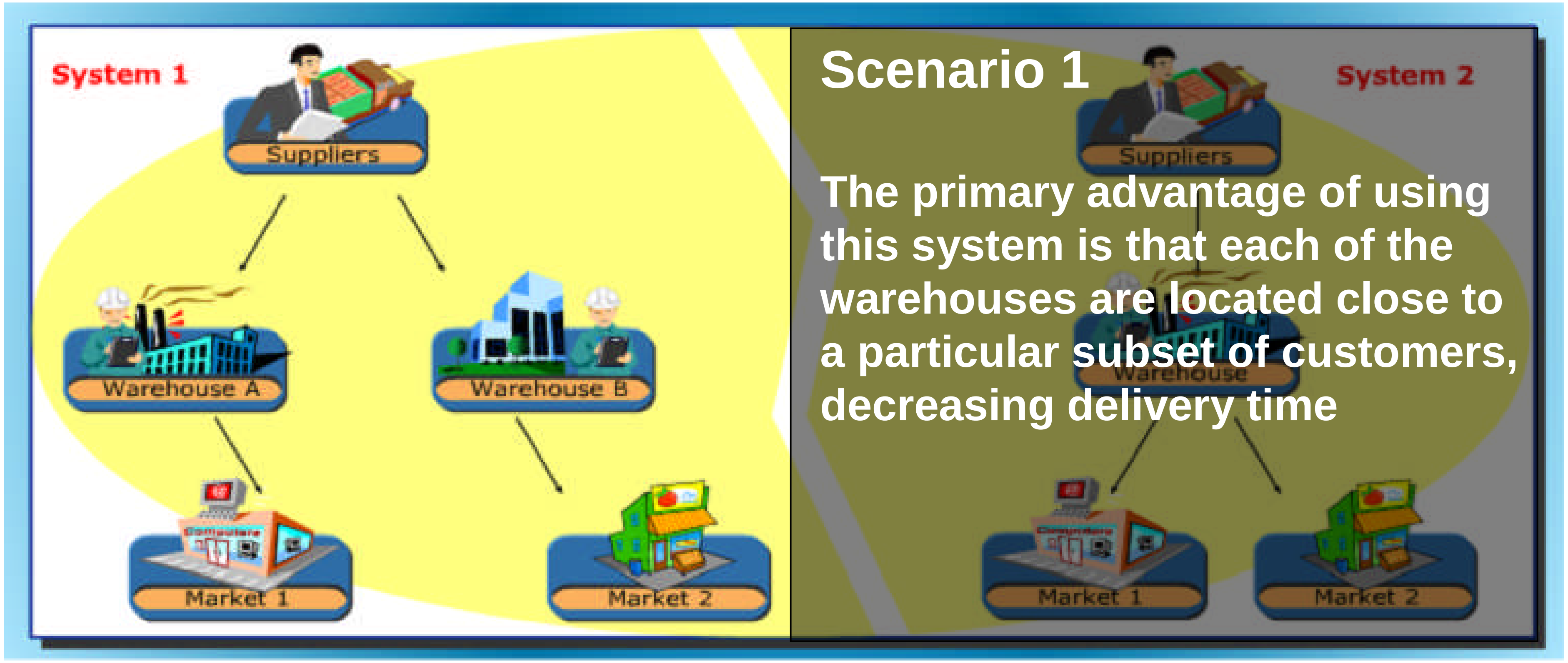

3.3 Risk Pooling

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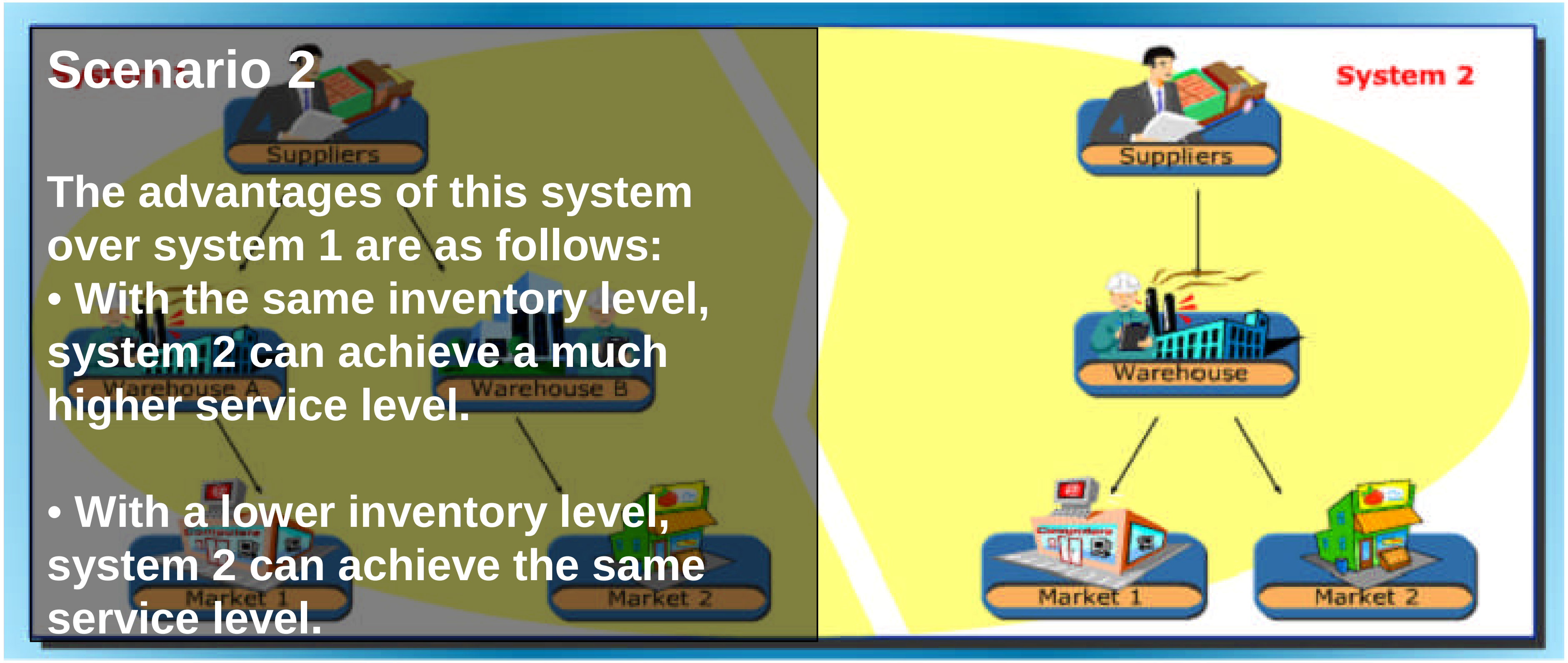


Scenario 2

The advantages of this system over system 1 are as follows:

- **With the same inventory level, system 2 can achieve a much higher service level.**

- **With a lower inventory level, system 2 can achieve the same service level.**

3.3 Risk Pooling

The reason why system 2 is more efficient is because it fulfills random demand

- A higher than average demand at one retailer will usually be offset by a lower than average demand from another retailer.
- As the number of retailers served by a warehouse increases, the likelihood of offsetting occurrence will also increase
- By centralising inventories, a company can ensure a higher service level and lower the possibility of a stockout.

3.3 Risk Pooling

Scenario:

Imagine we are now attempting to switch from system 1 to system 2. We have to decide how much we can reduce inventory while maintaining the current service level.

In order to achieve this, we will conduct a rigorous analysis of 2 products that has to maintain a 97% service level.

Note the following information:

- **Order costs is $60 for each order from the factory.**
- **Holding inventory costs are $0.27 per unit per week.**
- **Transportation cost is $1.05 per unit in system 1**
- **Transportation cost is $1.10 per unit in system 2**
- **1 week lead time**

3.3 Risk Pooling

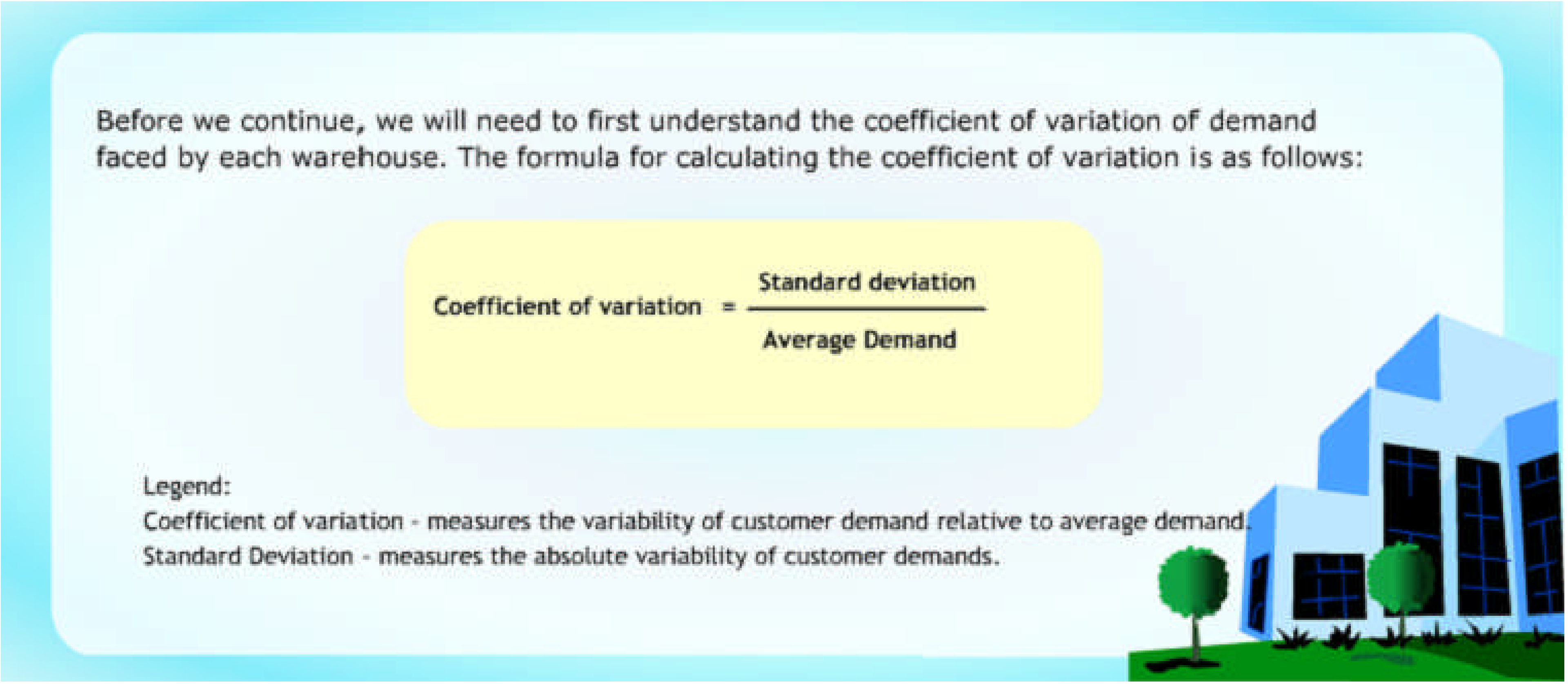
The table below shows the Historical Data for products A and B for the last 8 weeks in each market area.

Observe that product B is a slow-moving product and its demand is relatively small when compared to the demand for product A.

Historical Data for Product A and Product B

Week	1	2	3	4	5	6	7	8
Prod A, Market 1	33	45	37	38	55	30	18	58
Prod A, Market 2	46	35	41	40	26	48	18	55
Prod B, Market 1	0	2	3	0	0	1	3	0
Prod B, Market 2	2	4	0	0	3	1	0	0

3.3 Risk Pooling



3.3 Risk Pooling

The table to the right provides a summary of average weekly demand for each product.

It also presents the coefficient of variation of demand faced by each warehouse.

Summary of Historical Data

Warehouse	Product	AVG	STD	CV
Market 1	A	39.30	13.20	0.34
Market 2	A	38.60	12.00	0.31
Market 1	B	1.13	1.36	1.21
Market 2	B	1.25	1.58	1.26

3.3 Risk Pooling

Here, we see that the variability faced by the **central** warehouse is much smaller than the combined variabilities faced by the 2 existing warehouses.
This is re-confirmed when measured either by the standard deviation or the coefficient of variation.

Warehouse	Product	AVG	STD	CV	Reorder Point	Order-up-to-level	Avg. Inv	% Decrease
Market 1	A	39.30	13.20	0.34	65	197	91	
Market 2	A	38.60	12.00	0.31	62	193	88	
Market 1	B	1.13	1.36	1.21	4	29	14	
Market 2	B	1.25	1.58	1.26	5	29	15	
Central Market	A	77.90	20.70	0.27	118	304	132	36%
	B	2.38	1.90	0.81	6	29	20	43%

3.3 Risk Pooling

In conclusion, the 3 critical points of Risk Pooling are:

- Centralising inventory reduces both safety stock and average inventory in the system for the same service level. It also allows the reallocation of inventory from one market segment to another when the situation requires it.
- The higher the coefficient of variation, the greater the benefit obtained from risk pooling. This is because the need for keeping a higher level of safety stock is reduced when there is risk pooling.
- The benefits of risk pooling depend on the behaviour of demand from one market relative to another. Demand in two markets is positively correlated if it is very likely that an increase in demand in one market related in an increase in demand in the other. In these cases, the benefit of risk poling decreases when the correlation between two markets become increasingly positive.

Topic 4 – Best Practices in Supply Chain Management

Understand the emerging principles of supply chain management using postponement

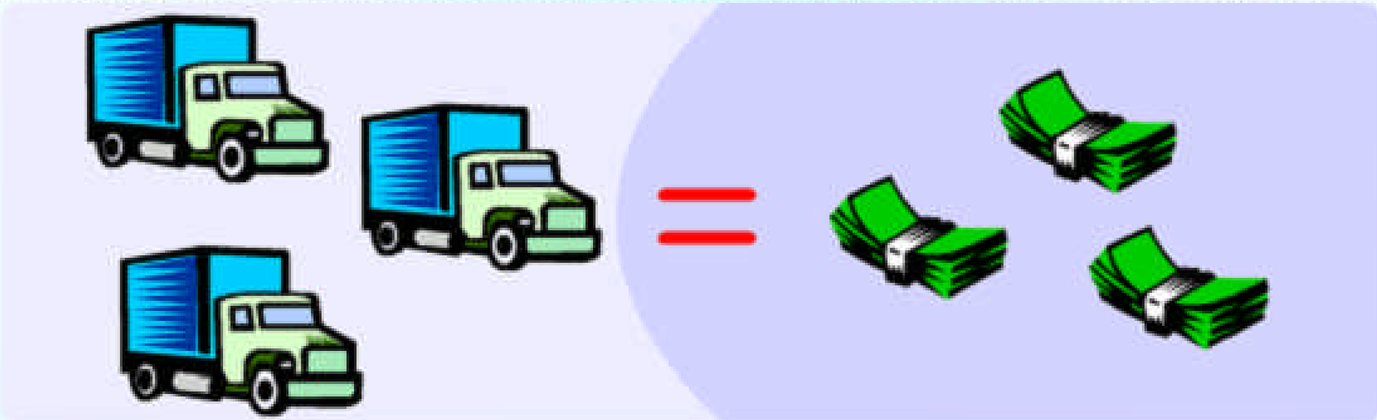
- justify the use of Express Logistics
- explain the various types of Postponement methods
- using Cross Docking to minimise storage costs

4.1 The Value of Express Logistics

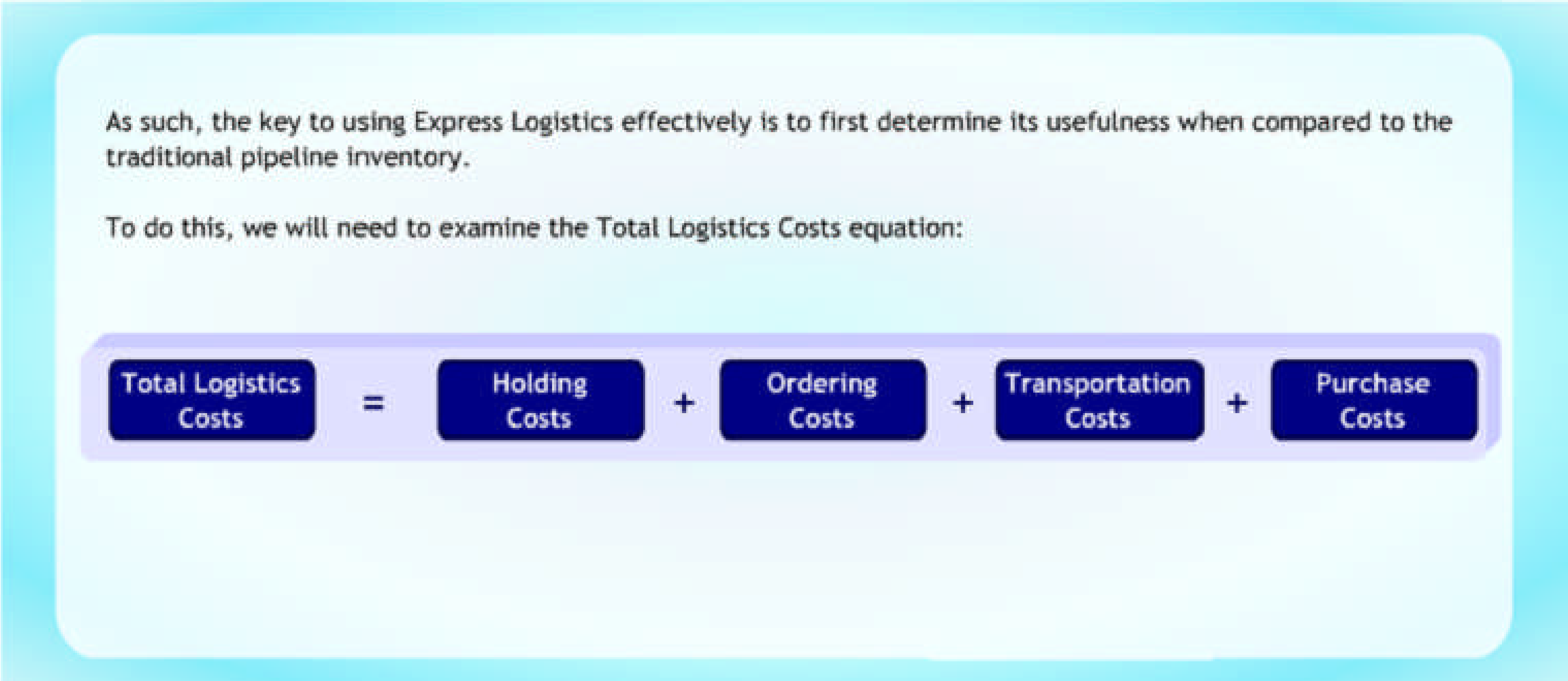
Express Logistics is a process whereby the service level can be increased while holding costs are reduced .

To achieve this, an efficient and robust delivery or transportation service is required to ship goods directly to the customers in the shortest time .

Unfortunately, the costs of maintaining such an effective delivery service means that transportation costs rises.

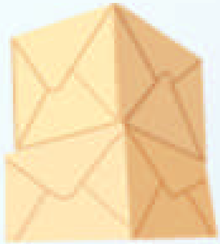


4.1 The Value of Express Logistics

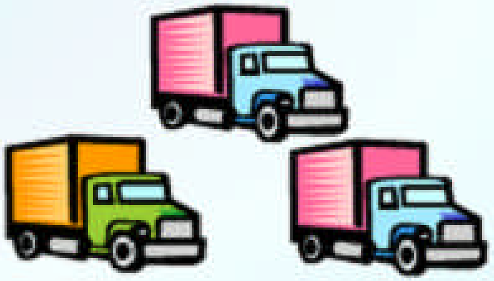


4.1 The Value of Express Logistics

The introduction of Express Logistics will change some of the cost elements found in the Total Logistics Equation.



By reducing the amount of inventory required for storage, Holding Costs is reduced.



Increasing the effectiveness of service delivery usually means a rise in Transportation Costs.

4.1 The Value of Express Logistics

The Total Logistics Costs Equation will therefore be affected in the following manner:

Total Logistics Costs = Holding Costs ↓ + Ordering Costs + Transportation Costs ↑ + Purchase Costs

(where ordering and purchase costs remain constant.)

By examining how the relationship between Holding and Transportation Costs affects the Total Logistics Costs, we can conclude that the use of Express Logistics is only justified if the increase in Transportation Cost is smaller than the reduction in Holding Cost at the channel.

4.2 The Value of Postponement

In this section, postponement refers specifically to form postponement and looks into:

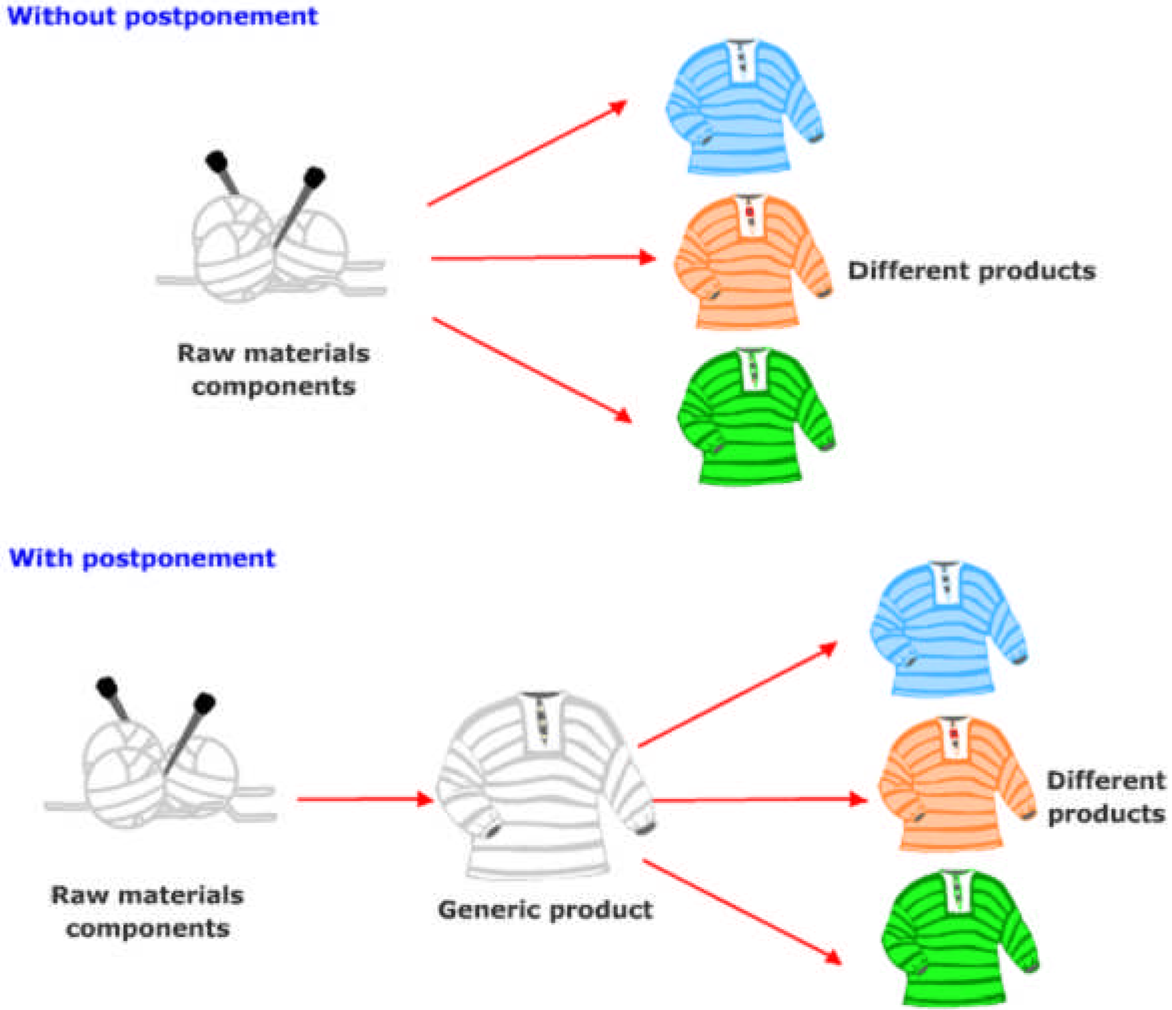
- Design product and manufacturing processes so that decisions about specific products can be delayed as late as possible

- This process is also known as Delayed Point Differentiation (DPD) or Late Point Differentiation (LPD)

- The primary benefit is to reduce demand uncertainty thereby increasing service level delay and reducing inventory costs

4.2 The Value of Postponement

Compare the 2 supply chain processes below to see how postponement changes the process of delivering the end product to consumers.



4.2 The Value of Postponement

Example:

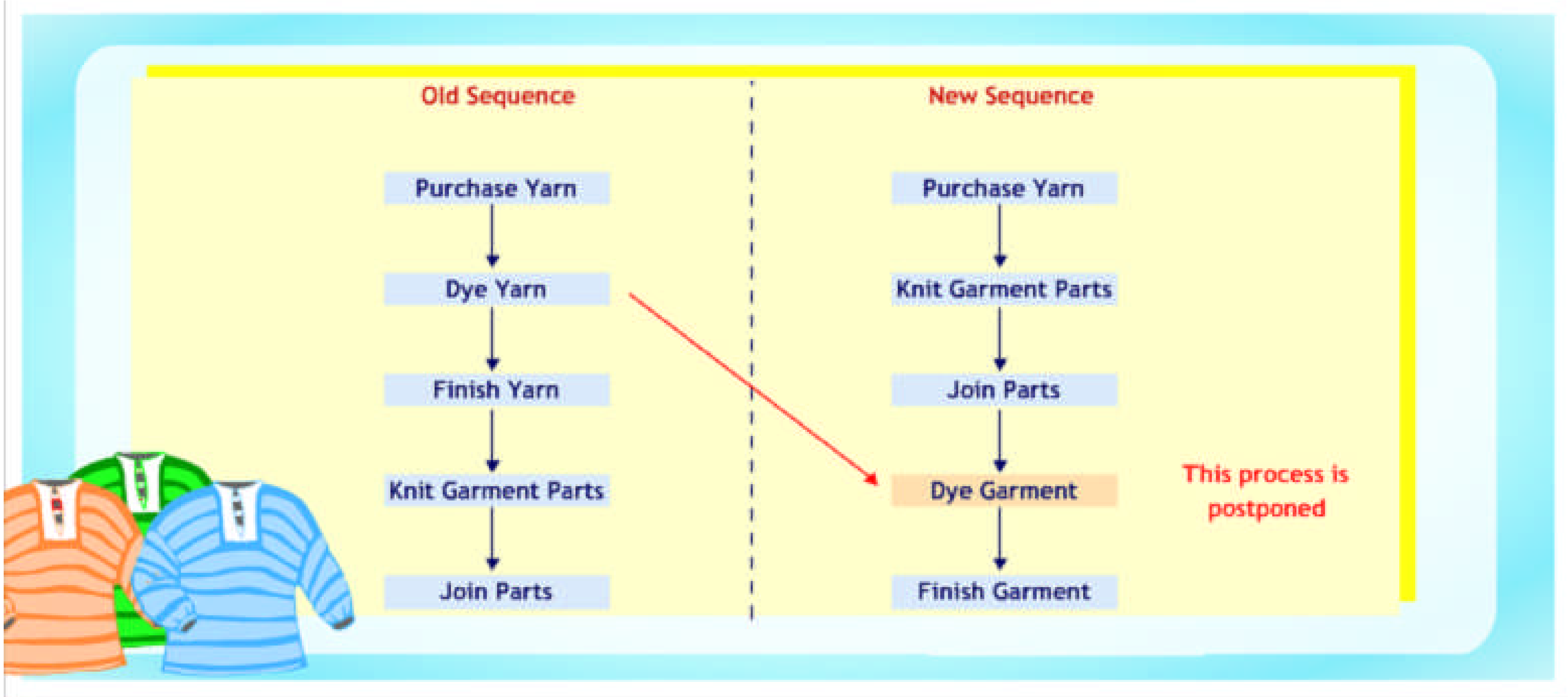
Let us see how Benneton, a world leader in knitwear uses form postponement to its advantage.

A Wool Plant in Castrette, near Treviso, knitting division.

The computerized knitting room is capable of automatically producing the most complex product designs

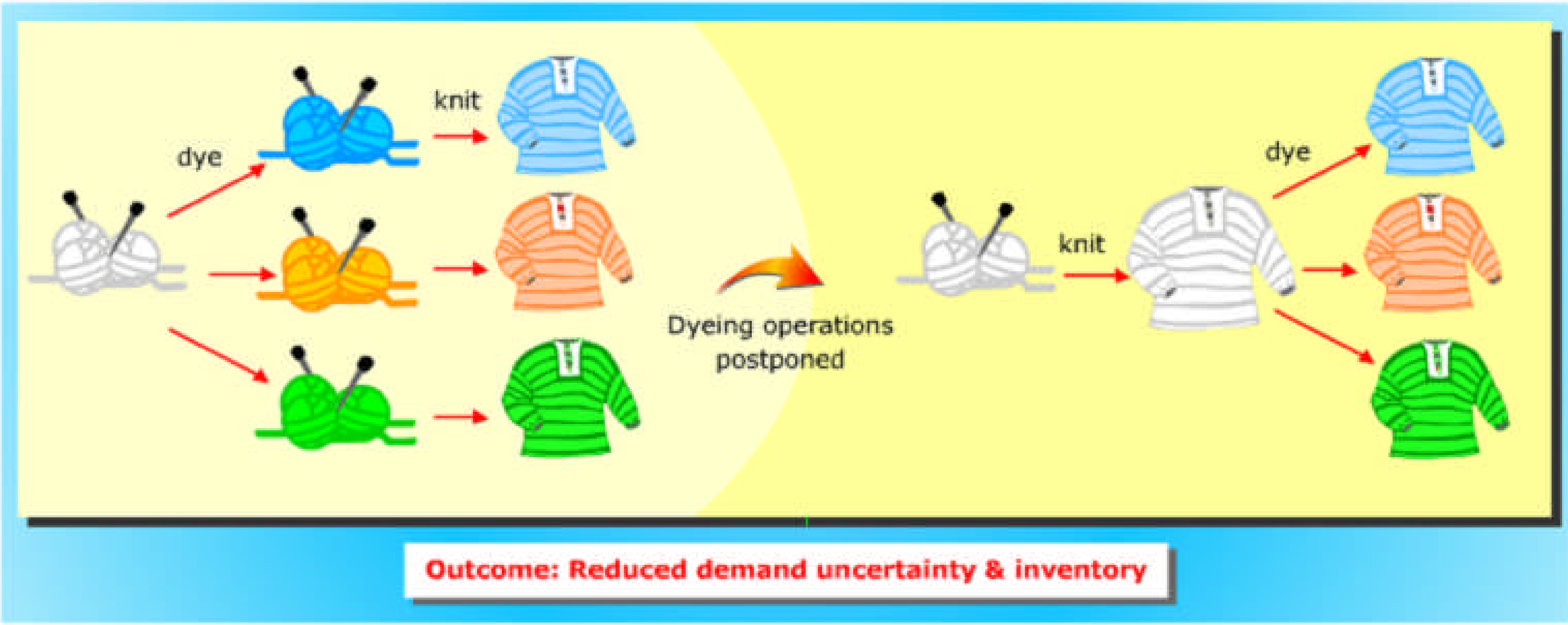
Dyeing vats are used to change the colours of the finished knitted product.

4.2 The Value of Postponement



4.2 The Value of Postponement

Bennetton now has the luxury of time to produce the knitted clothing only after the season's fashion preferences become more established (the lead-time needed for knitting is much longer than the lead-time needed for dyeing).



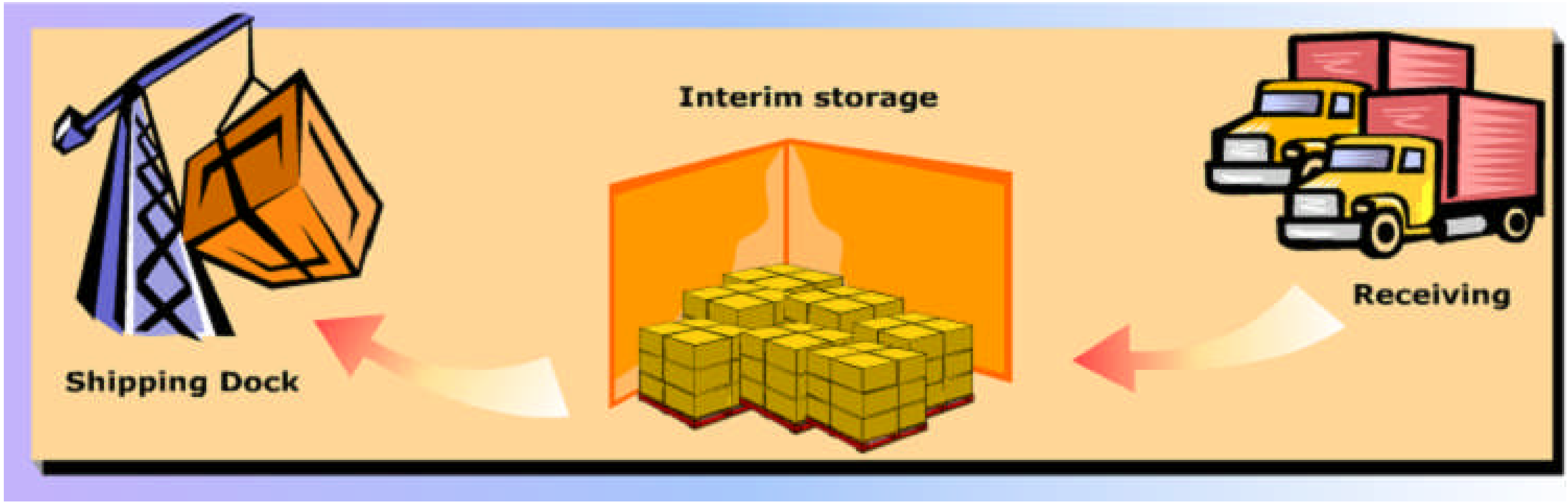
4.3 The Value of Cross-Docking

In this section, we will examine the Cross-Docking process in the following ways:

- Understand the flow of Cross-Docking and how products are delivered from the manufacturer to the retailer
- Examine the challenges associates with using Cross-Docking
- Explore the different options in which Cross-Docking can be applied

4.3 The Value of Cross-Docking

Cross-Docking is a process where products are moved directly from receiving to the shipping dock with no or very short interim storage.



The main users of Cross-Docking are mass merchandisers, grocery companies, LTL trucking companies, air cargo carriers….etc
The products usually associated with Cross-Docking include seasonal items, promotional goods, store-specific pallets or high volume items.

4.3 The Value of Cross-Docking

The advantages of Cross-Docking are as follows:

- Speeds up the flow of products from the supplier to the customer.
- Minimises the use of labor in the process.
- Minimal or no storage and handling activities.
- Eliminates the need to put away goods for storage and the need to repack them for delivery.
- Reduces the amount of finished goods inventory in system.
- Increases inventory turns.
- Avoids LTL deliveries to stores.
- Reduces the need for distribution facilities.
- Saves money through reduced handling, packing and inventory storage costs.

4.3 The Value of Cross-Docking

4.3 The Value of Cross-Docking

It requires strong IT capabilities & real-time info sharing (i.e. advance information systems).

It requires buyer cooperation and timely decisions.

May necessitate new facility layout, bar code scanning equipment, and WMS.

It may be difficult to maintain product visibility as it moves through the system.

The products' availability, accuracy, & quality are critical as there is very little room for error.

Accurate demand forecasts are essential.

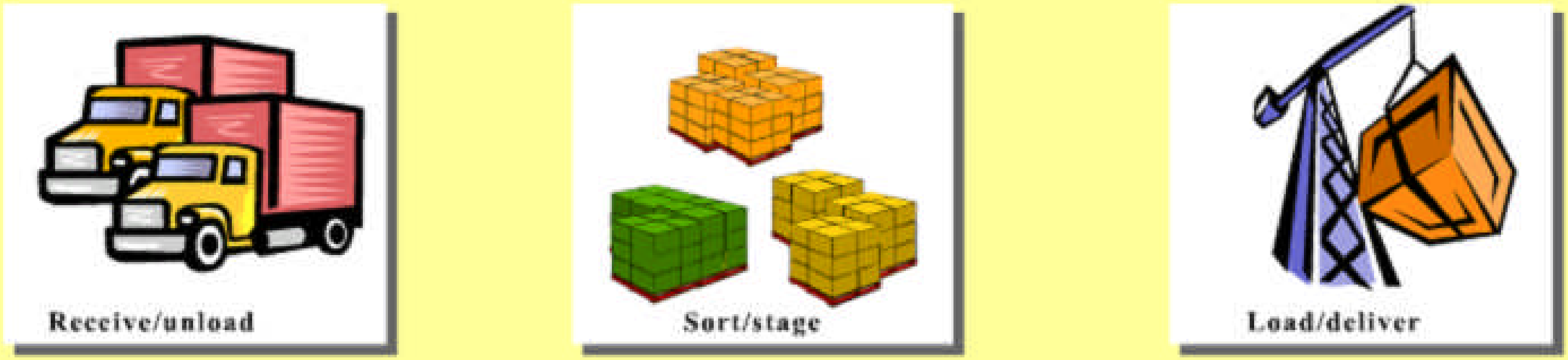
There is a need for a fast and responsive transportation system.

4.3 The Value of Cross-Docking

Options available to implementing Cross-Docking

Option 1 – Basic Cross-Docking

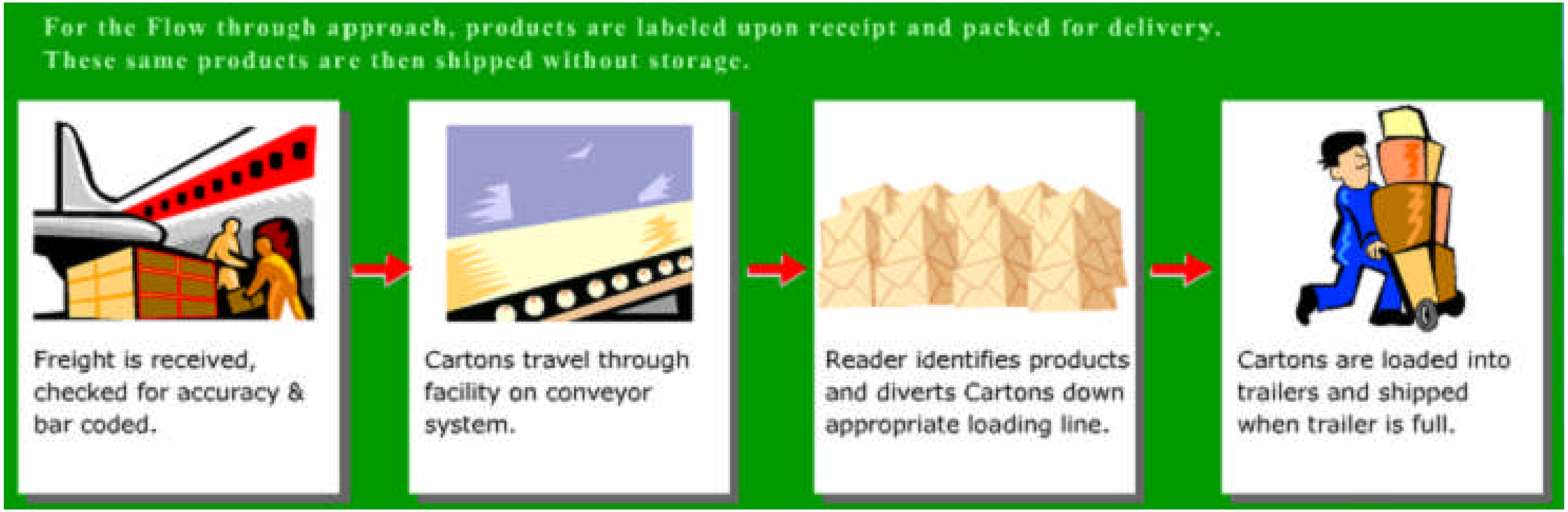
For the basic approach, products assembled by the manufacturer are moved directly through the crossdock facility to shipping dock with no breakbulk.



4.3 The Value of Cross-Docking

Options available to implementing Cross-Docking

Option 2 – Flow Through Cross-Docking



4.3 The Value of Cross-Docking

Examples:

1. The NUMMI plant in California uses cross-docks in Chicago and Memphis to collect, consolidate and sort freight from multiple vendors into containers that are shipped via rail to the plant

2. Suppliers send parts in bulk to General Motor’s cross-dock in Memphis. Parts are sorted for delivery to 15 different production facilities in the Midwest.

Topic 5 – Resource Planning and Optimisation

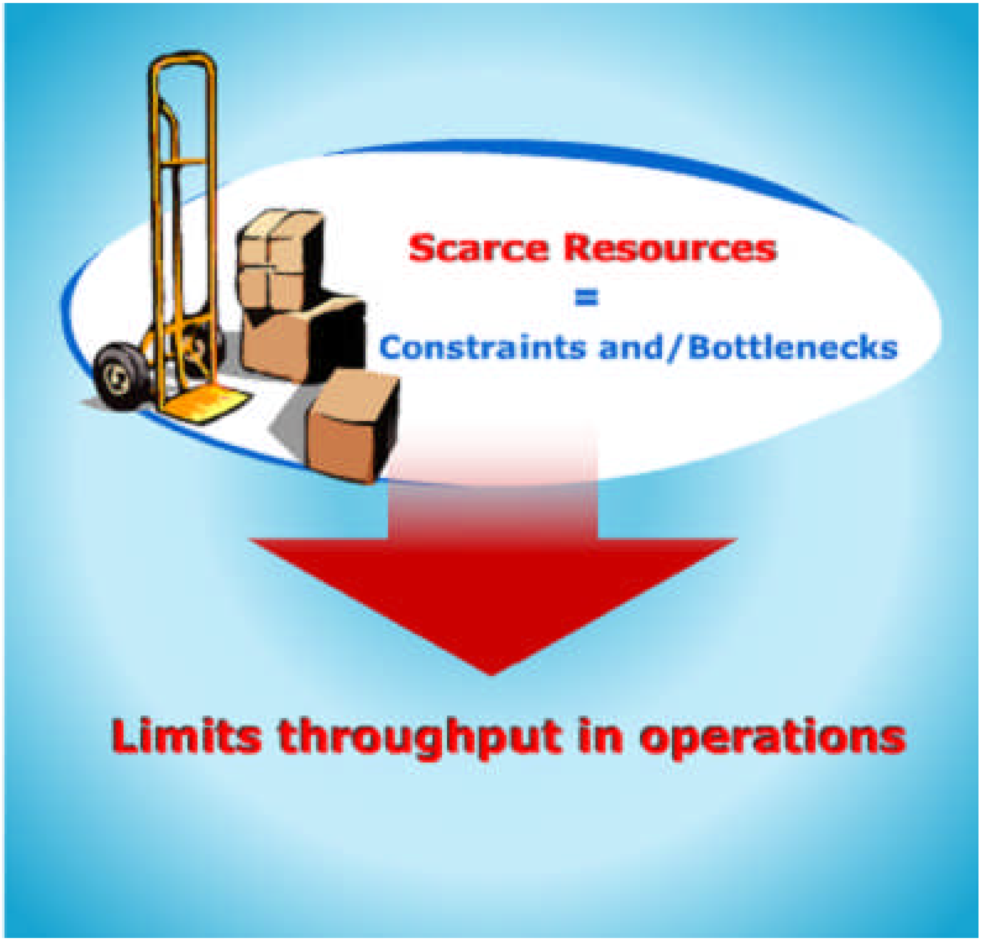
Evaluate the different modes of matching demand with supply and their trade-offs

- understand the Theory of Constraints (TOC)
- explain the logic of Materials Requirement Planning (MRP)
- understand Enterprise Resource Planning (ERP) and its components

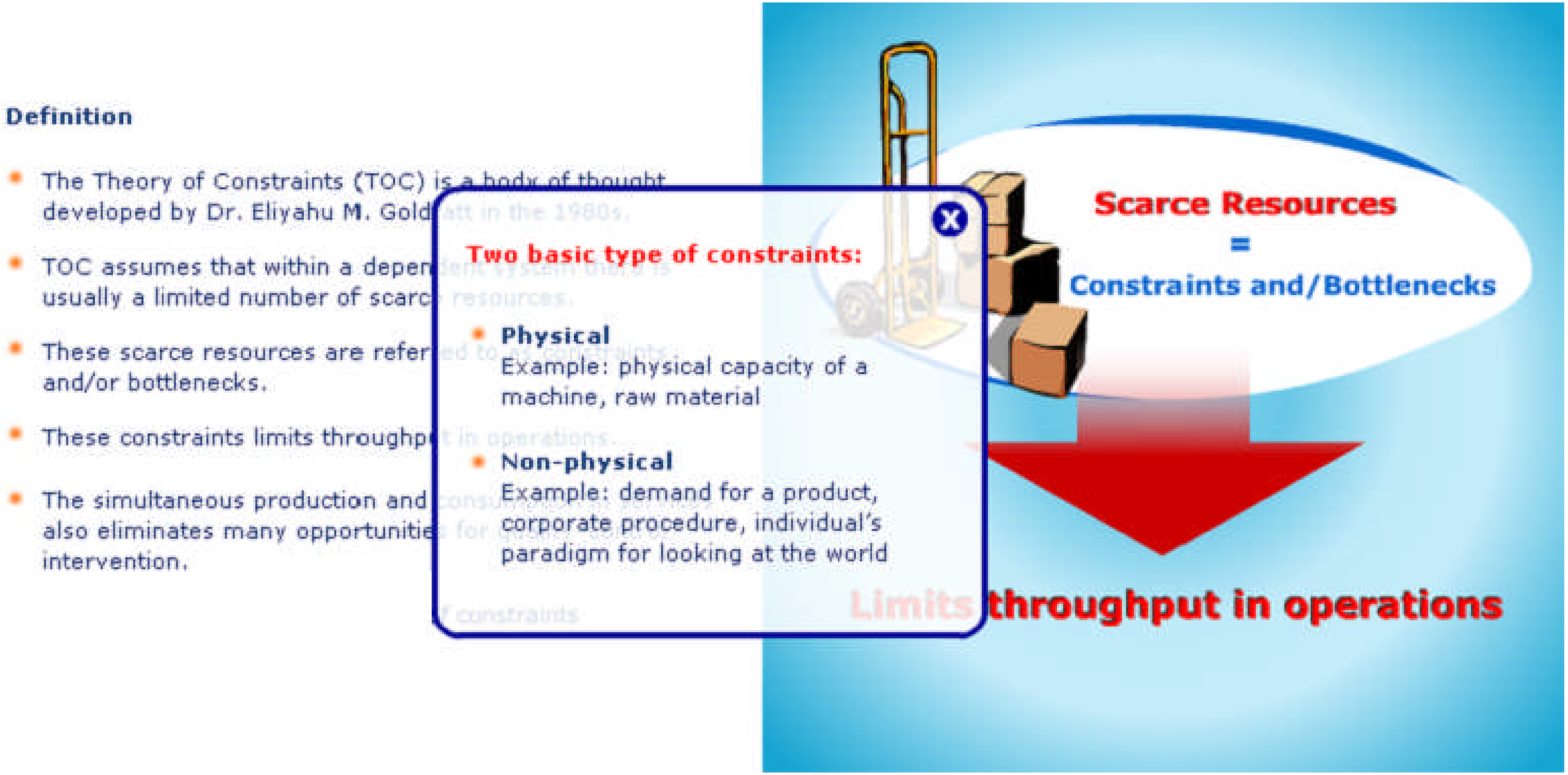
5.1 Theory of Constraints

Definition

- The Theory of Constraints (TOC) is a body of thought developed by Dr. Eliyahu M. Goldratt in the 1980s.
- TOC assumes that within a dependent system there is usually a limited number of scarce resources.
- These scarce resources are referred to as constraints and/or bottlenecks.
- These constraints limits throughput in operations.
- The simultaneous production and consumption in services also eliminates many opportunities for quality-control intervention.

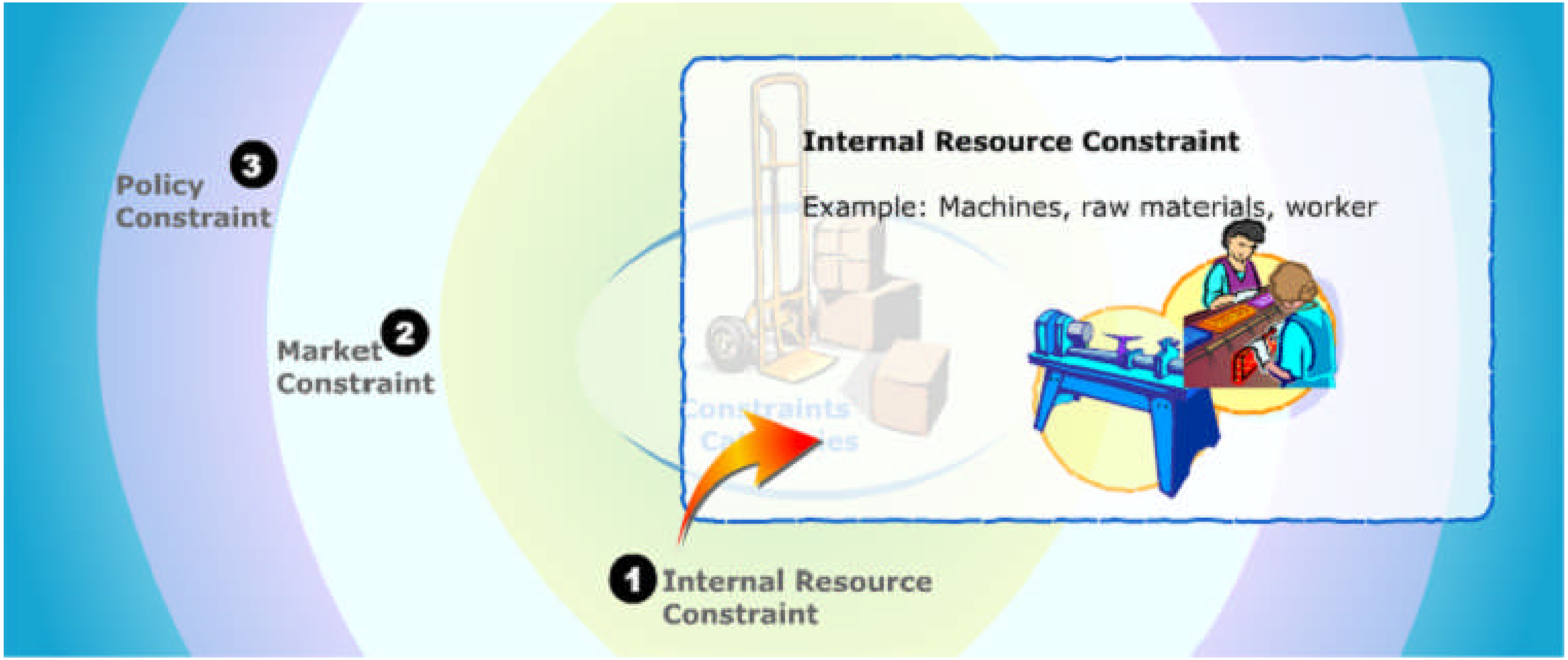


5.1 Theory of Constraints



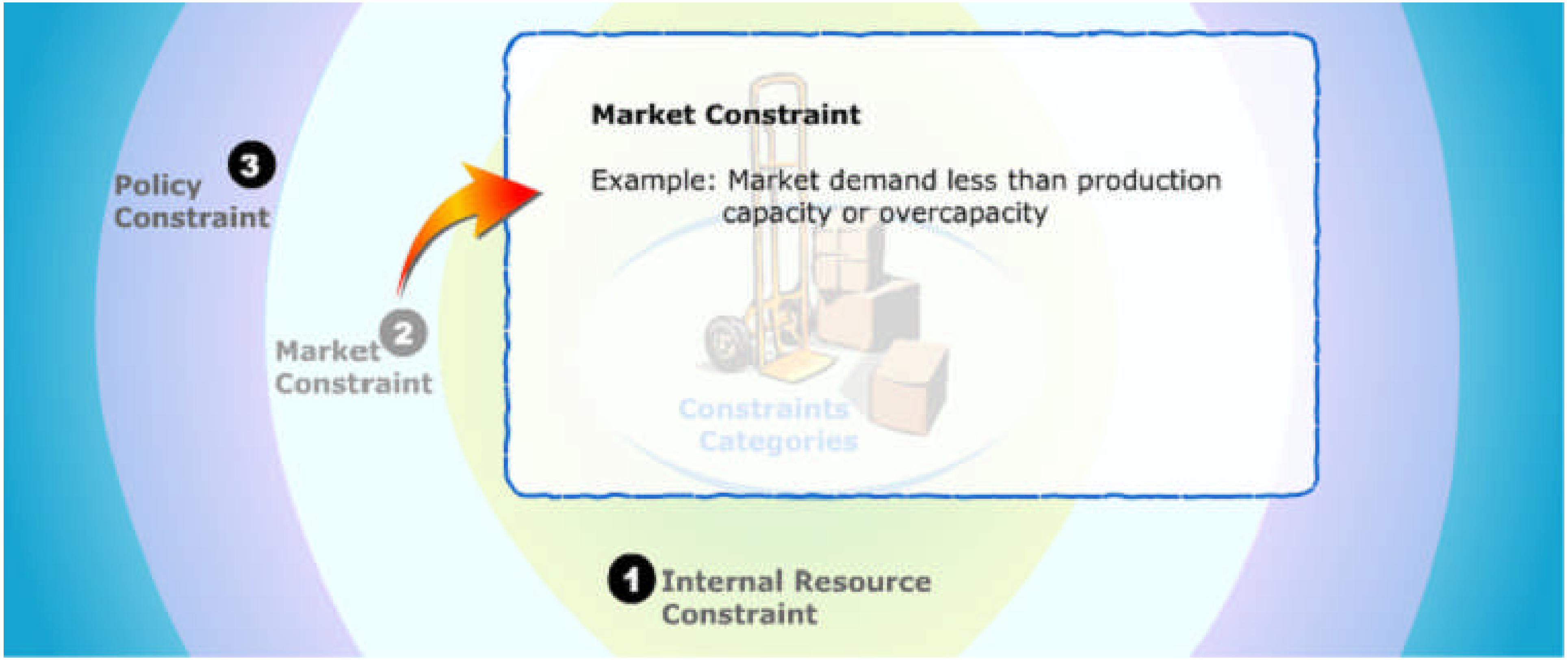
5.1 Theory of Constraints

Constraints fall into three categories



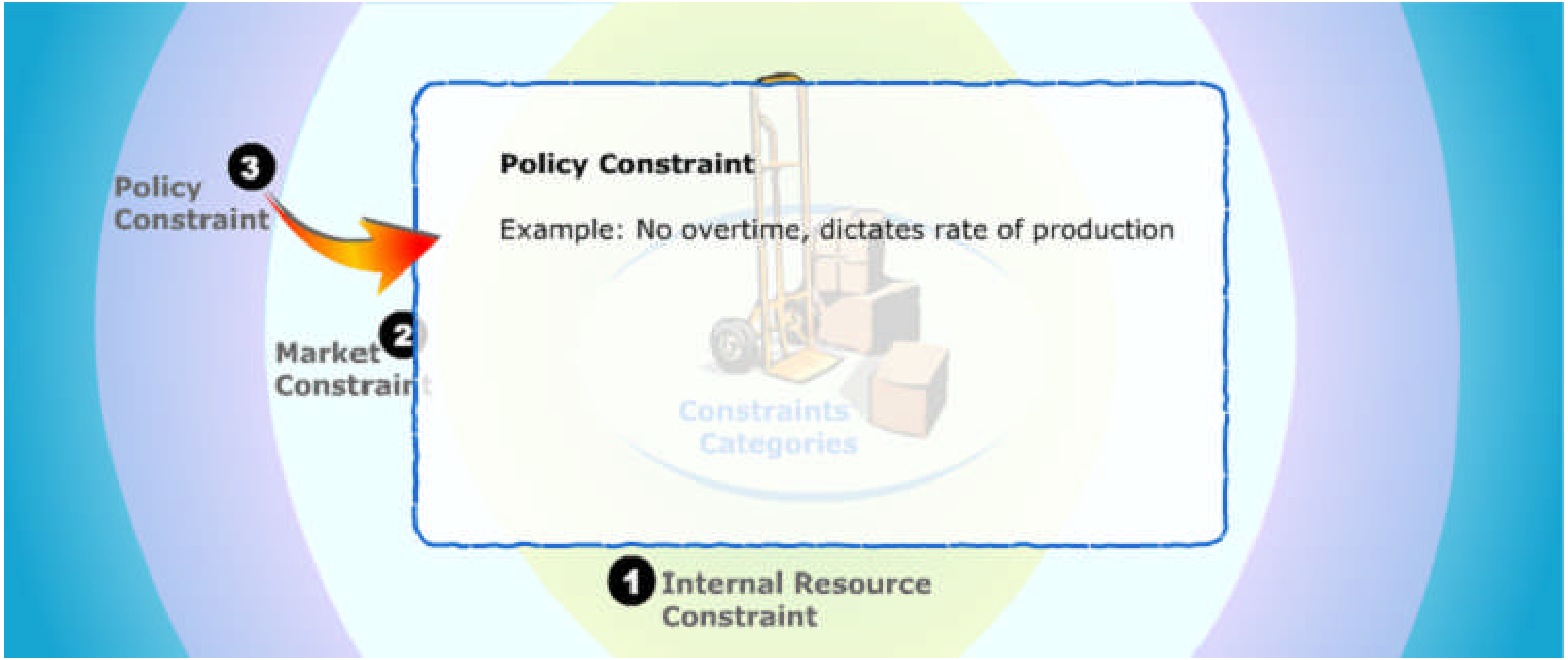
5.1 Theory of Constraints

Constraints fall into three categories



5.1 Theory of Constraints

Constraints fall into three categories



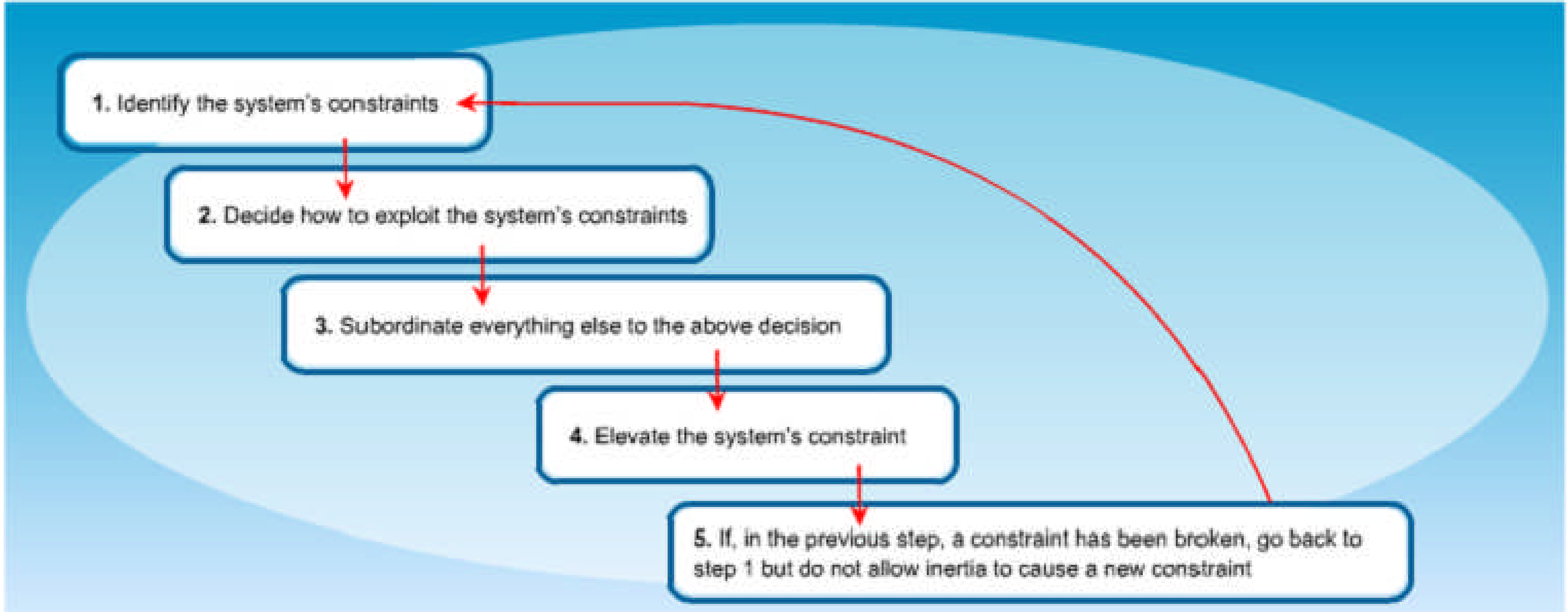
5.1 Theory of Constraints

Performance Measures

Two types of performance measures are used.

5.1 Theory of Constraints

The Theory of Constraints is illustrated by the five steps process shown below.



5.1 Theory of Constraints

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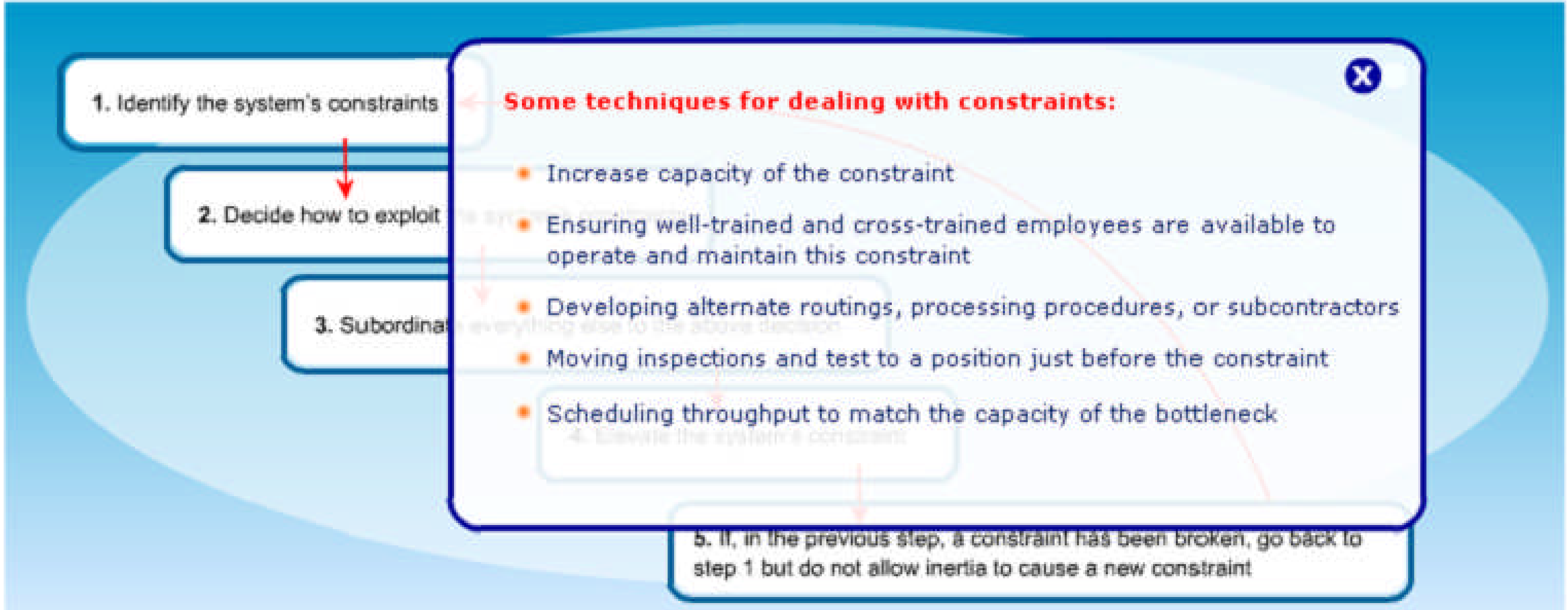
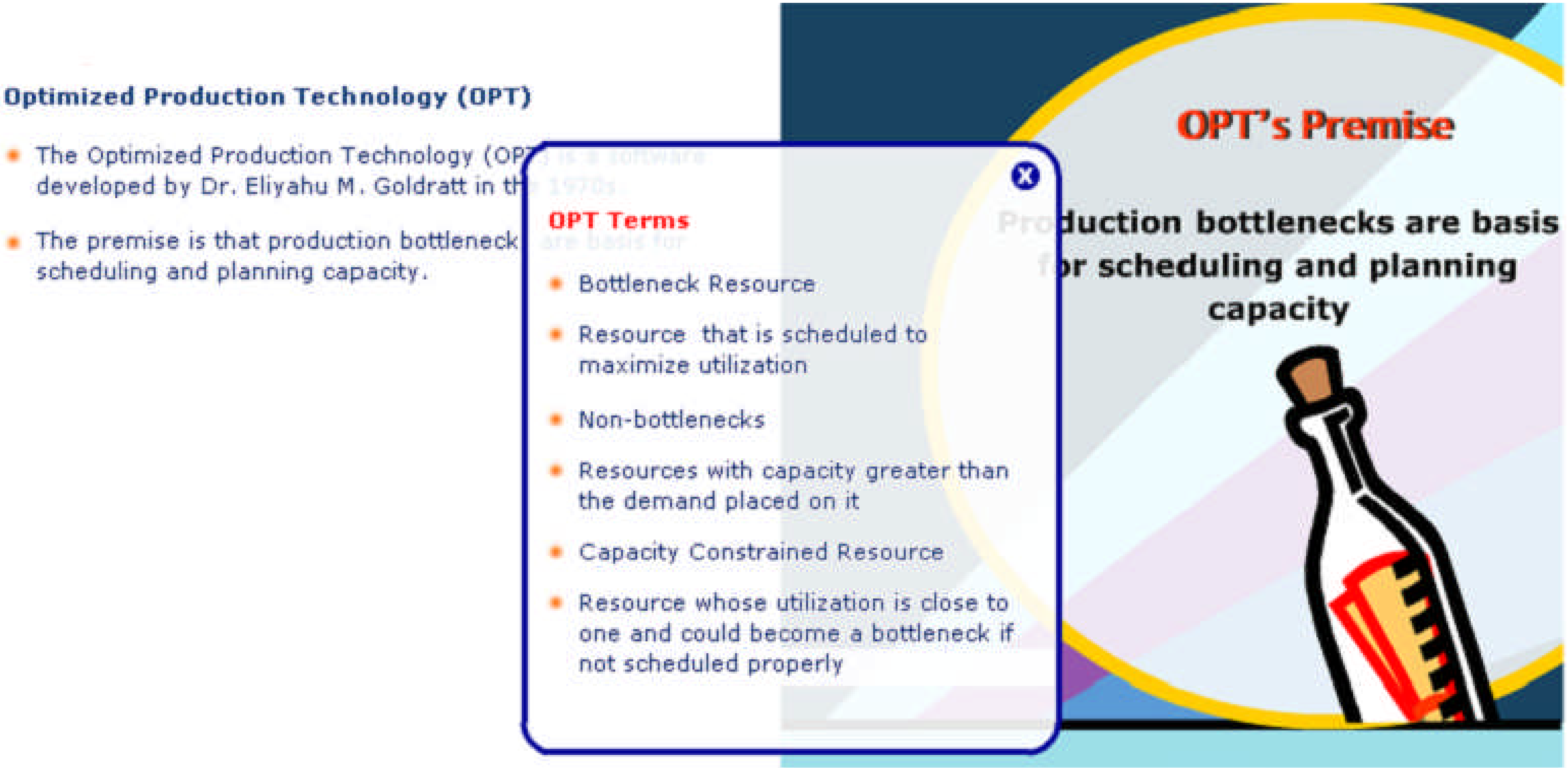


5.1 Theory of Constraints

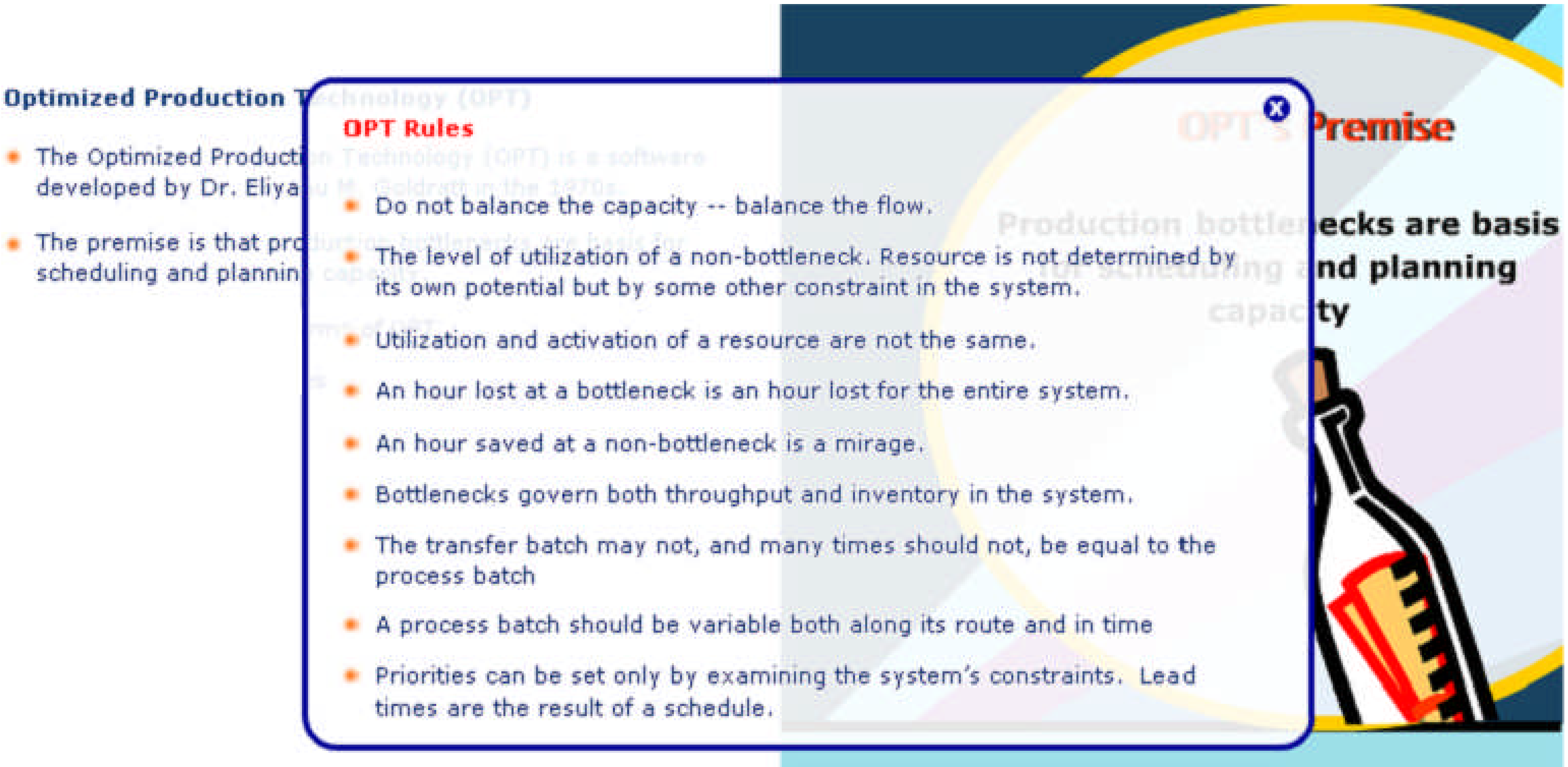
Optimized Production Technology (OPT)

- The Optimized Production Technology (OPT) is a software developed by Dr. Eliyahu M. Goldratt in the 1970s.
- The premise is that production bottlenecks are basis for scheduling and planning capacity.

5.1 Theory of Constraints



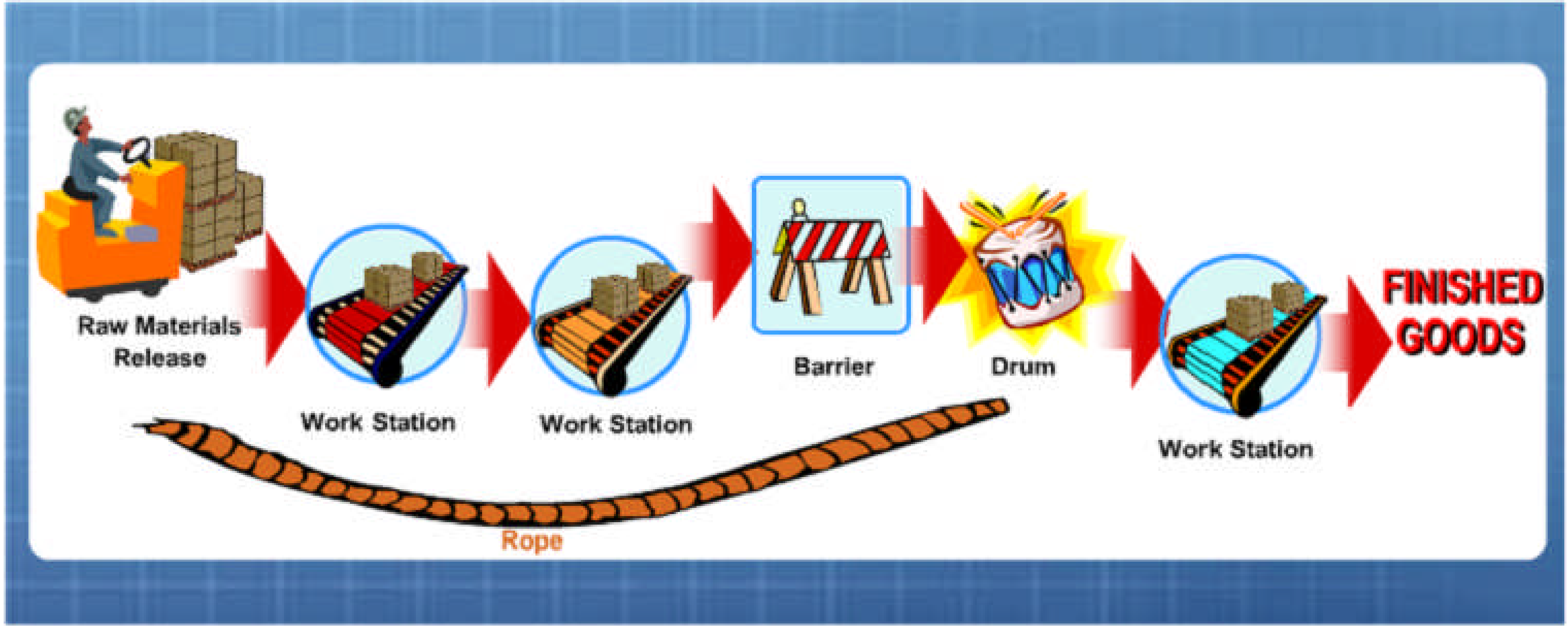
5.1 Theory of Constraints



5.1 Theory of Constraints

Drum-Buffer Rope (DBR)

Drum-Buffer-Rope (DBR) is a production control technique used to implement the steps of TOC.



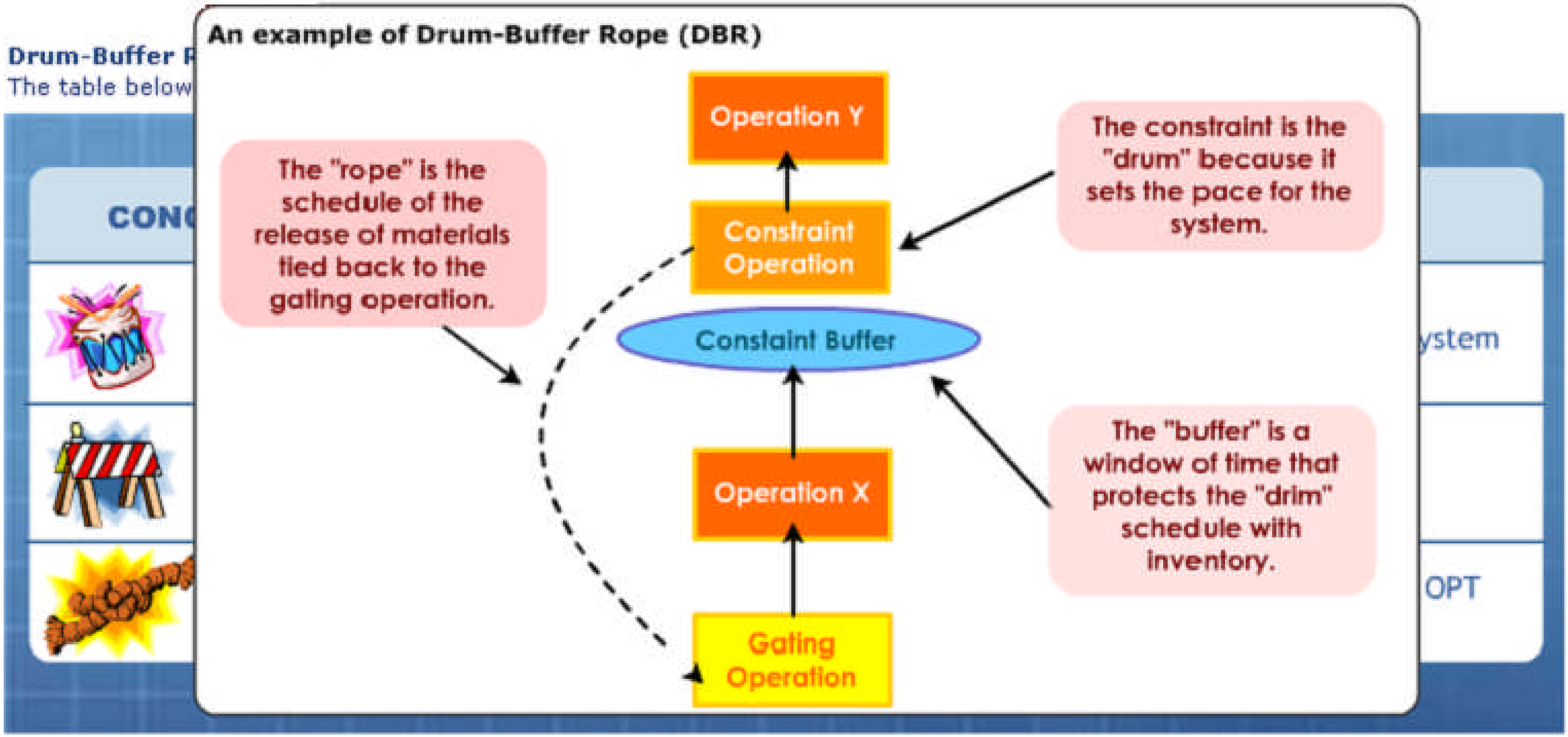
5.1 Theory of Constraints

Drum-Buffer Rope (DBR)

The table below is a summary of the DBR concept.

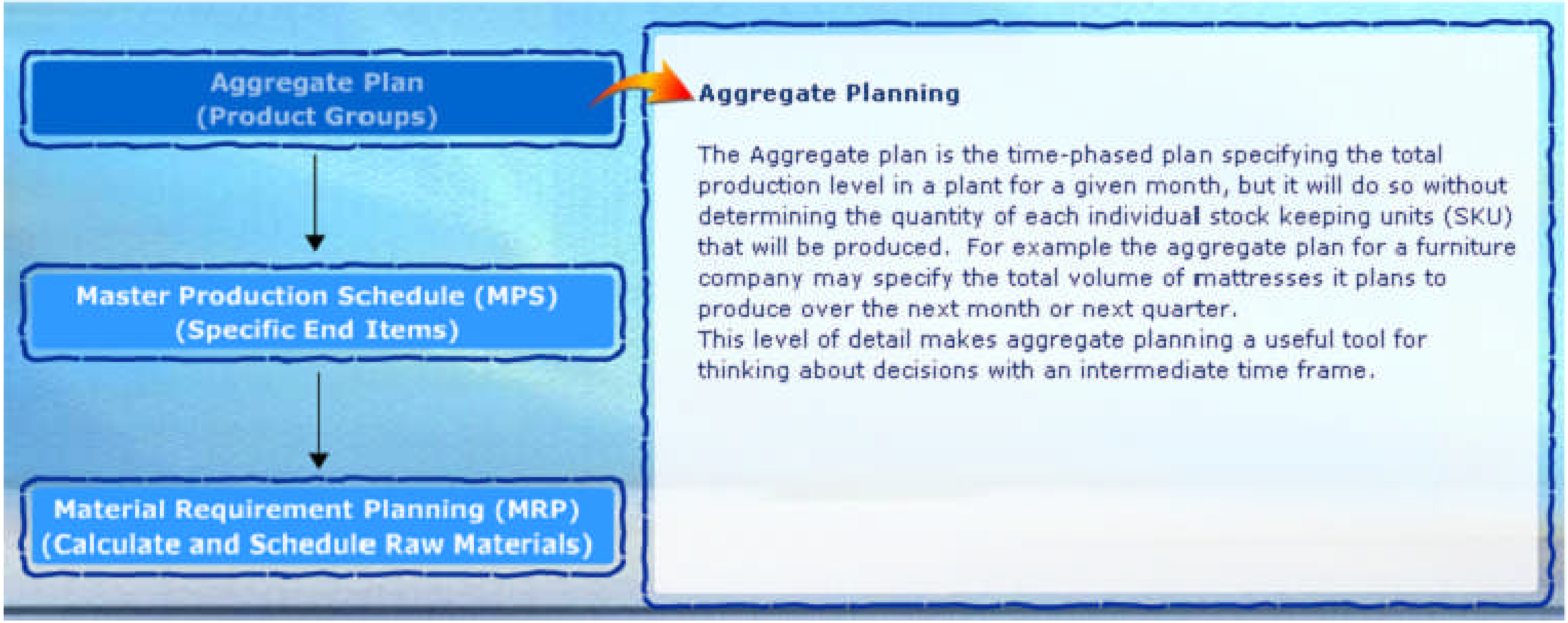
CONCEPT	PURPOSE	DESCRIPTION
 Drum	Sets the pace	The constraint's production rate in the system
 Barrier	Protects the pace	The inventory in front of the constraint
 Rope	Enforces the pace	Some type of pull system e.g. Kanban or OPT schedule

5.1 Theory of Constraints



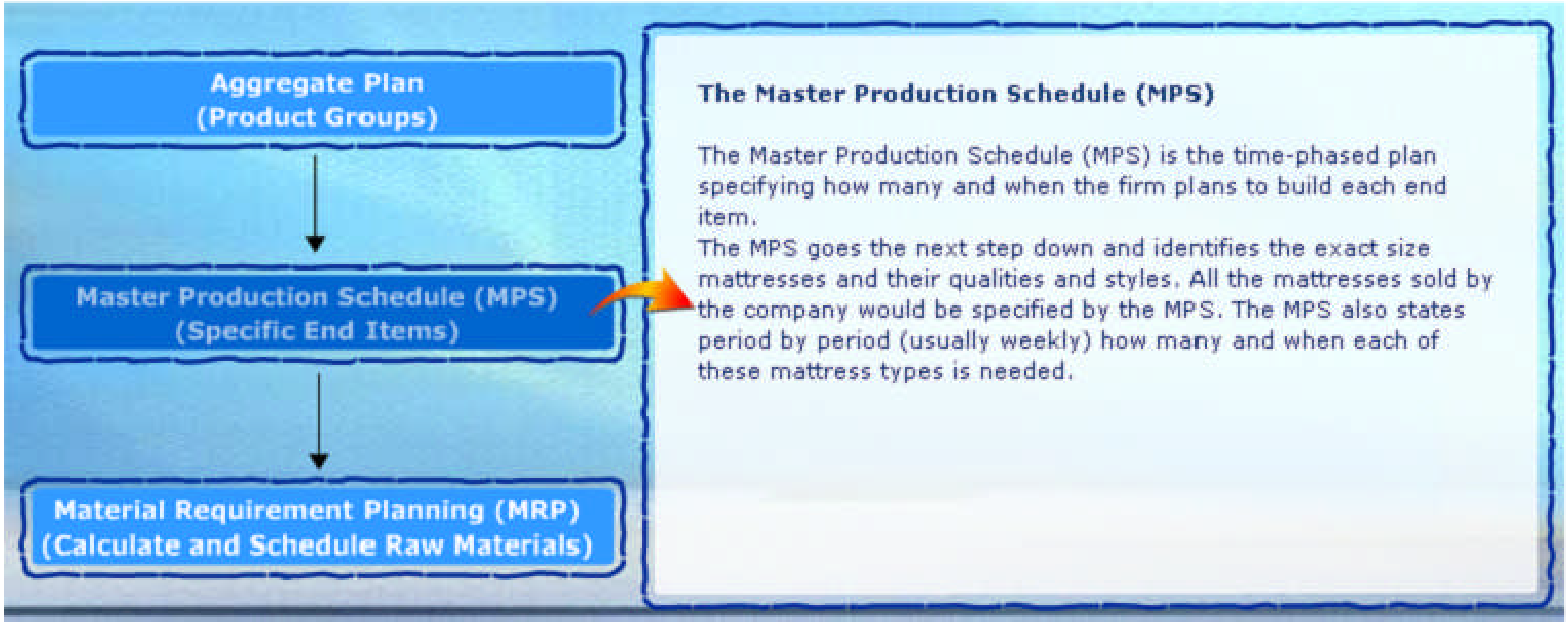
5.2 Material Requirements Planning

Definition

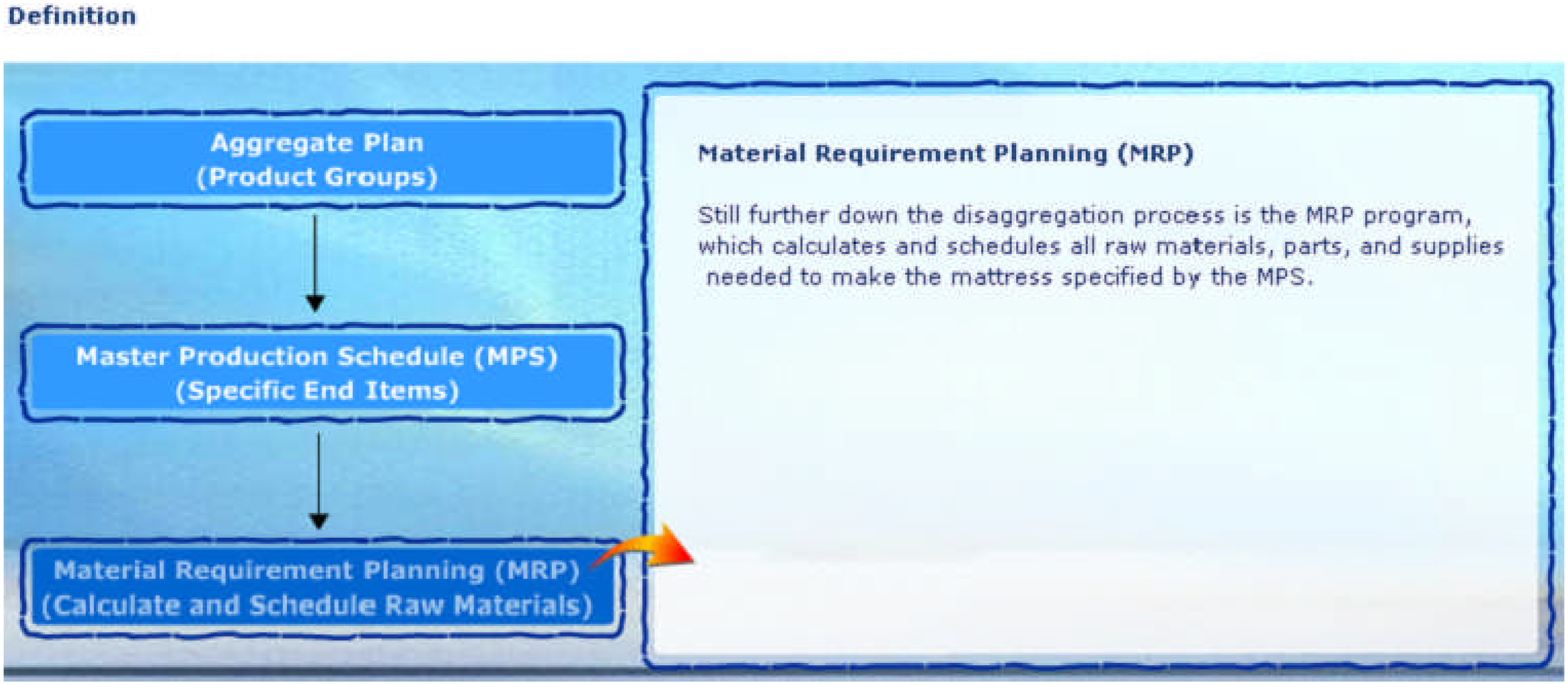


5.2 Material Requirements Planning

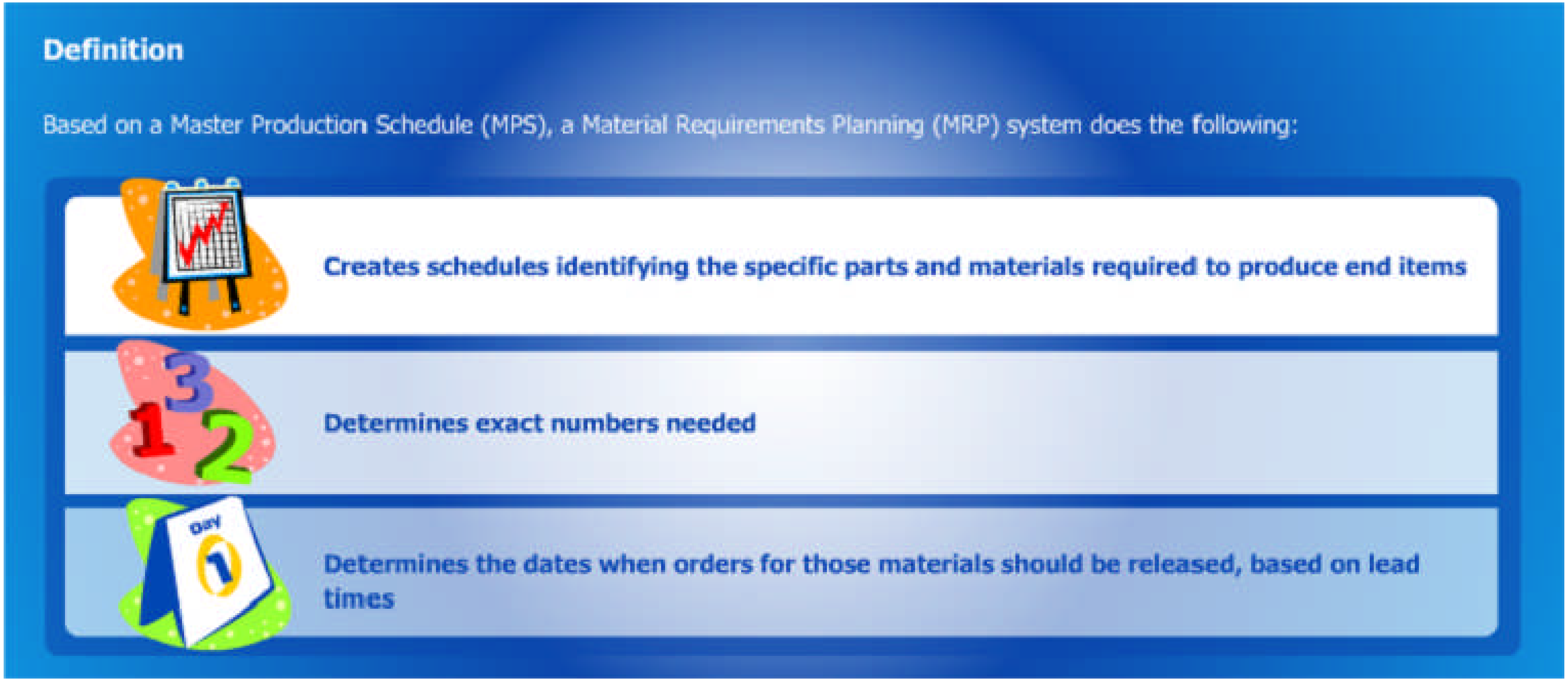
Definition



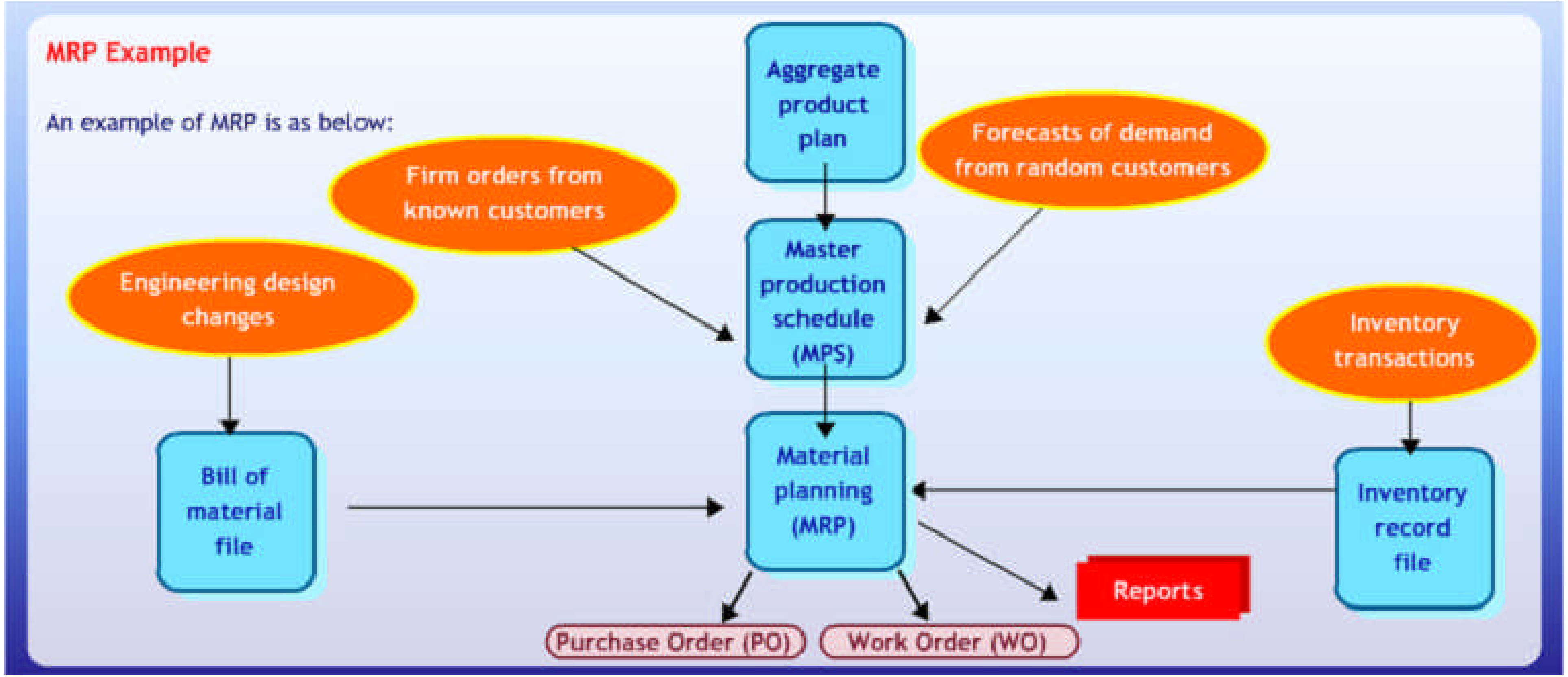
5.2 Material Requirements Planning



5.2 Material Requirements Planning



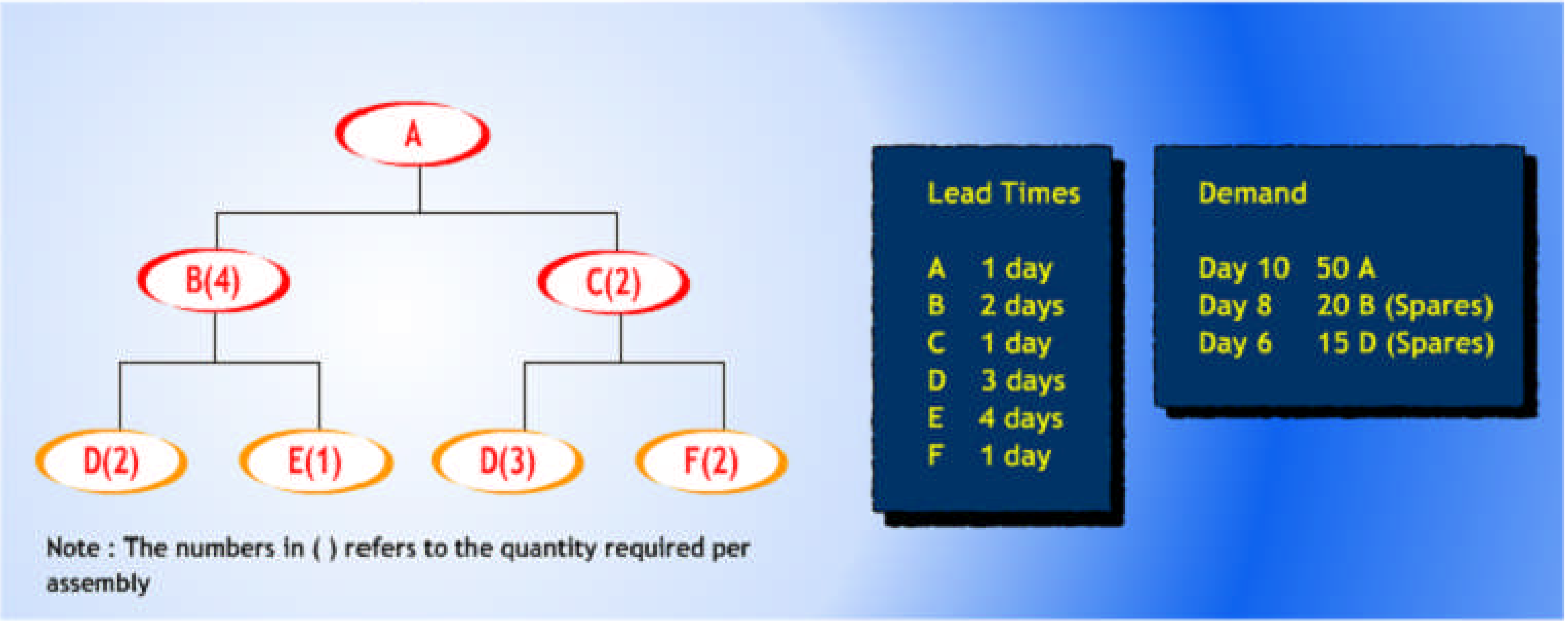
5.2 Material Requirements Planning



5.2 Material Requirements Planning

Material Requirements Planning (MRP) Schedule

The product structure for Part A is given as below.



5.2 Material Requirements Planning

Steps in creating the Materials Requirement Plan

1) Create a timeline based on the required deadline

2) First 2 rows consist of the final product – Required row, followed by Order placement

3) Create subsequent rows based on the the order the part appears in the Bill of Materials (BOM)

4) Populate the table with the Required quantity of the finished assembly

5) Note the lead time, and populate the Order Placement of the finished assembly, remembering to offset by the lead time

6) From the BOM, trace the relationship with the next level, and populate the Required quantity from the Order quantity of the parent part (remembering to factor in the proportions)

7) Note the lead time, and populate the Order Placement of the part, remembering to offset by the lead time

8) Repeat this until you reach individual parts which do not have any sub-parts

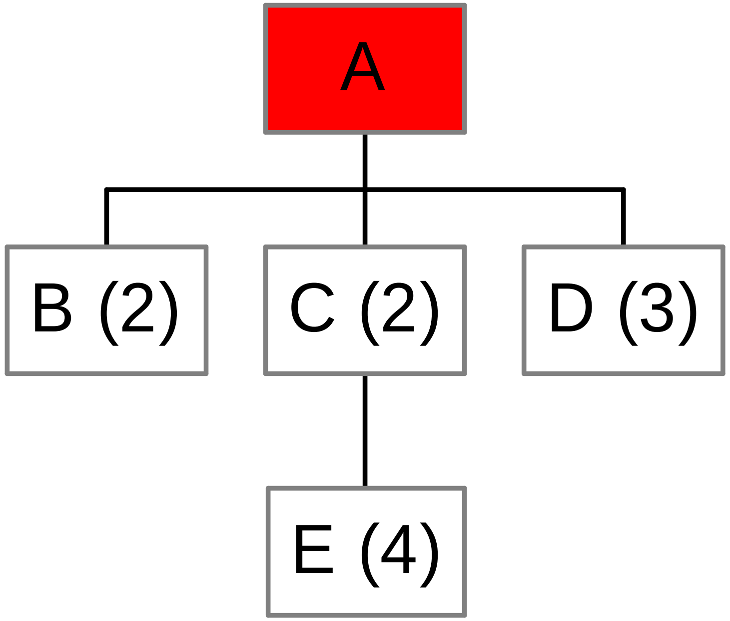
5.2 Material Requirements Planning

The schedule for Part A is given as below.

		DAY									
		1	2	3	4	5	6	7	8	9	10
A	Required										50
	Order Placement									50	
B	Required								20	200	
	Order Placement						20	200			
C	Required									100	
	Order Placement								100		
D	Required						55	400	300		
	Order Placement			55	400	300					
E	Required						20	200			
	Order Placement		20	200							
F	Required								200		
	Order Placement							200			

5.2 Material Requirements Planning

Another MRP example



Lead Times	Demand
A – 1 day	Day 6 – 100 units of A
B – 3 days	
C – 2 days	
D – 1 day	
E – 2 days	

Based on the information, work out the Materials Requirement Plan

5.2 Material Requirements Planning

MRP example - solution

	Day	1	2	3	4	5	6
A	Required						**100**
	Order Placement					**100**	
B	Required					**200**	
	Order Placement		**200**				
C	Required					**200**	
	Order Placement			**200**			
D	Required					**300**	
	Order Placement				**300**		
E	Required			**800**			
	Order Placement	**800**					

5.2 Material Requirements Planning

Time Fences:

- **Frozen** – No schedule changes are allowed within this window

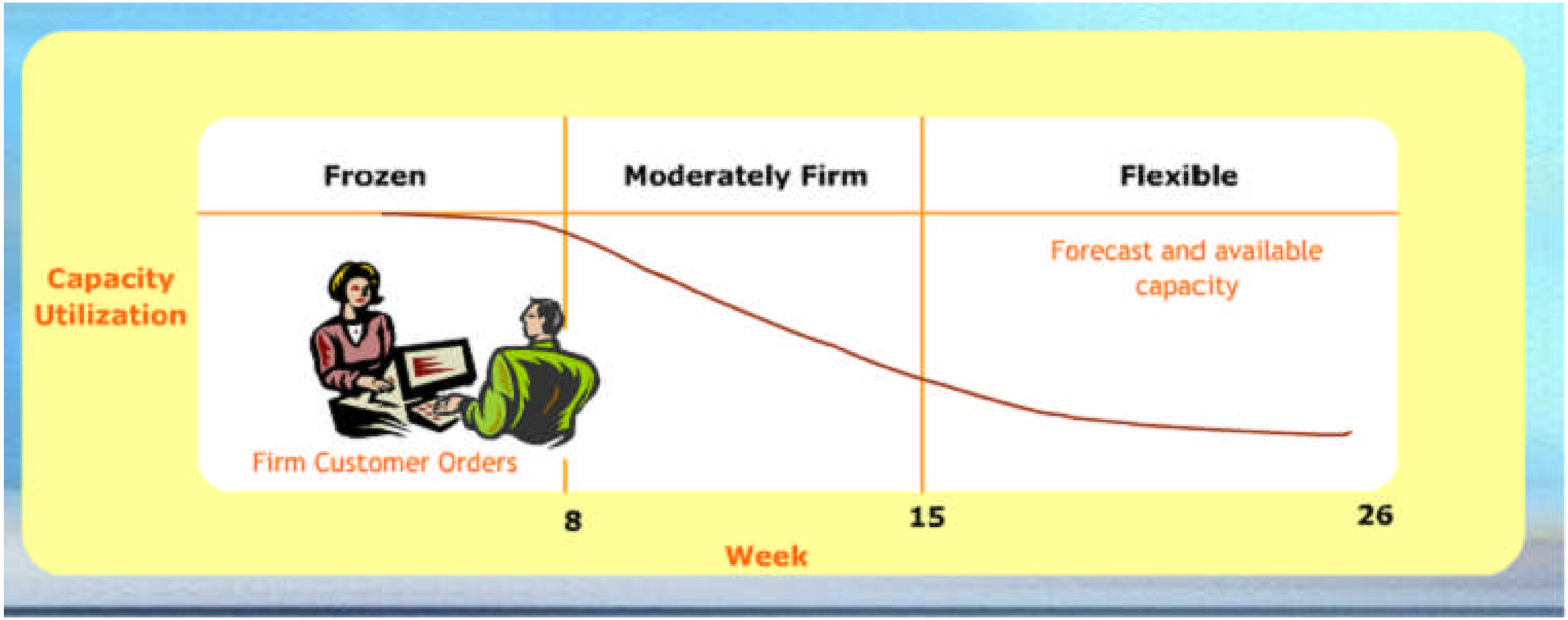
- **Moderately Firm** – Specific changes are allowed within product groups as long as parts are available

- **Flexible** – Signification variation is allowed as long as overall capacity requirements remain the same levels

5.2 Material Requirements Planning

Time Fences:

The graph below illustrates the relationship between demand and time fences.

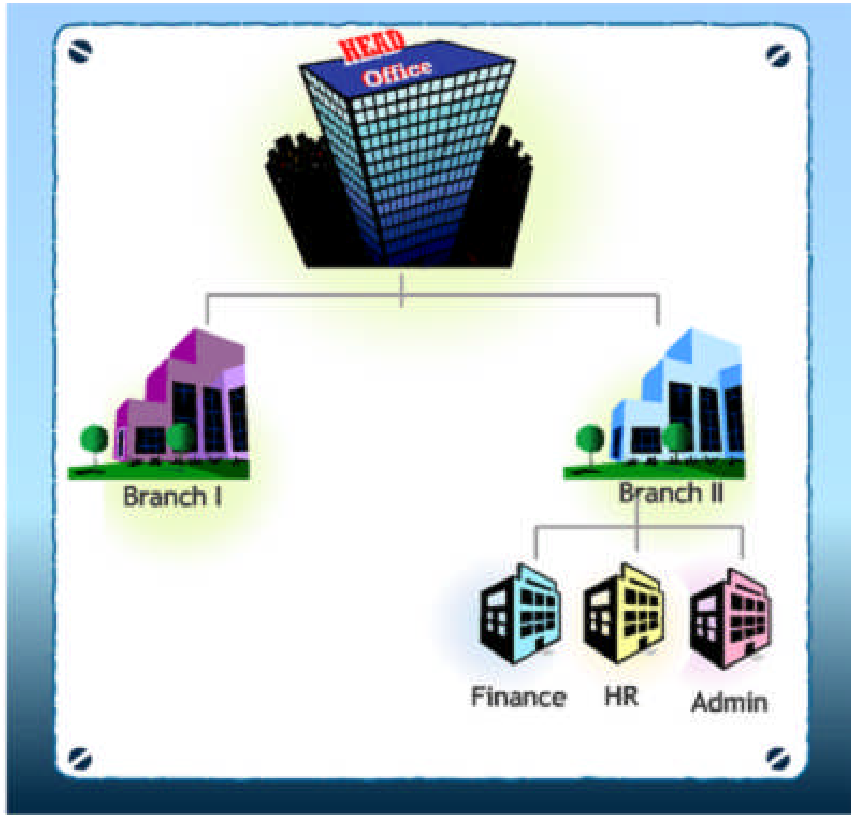


5.3 Enterprise Requirements Planning

Definition:

- An **ERP** or **Enterprise Resource Planning** system integrates information and business processes to enable information entered once to be shared throughout the organisation.

- **ERP** (**Enterprise Resource Planning)** is an industry term for the broad set of activities supported by multi-module application software that helps an organisation to manage the important part of its business.

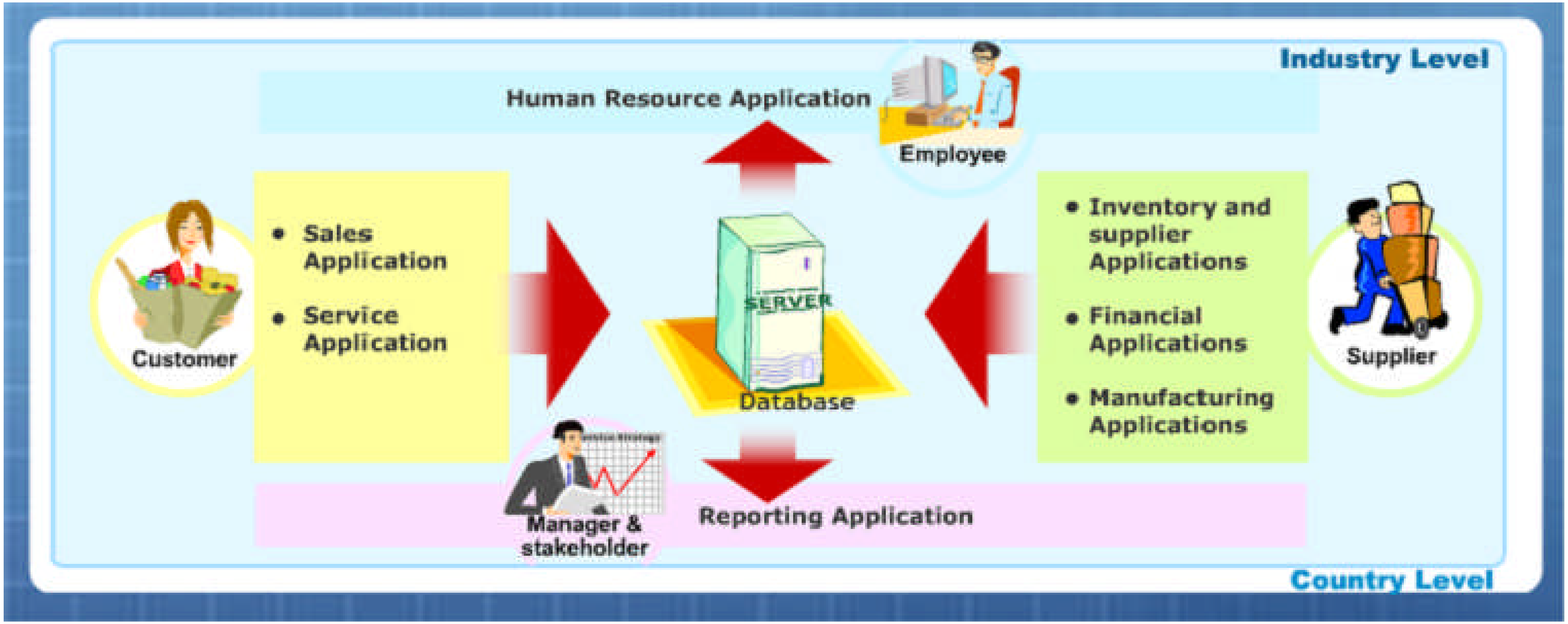


5.3 Enterprise Requirements Planning

5.3 Enterprise Requirements Planning

Components of ERP

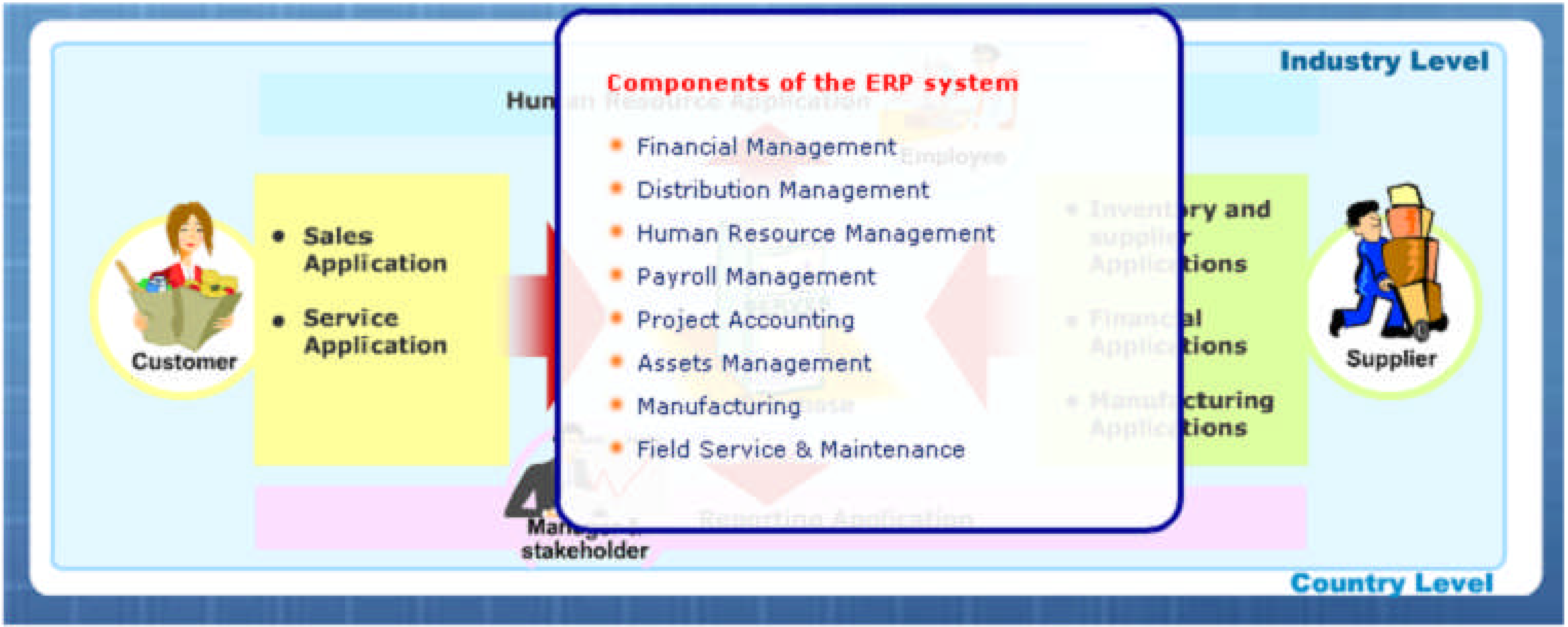
The diagram below illustrates the anatomy of an ERP application.



5.3 Enterprise Requirements Planning

Components of ERP

The diagram below illustrates the anatomy of an ERP application.

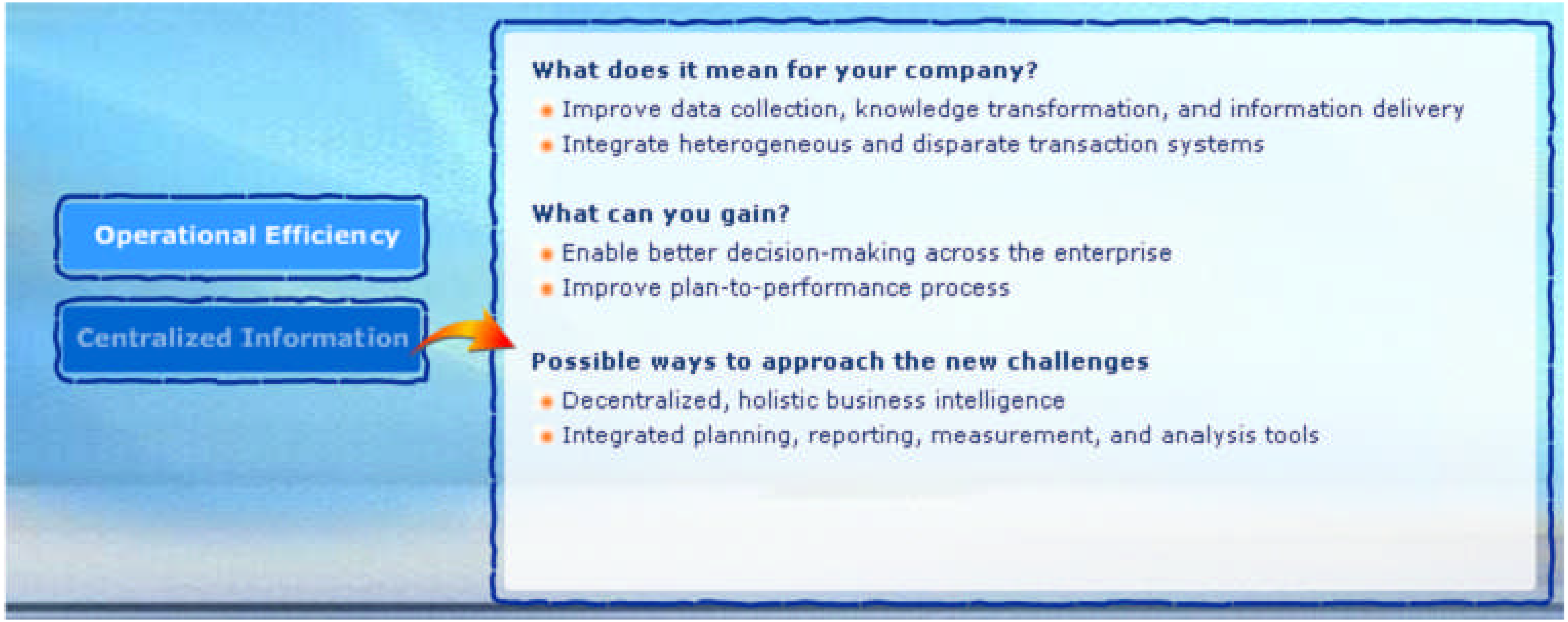


5.3 Enterprise Requirements Planning

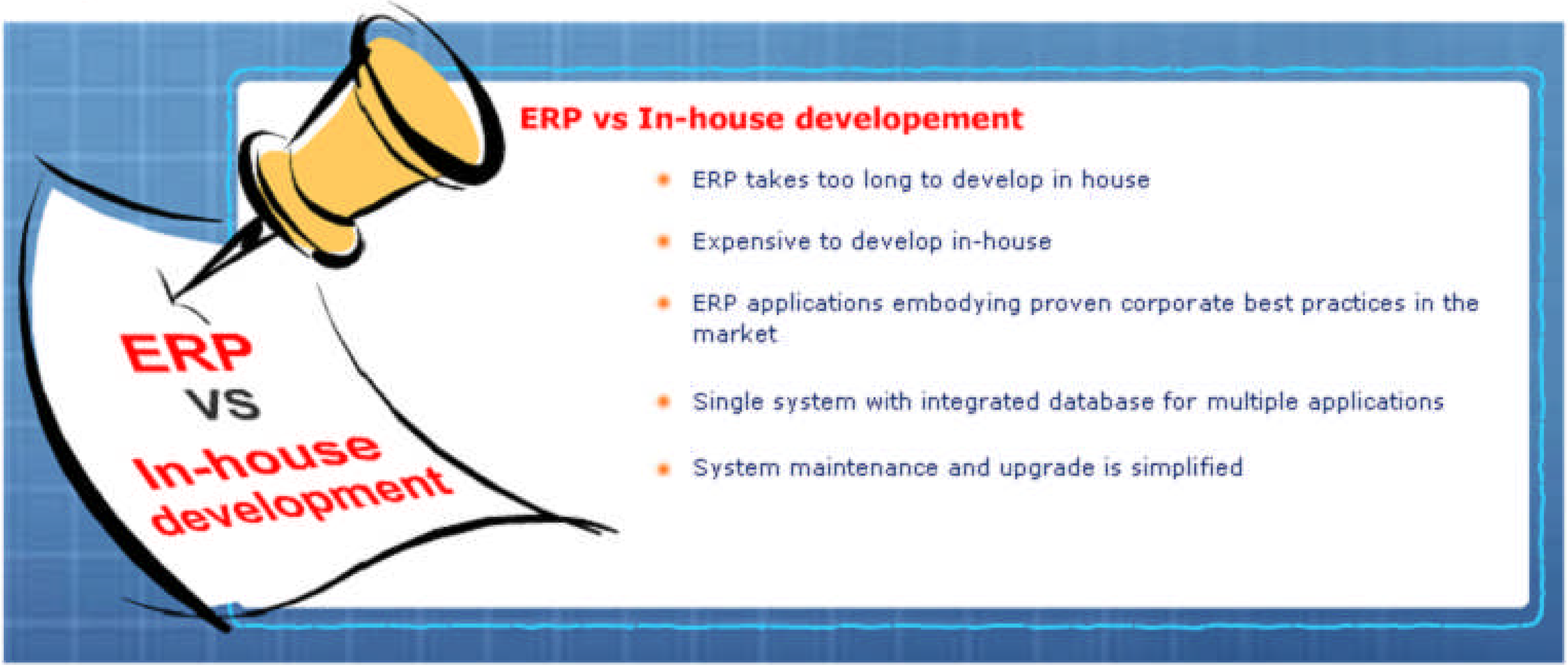
ERP Justification

5.3 Enterprise Requirements Planning

ERP Justification



5.3 Enterprise Requirements Planning



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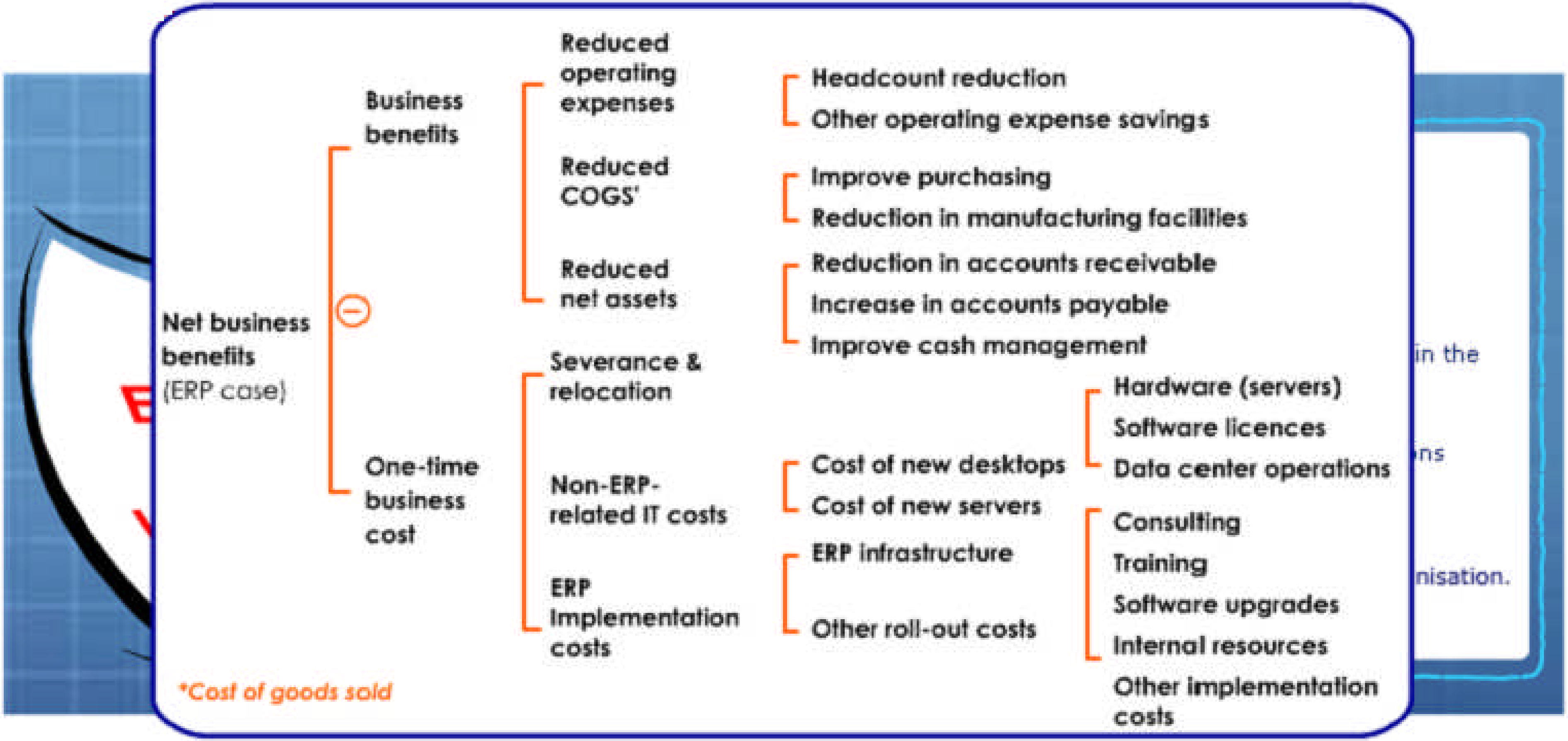

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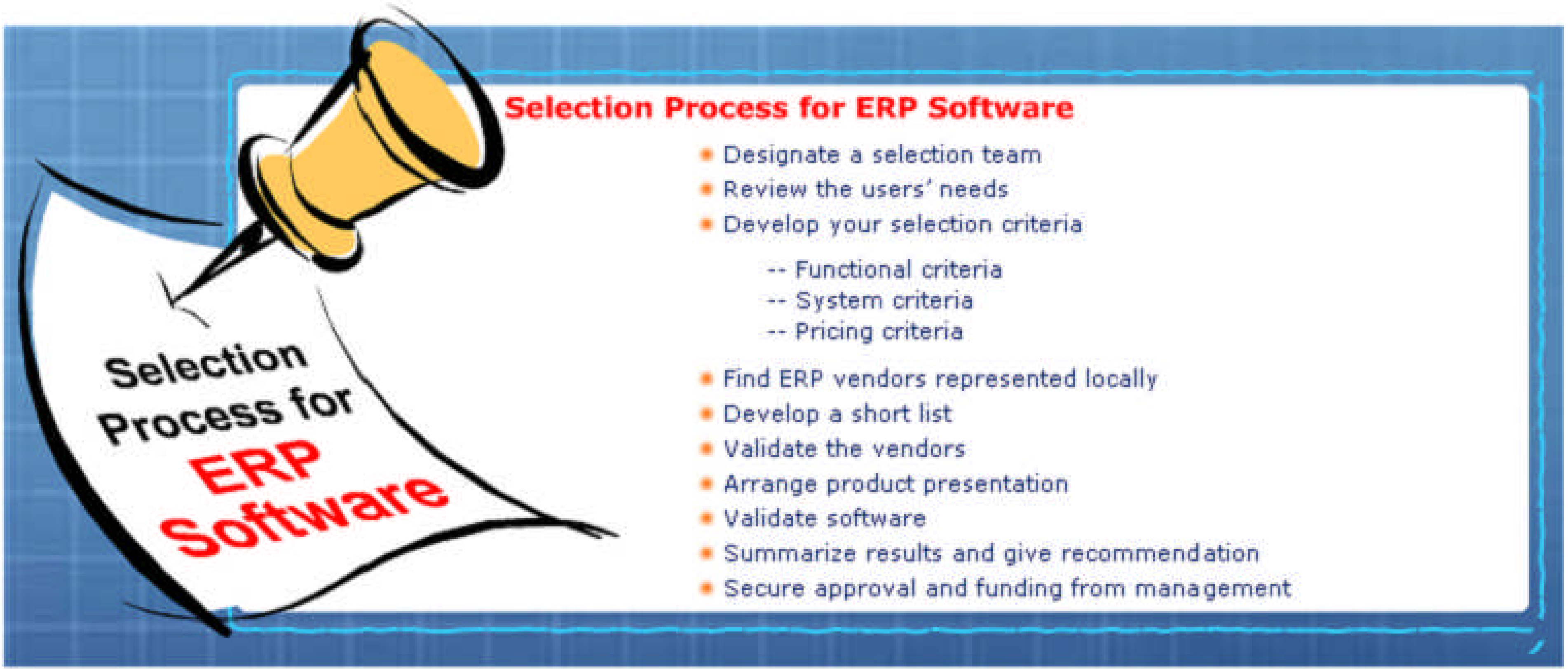
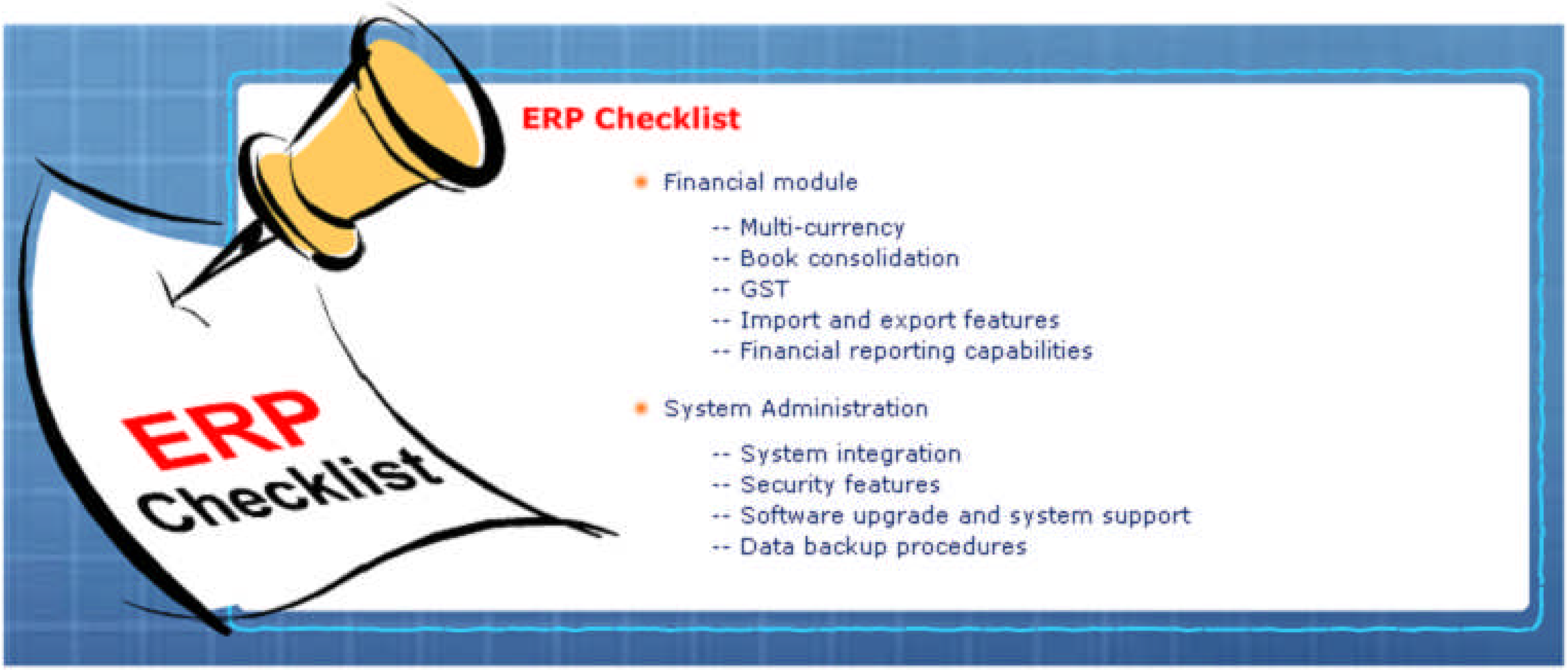
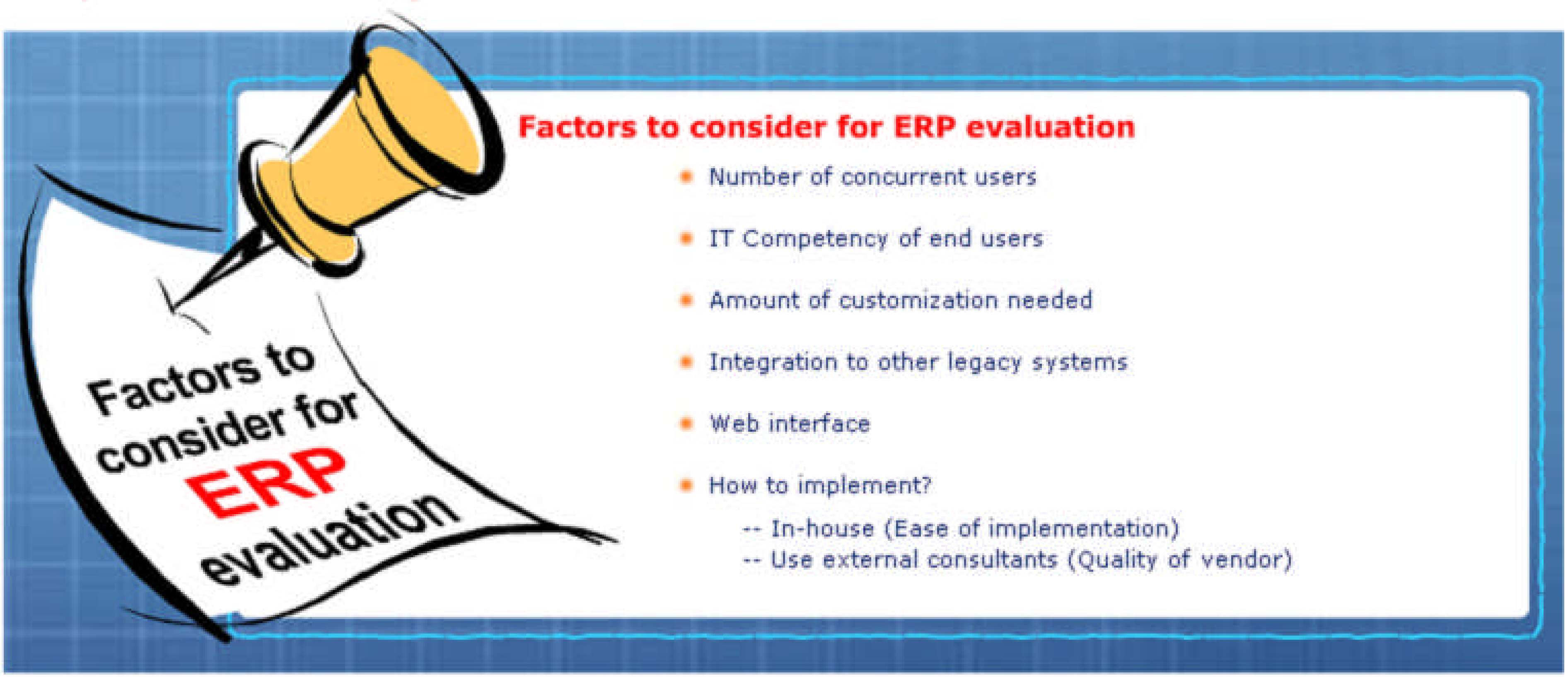


5.3 Enterprise Requirements Planning



5.3 Enterprise Requirements Planning



Topic 6 – Forecasting and JIT

Understand the various forecasting methods to increase accuracy and the JIT techniques to reduce wastages

- explain the various types of forecasting and aggregate planning
- understand Just-in-Time (JIT) production system

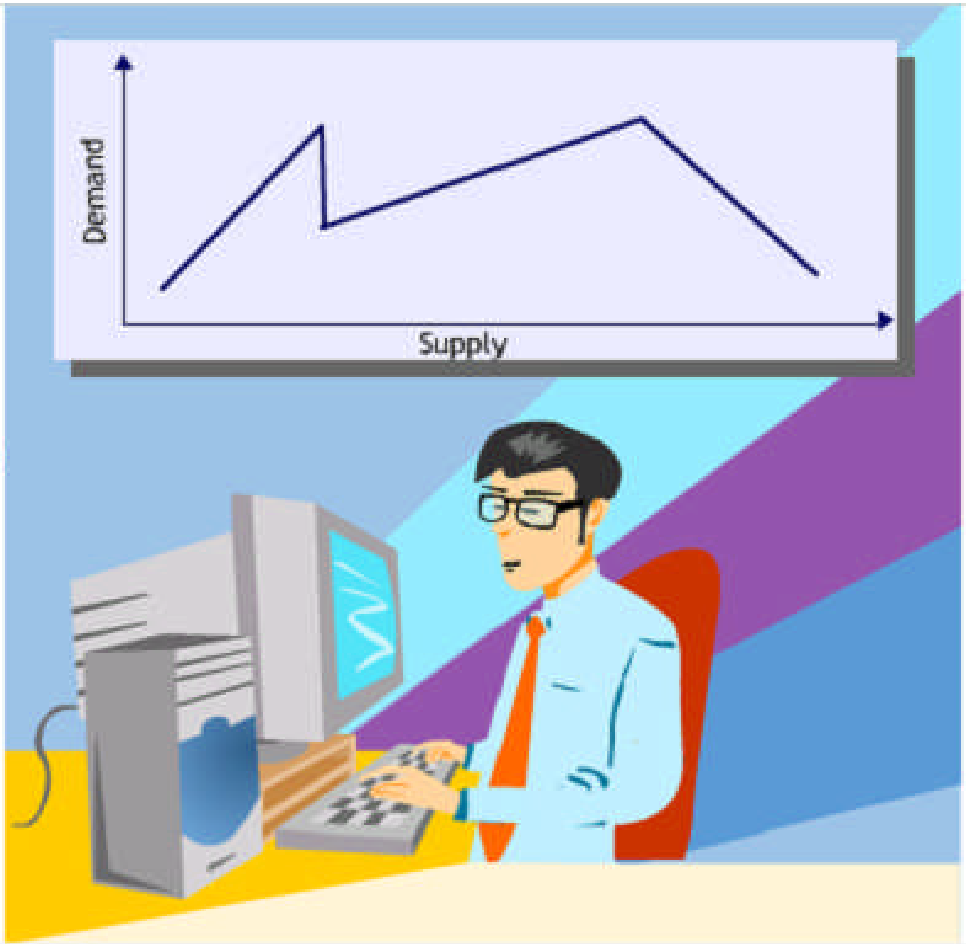
6.1 Forecasting and Aggregate Planning

The Role of Forecasting in A Supply Chain

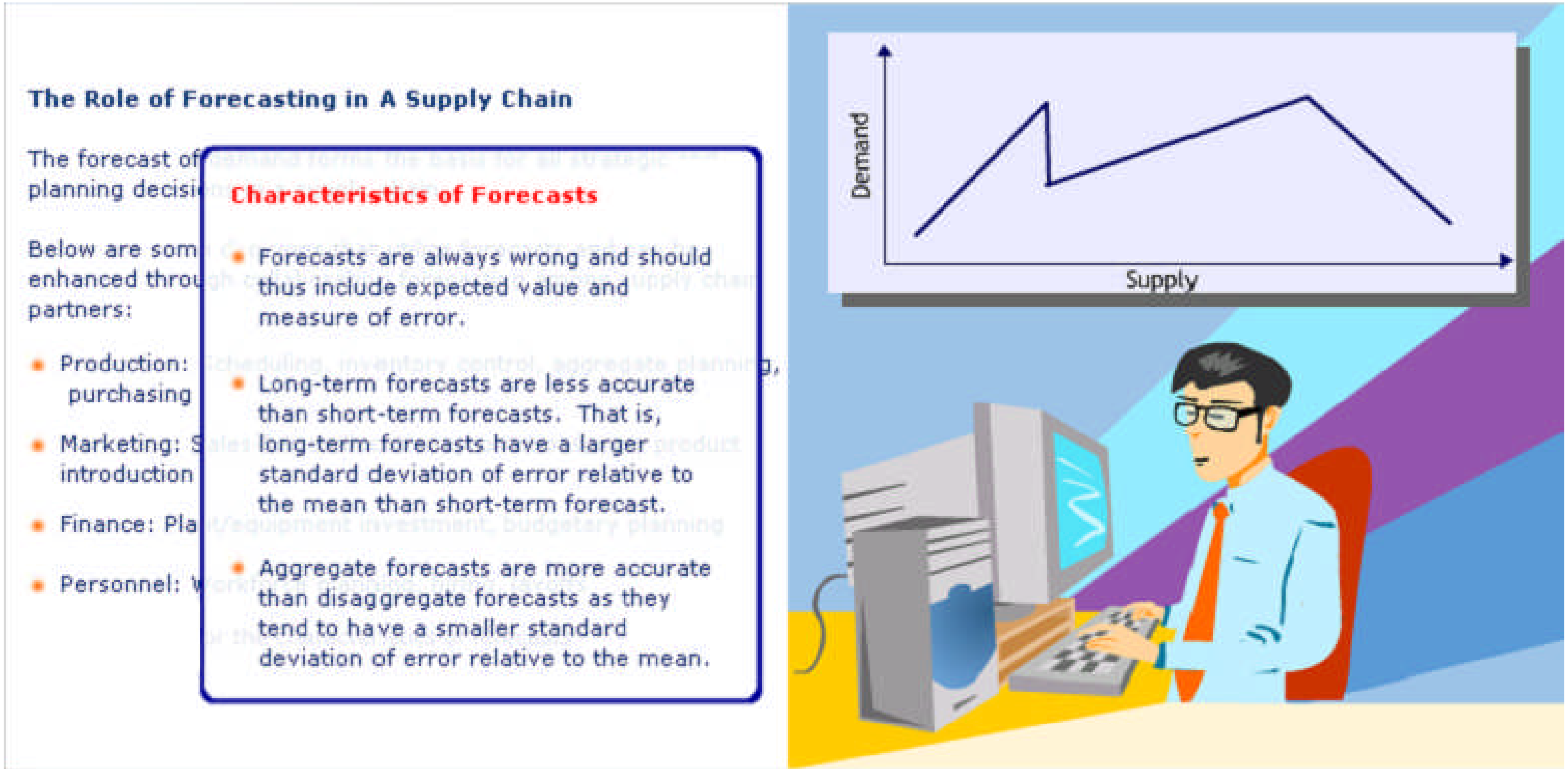
The forecast of demand forms the basis for all strategic and planning decisions in a supply chain.

Below are some decisions that utilize forecasts and can be enhanced through collaboration forecasting among supply chain partners:

- Production: Scheduling, inventory control, aggregate planning, purchasing
- Marketing: Sales-force allocation, promotions, new product introduction
- Finance: Plant/equipment investment, budgetary planning
- Personnel: Workforce planning, hiring, layoffs



6.1 Forecasting and Aggregate Planning



6.1 Forecasting and Aggregate Planning

Forecasting Methods are classified according to the following four types:

1. Qualitative

Qualitative Forecasting methods are primarily subjective and rely on human judgment. They are most appropriate when there is little historical data available or when experts have market intelligence that is critical in making the forecast. Such methods may be necessary to forecast demand several years into the future in a new industry.

2. Time Series

Time Series Forecasting methods use historical demand to make a forecast. They are based on the assumption that past demand history is a indicator of future demand. These methods are most appropriate when the basic demand pattern does not vary significantly from one year to the next. These are the simplest methods to implement and can serve as a good starting point for a demand forecast.

6.1 Forecasting and Aggregate Planning

Forecasting Methods (cont'd)

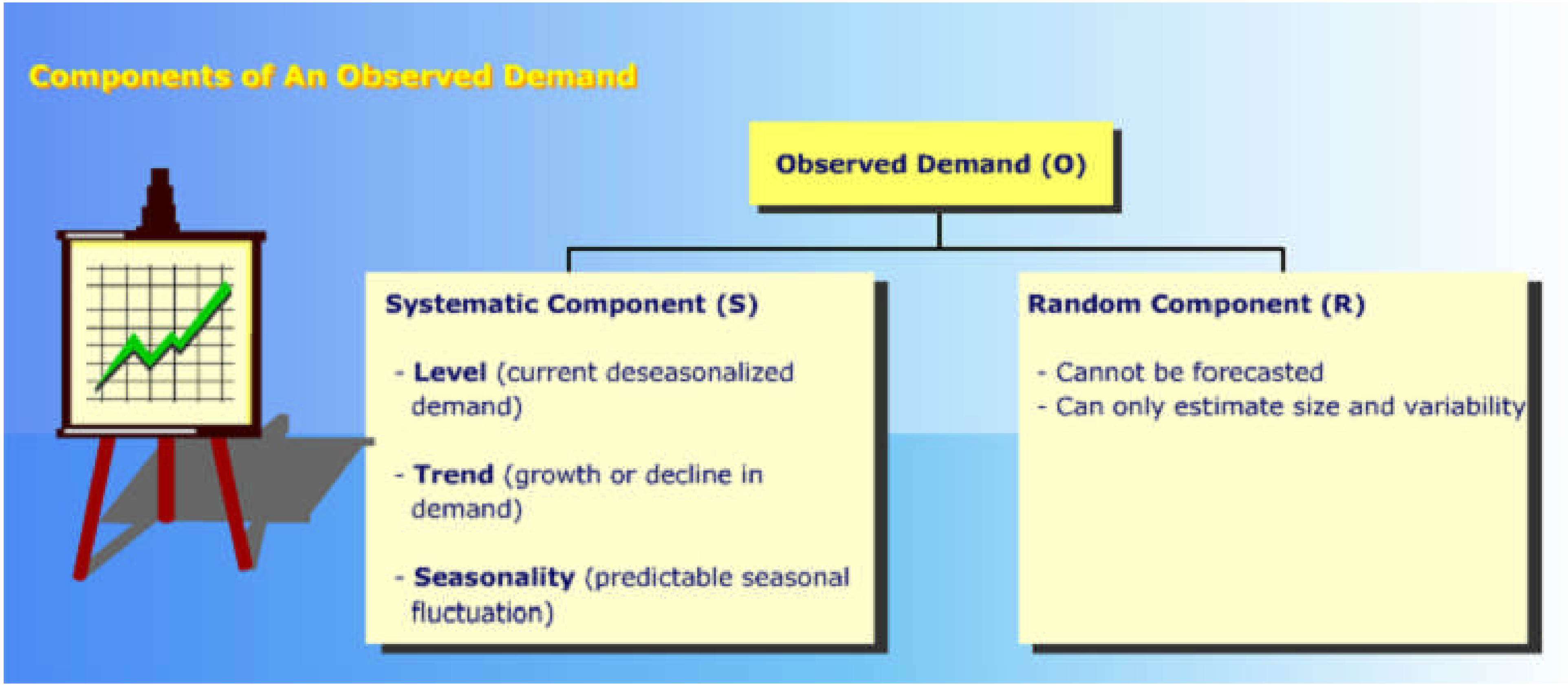
3. Causal

Causal Forecasting methods assume that the demand forecast is highly correlated with certain factors in the environment (e.g. the state of the economy, interest rates etc). Causal forecasting methods find this correlation between demand and environmental factors and use estimates of what environmental factors will be to forecast future demand. For example, product pricing is strongly correlated with demand. Companies can thus use causal methods to determine the impact of price promotions on demand.

4. Simulation

Simulation forecasting methods imitate the customer choices that give rise to demand to arrive at a forecast. Using simulation, a firm can combine time series and causal methods to answer such questions as: what will the impact of a price promotion be? What will the impact be of a competitor opening a store nearby? Airlines simulate customer buying behaviour to forecast demand for higher fare seats when there are no seats available at the lower fares.

6.1 Forecasting and Aggregate Planning



6.1 Forecasting and Aggregate Planning

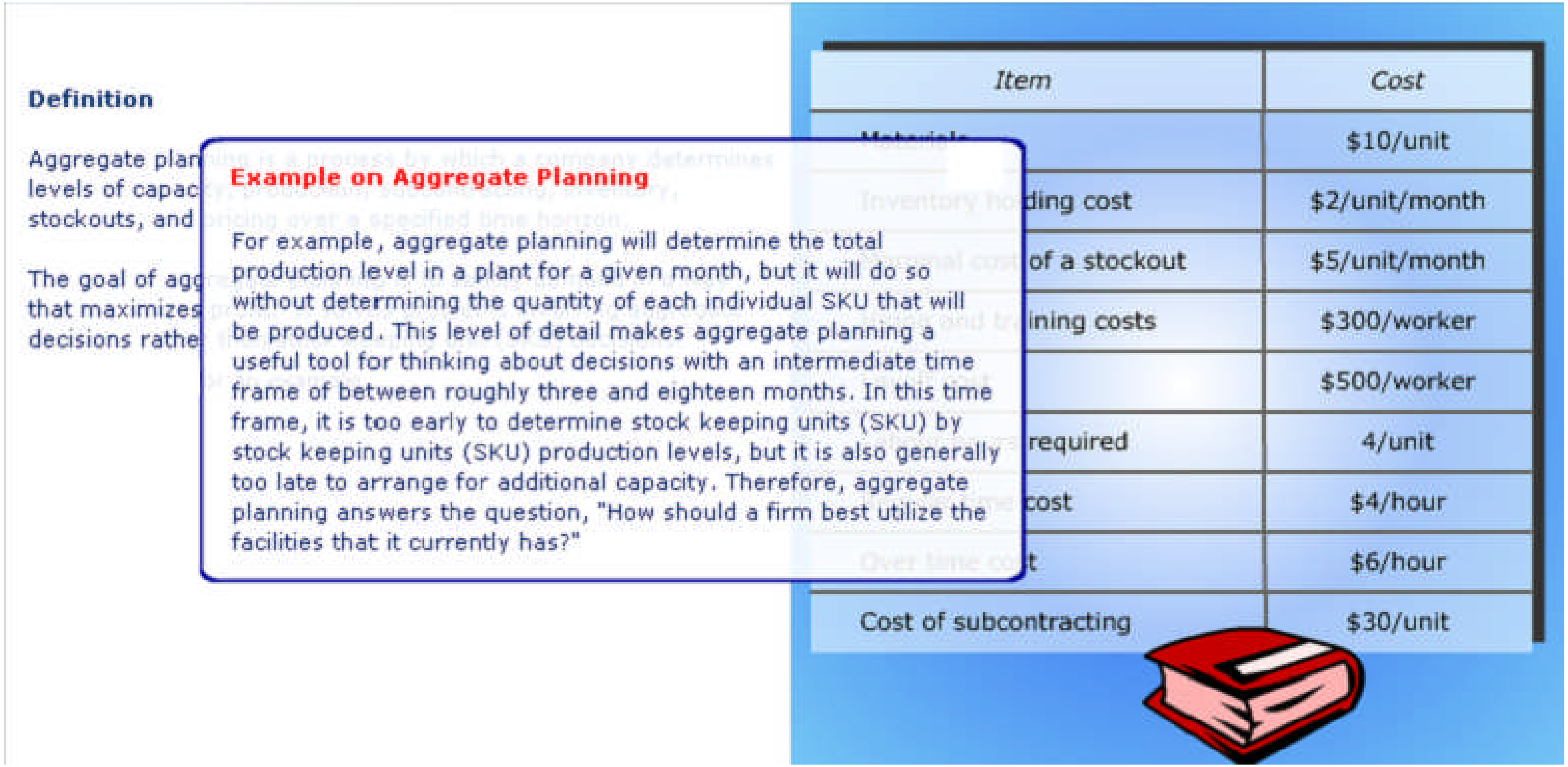
Definition

Aggregate planning is a process by which a company determines levels of capacity, production, subcontracting, inventory, stockouts, and pricing over a specified time horizon.

The goal of aggregate planning is to satisfy demand in a way that maximizes profit. It solves problems involving aggregate decisions rather than stock keeping unit (SKU) decisions.

Item	*Cost*
Materials	$10/unit
Inventory holding cost	$2/unit/month
Marginal cost of a stockout	$5/unit/month
Hiring and training costs	$300/worker
Layoff cost	$500/worker
Labour hours required	4/unit
Regular time cost	$4/hour
Over time cost	$6/hour
Cost of subcontracting	$30/unit

6.1 Forecasting and Aggregate Planning



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The goal of agg[illegible] that maximizes [illegible] decisions rathe[illegible]

Example on Aggregate Planning

For example, aggregate planning will determine the total production level in a plant for a given month, but it will do so without determining the quantity of each individual SKU that will be produced. This level of detail makes aggregate planning a useful tool for thinking about decisions with an intermediate time frame of between roughly three and eighteen months. In this time frame, it is too early to determine stock keeping units (SKU) by stock keeping units (SKU) production levels, but it is also generally too late to arrange for additional capacity. Therefore, aggregate planning answers the question, "How should a firm best utilize the facilities that it currently has?"

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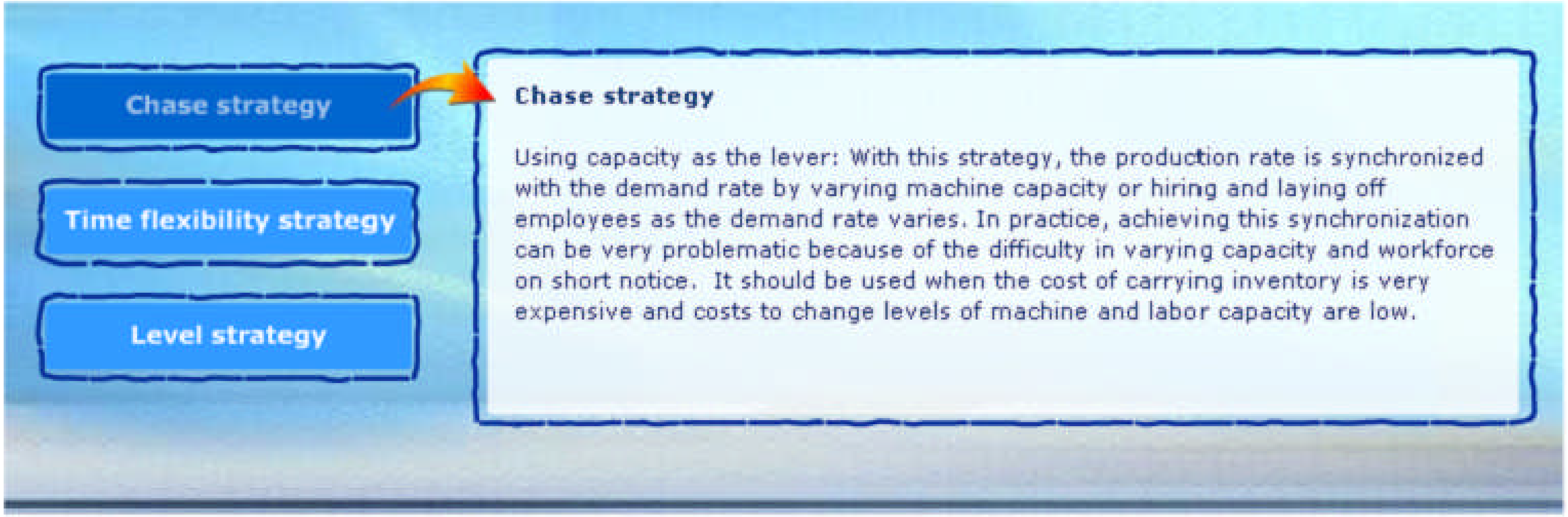
6.1 Forecasting and Aggregate Planning

Fundamental tradeoffs in Aggregate Planning

The fundamental trade-offs available to a planner are between capacity (regular time, overtime, subcontracted), inventory and backlog/lost sales.

There are essentially three distinct aggregate planning strategies for achieving balance between these costs. The three strategies are as follows:



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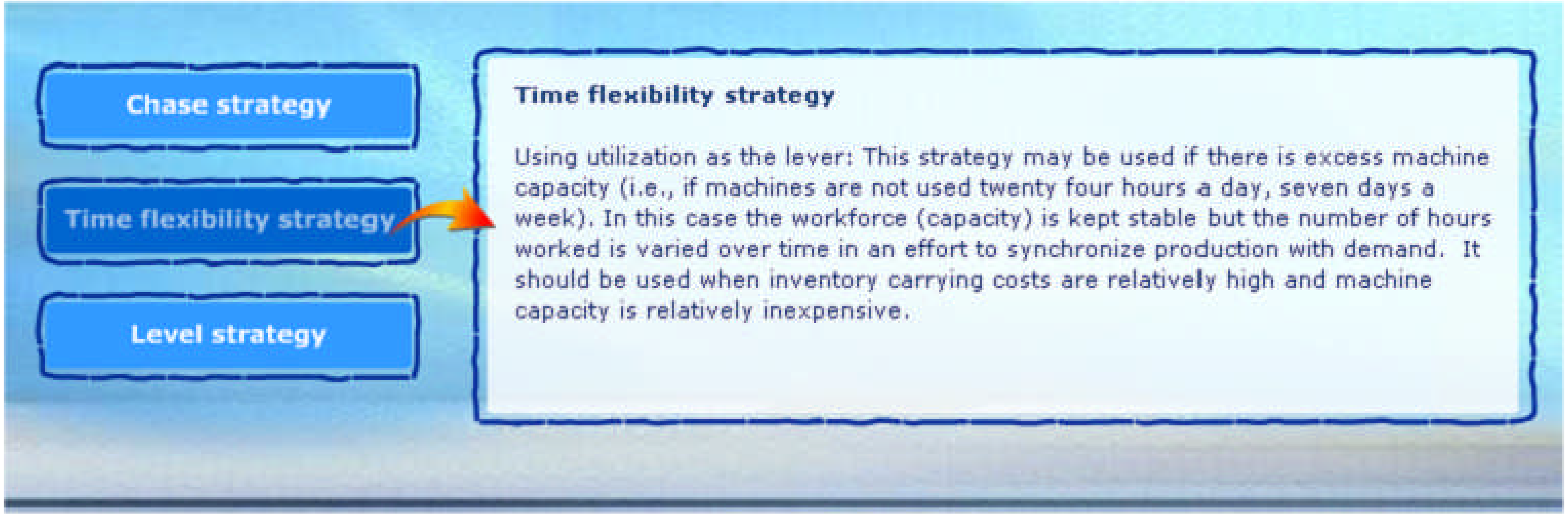

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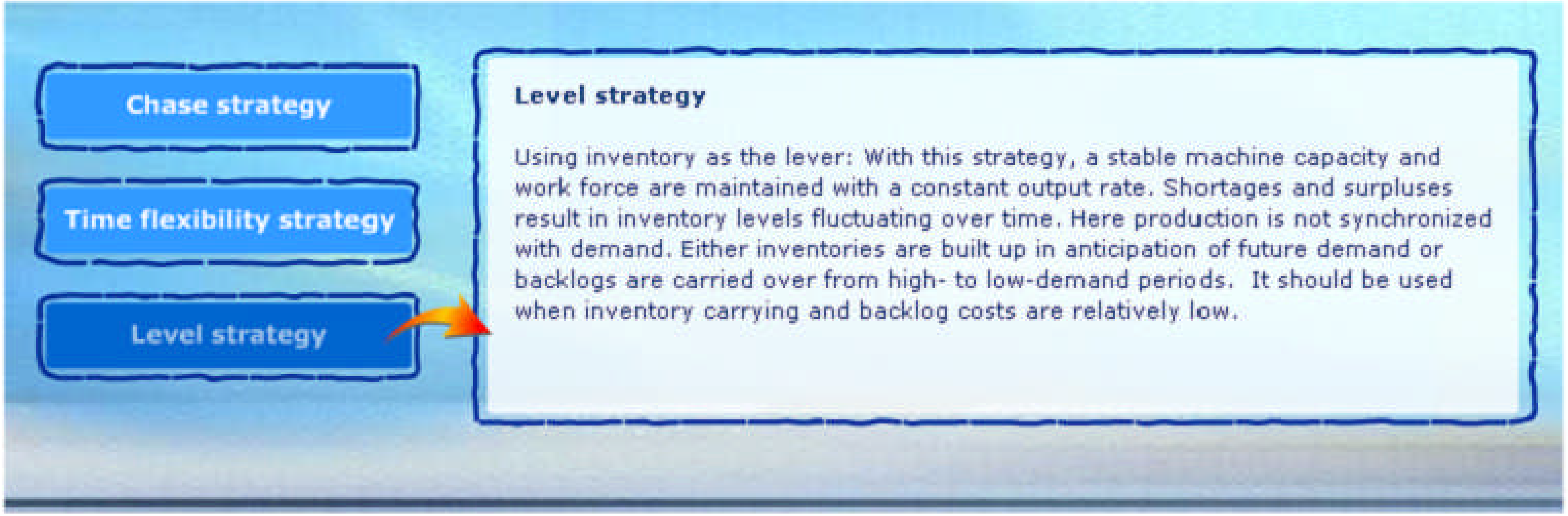

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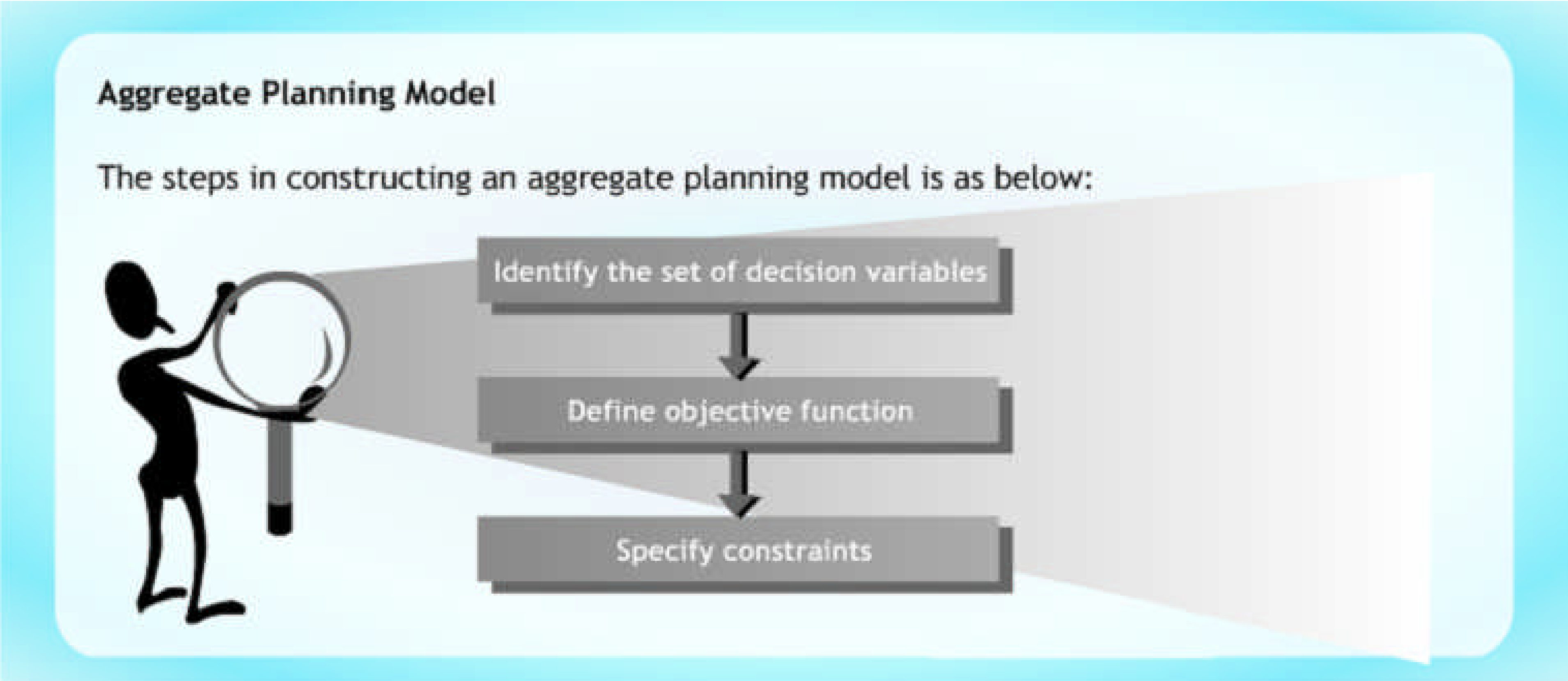


6.1 Forecasting and Aggregate Planning

Identify Set of Decision Variables

The following decision variables are defined for the aggregate planning model:

W_t = Workforce size for month t, t = 1, ..., 6
H_t = Number of employees hired at the beginning of month t, t = 1, ..., 6
L_t = Number of employees laid off at the beginning of month t, t = 1, ..., 6
P_t = Production in month t, t = 1, ..., 6
I_t = Inventory at the end of month t, t = 1, ..., 6
S_t = Number of units stocked out at the end of month t, t = 1, ..., 6
C_t = Number of units subcontracted for month t, t = 1, ..., 6
O_t = Number of overtime hours worked in month t, t = 1, ..., 6

6.1 Forecasting and Aggregate Planning

Define Objective Function

The total cost incurred during the planning horizon is a sum of all these cost:

+ Regular time labour cost $\sum_{t=1}^{6} 640\, W_t$
+ Overtime labour cost $\sum_{t=1}^{6} 6\, O_t$
+ Cost of hiring and layoffs $\sum_{t=1}^{6} 300\, H_t + \sum_{t=1}^{6} 500\, L_t$
+ Cost of inventory and stockout $\sum_{t=1}^{6} 2\, I_t + \sum_{t=1}^{6} 5\, S_t$
+ Cost of materials and subcontracting $\sum_{t=1}^{6} 10\, P_t + \sum_{t=1}^{6} 30\, C_t$

6.1 Forecasting and Aggregate Planning

Define Objective Function

Denote the demand in Period t by D_t. The objective function is to **minimize the total cost** (equivalent to maximizing total profit as all demand is to be satisfied) incurred during the planning horizon. The cost incurred has the following components:

- Regular time labor cost
- Overtime labor cost
- Cost of hiring and layoffs
- Cost of holding inventory
- Cost of stocking out
- Cost of subcontracting
- Material cost

6.1 Forecasting and Aggregate Planning

Define Objective Function

***1. Regular time labor cost*.**

Workers are paid a regular time wage of $640 ($4/hour x eight hours/day x twenty days/month) per month. Because Wt is the number of workers in Period t, the regular time labor cost over the planning horizon is given by the following:

Regular time labor cost = $\sum_{t=1}^{6} 640 W_t$

2. Overtime labor cost.

Overtime labor cost is $6 per hour and O_t represents the number of overtime hours worked in Period *t*, the overtime cost over the planning horizon is given as follows:

Overtime labor cost = $\sum_{t=1}^{6} 6 O_t$

6.1 Forecasting and Aggregate Planning

Define Objective Function

3. Cost of hiring and layoffs.

The cost of hiring a worker is $300 and the cost of laying off a worker is $500. H_t and L_t represent the number hired and the number laid off respectively in Period t. Thus the cost of hiring and layoff is given by the following:

Cost of hiring and layoffs = $\sum_{t=1}^{6} 300 H_t + \sum_{t=1}^{6} 500 L_t$

4. Cost of inventory and stockout.

The cost of carrying inventory is $2 per unit per month and the cost of stocking out is $5 per unit per month. I_t and S_t represent the units in inventory and the units stocked out, respectively, in Period *t*. Thus, the cost of holding inventory and stocking out is given as follows:

Cost of holding inventory and stocking out = $\sum_{t=1}^{6} 2 I_t + \sum_{t=1}^{6} 5 S_t$

6.1 Forecasting and Aggregate Planning

Define Objective Function

5. Cost of materials and subcontracting.

The material cost is \$10 per unit and the subcontracting cost is \$30/unit. P_t represents the quantity produced and C_t represents the quantity subcontracted in Period t. Thus, the material and subcontracting cost is given by the following:

Cost of materials and subcontracting = $\sum_{t=1}^{6} 10 P_t + \sum_{t=1}^{6} 30 C_t$

6.1 Forecasting and Aggregate Planning

Specify constraints

The constraints that the decision variables may not violate are stipulated below:

+ Workforce, hiring, and layoff constraints $W_t = W_{t-1} + H_t - L_t$ *for* $t = 1,\dots,6$

+ Capacity constraints $P_t \leq 40W_t + O_t / 4$ *for* $t=1,\dots,6$

+ Inventory balance constraints $I_{t-1} + P_t + C_t = D_t + S_{t-1} + I_t - S_t$ *for* $t=1,\dots6$

+ Overtime limit constraints $O_t = 10W_t$ *for* $t=1,\dots6$

6.1 Forecasting and Aggregate Planning

Specify Constraints

1. Workforce, hiring, and layoff constraints.

The workforce size W_t in Period t is related to the workforce size W_{t-1} in Period $_{t-1}$, the number hired H_t in Period *t*, and the number laid off L_t in Period *t* as follows:

$$W_t = W_{t-1} + H_t - L_t \qquad \text{for} \qquad t = 1, \ldots, 6$$

2. Capacity constraints.

In each period, the amount produced cannot exceed the available capacity. This set of constraints limits the total production by the total internally available capacity (which is determined based on the available labor hours, regular or overtime). Subcontracted production is not included in this constraint as the constraint is limited to production within the plant. As each worker can produce 40 units per month on regular time (four hours per unit) and one unit for every four hours of overtime, we have the following:

$$P_t \leqslant 40W_t + O_t/4 \qquad \textit{for} \qquad t = 1, \ldots, 6$$

6.1 Forecasting and Aggregate Planning

Specify Constraints

3. Inventory balance constraints.

The third set of constraints balances inventory at the end of each period. Net demand for Period t is obtained as the sum of the current demand D_t and the previous backlog S_{t-1}. This demand is either filled from current production (inhouse production P_t or subcontracted production C_t) and previous inventory I_{t-1} (in which case some inventory I_t may be left over) or part of it is backlogged S_t. This relationship is captured by the following equation:

$$I_{t-1} + P_t + C_t = D_t + S_{t-1} + I_t - S_t \qquad \text{for} \qquad t = I, \ldots, 6$$

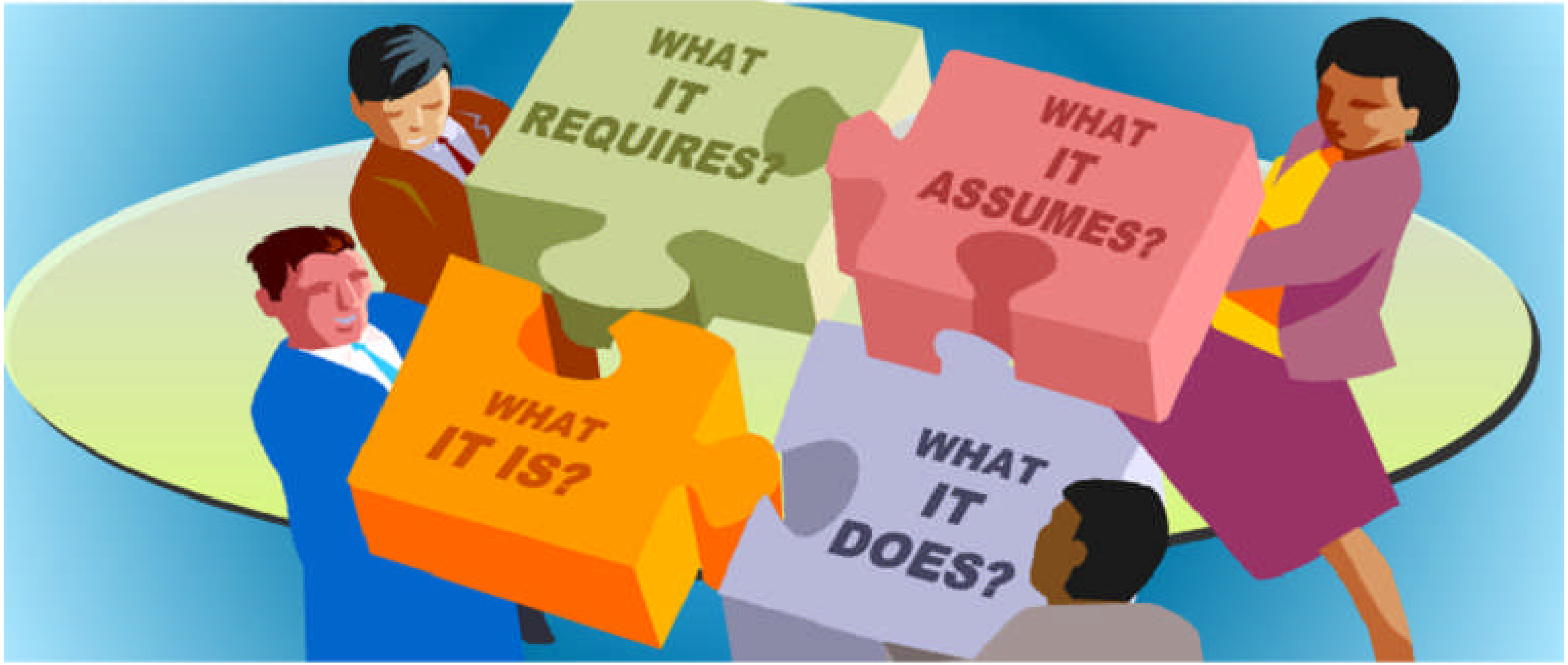
4. Overtime limit constraints.

The fourth set of constraints requires that no employee work more than ten hours of overtime each month. This requirement limits the total amount of overtime hours available as follows:

$$O_t \leqslant 10W_t \qquad \text{for} \qquad t = 1, \ldots 6$$

6.2 Just-In-Time Production Systems

Definition of Just-In-Time (JIT) Production System



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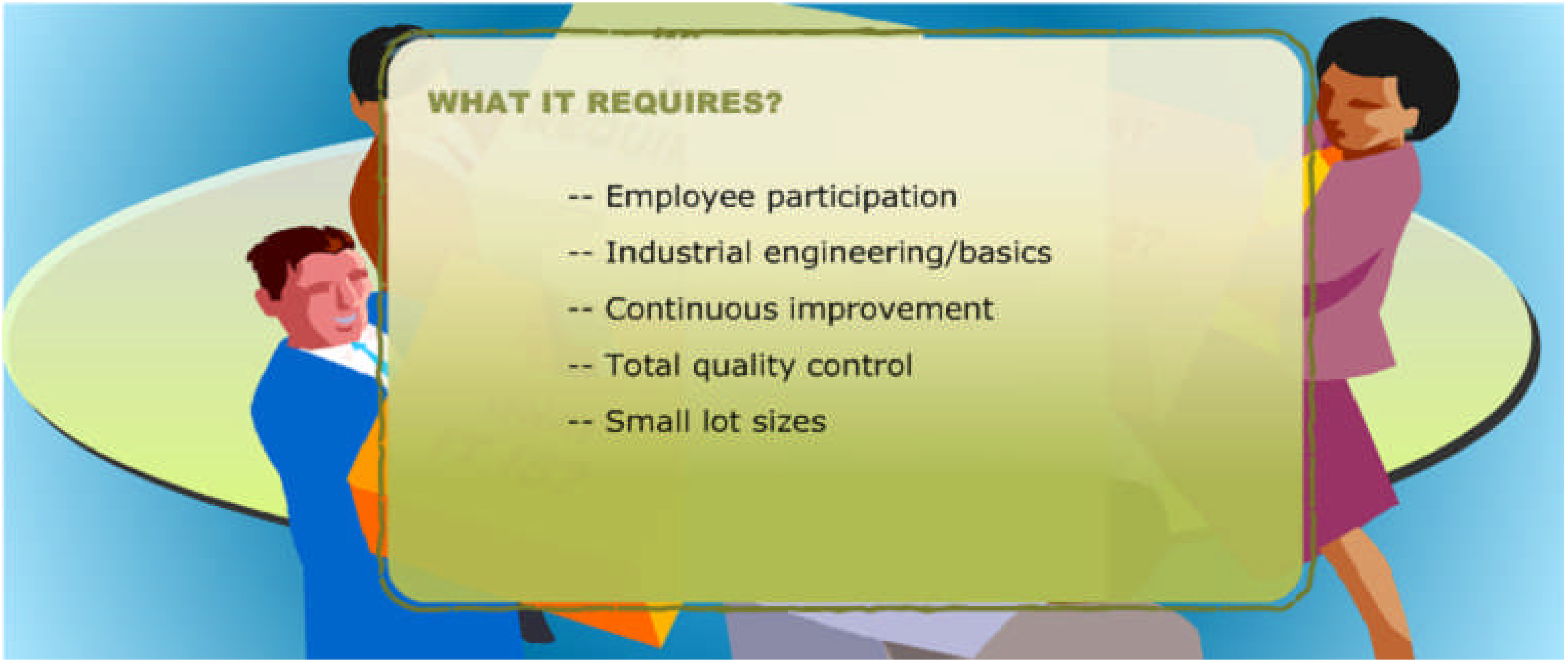

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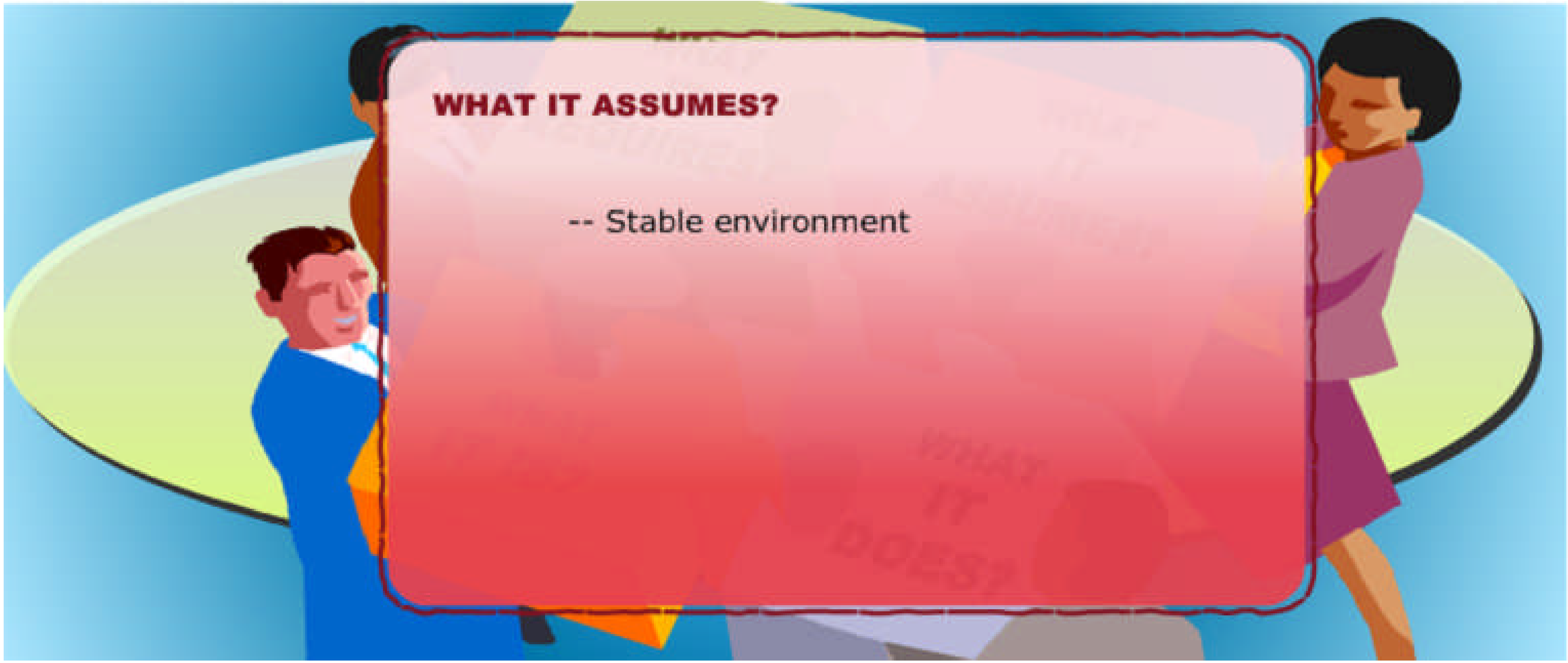

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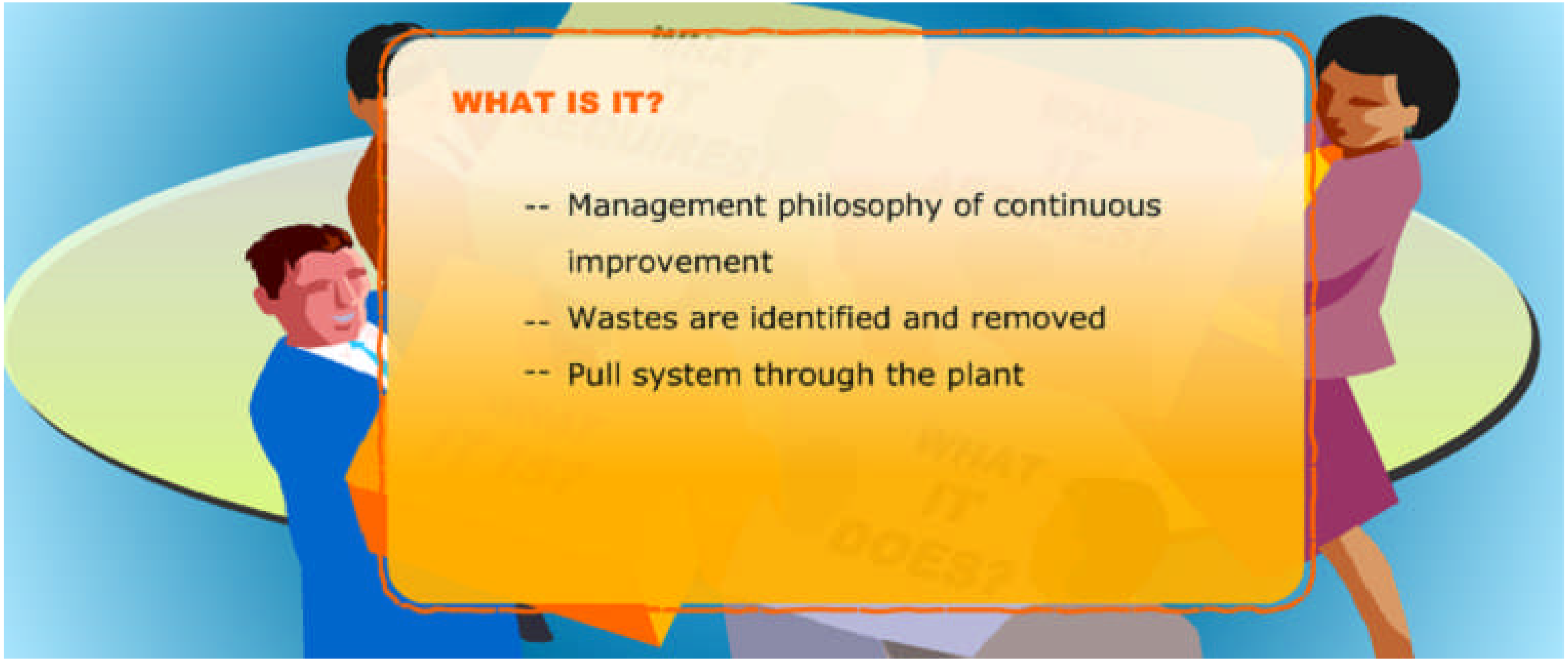

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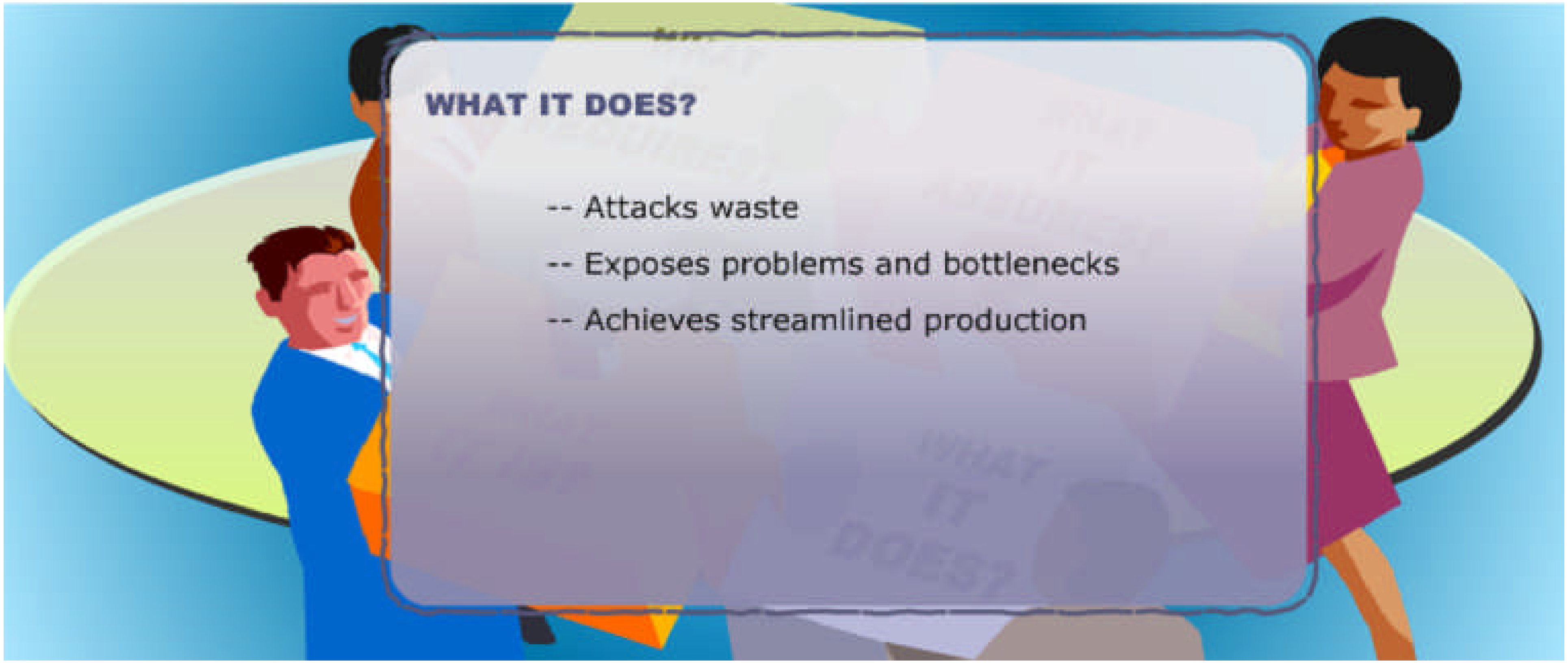
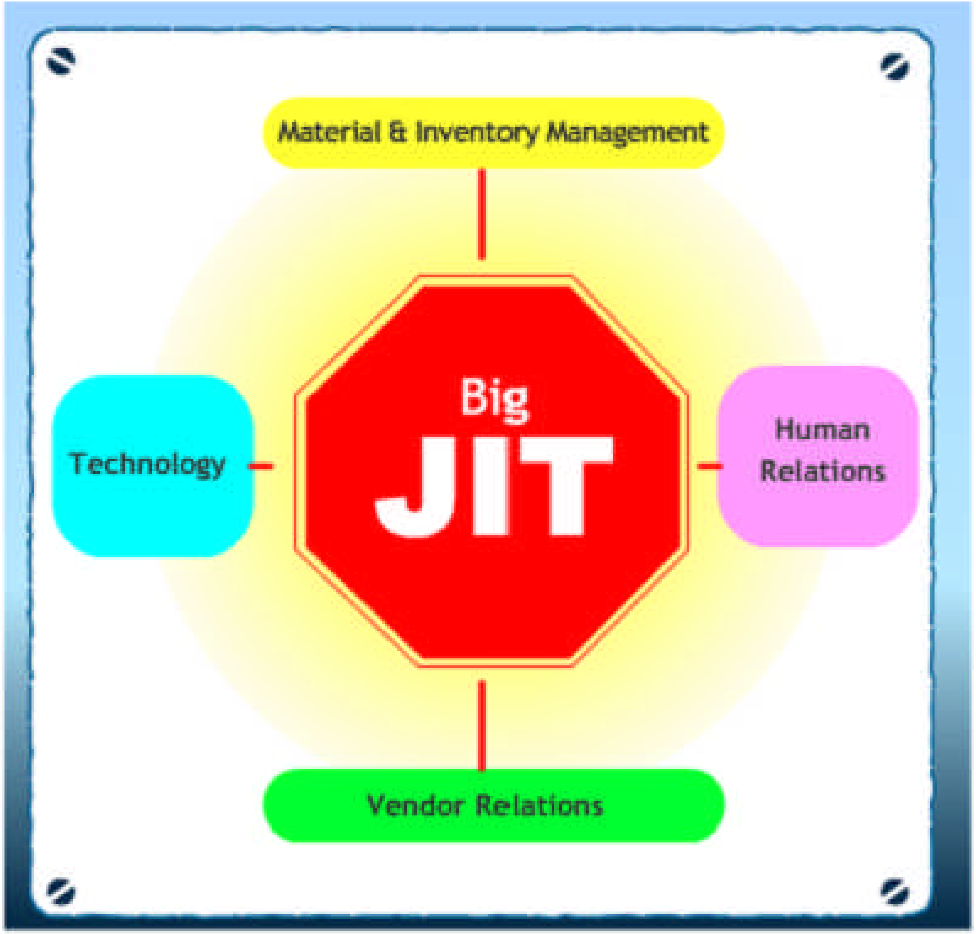


6.2 Just-In-Time Production Systems

"Big JIT"

- Also called Lean Management
- Broad focus
- Philosophical focus on elimination of all sources of waste



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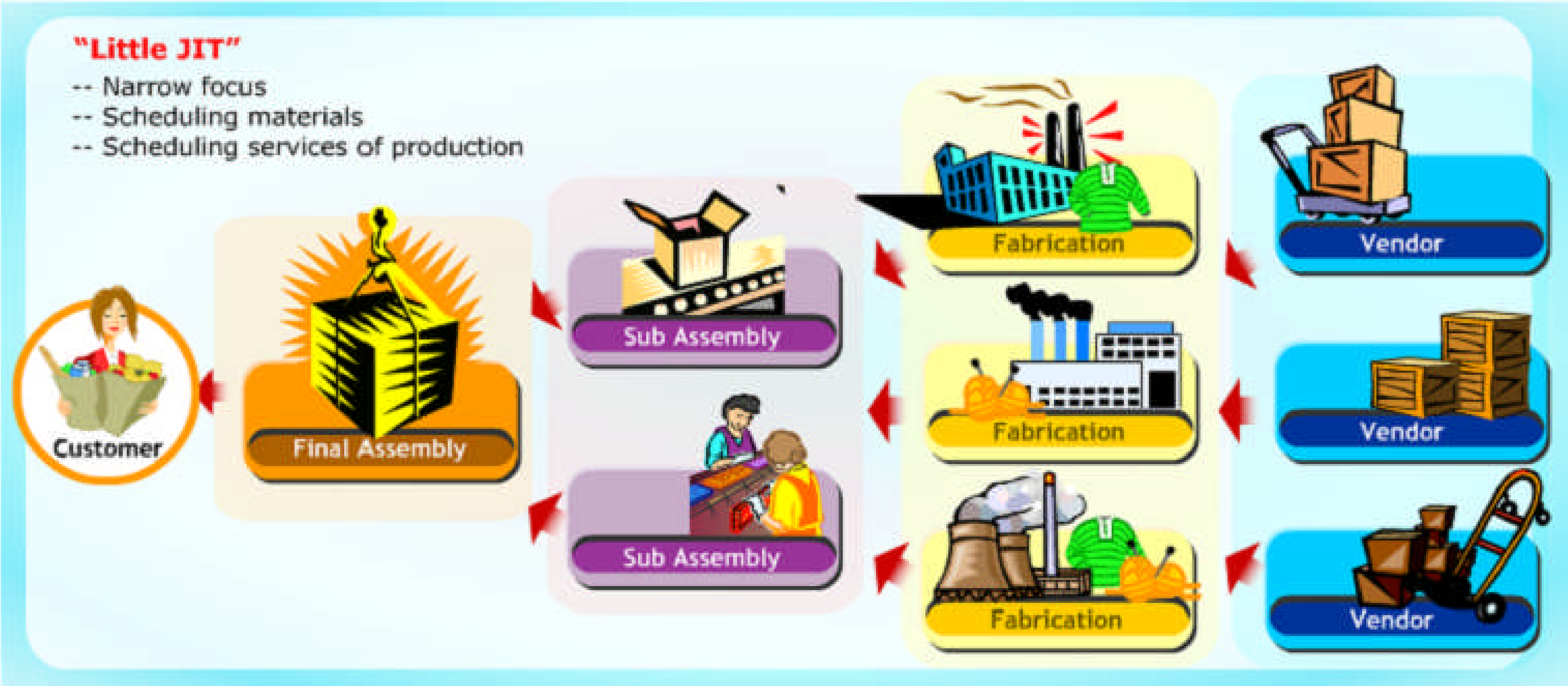


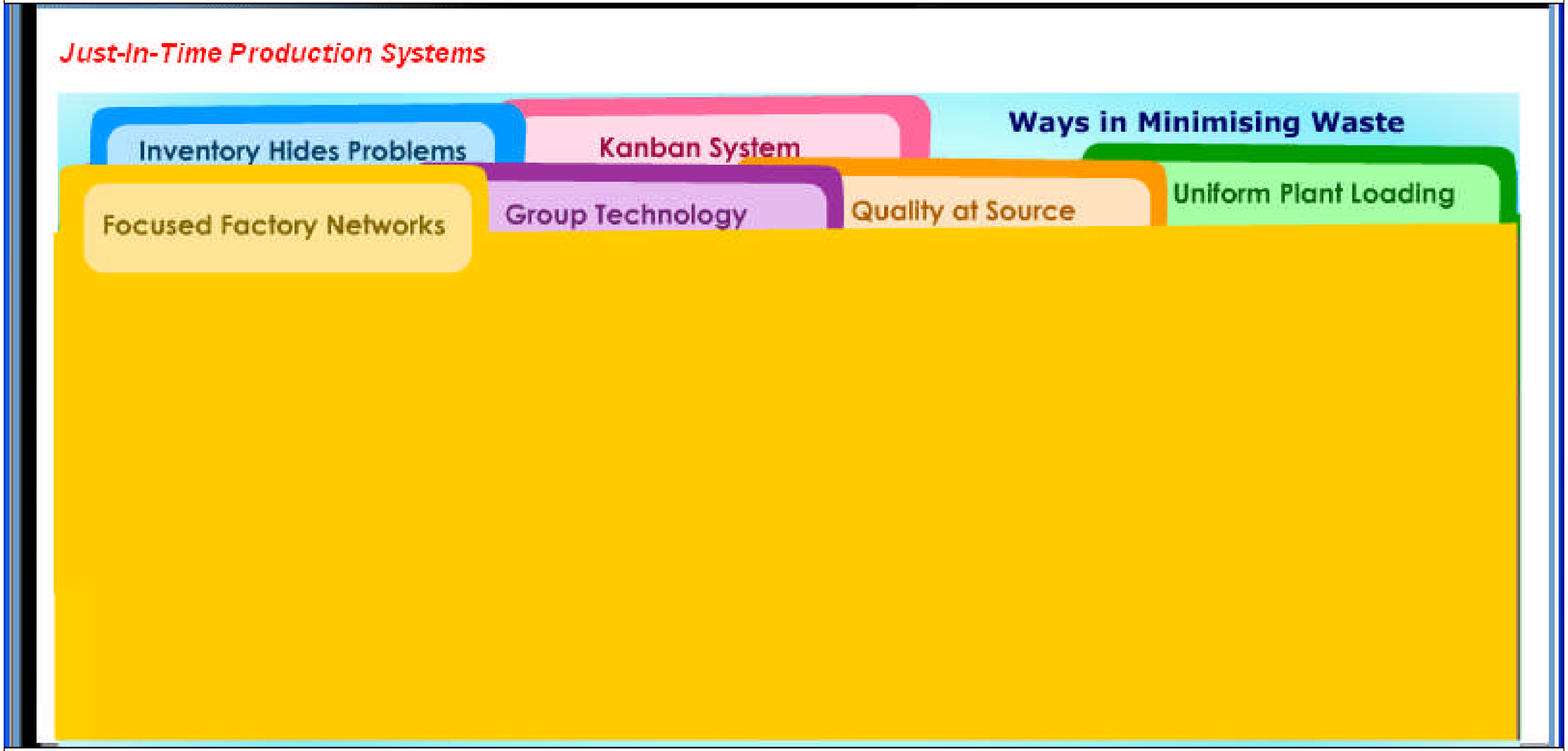
6.2 Just-In-Time Production Systems

Types of waste in operation

- Waste from overproduction
- Waste of waiting time
- Transportation waste
- Inventory waste
- Processing waste
- Waste due to movement
- Waste from product defects

6.2 Just-In-Time Production Systems

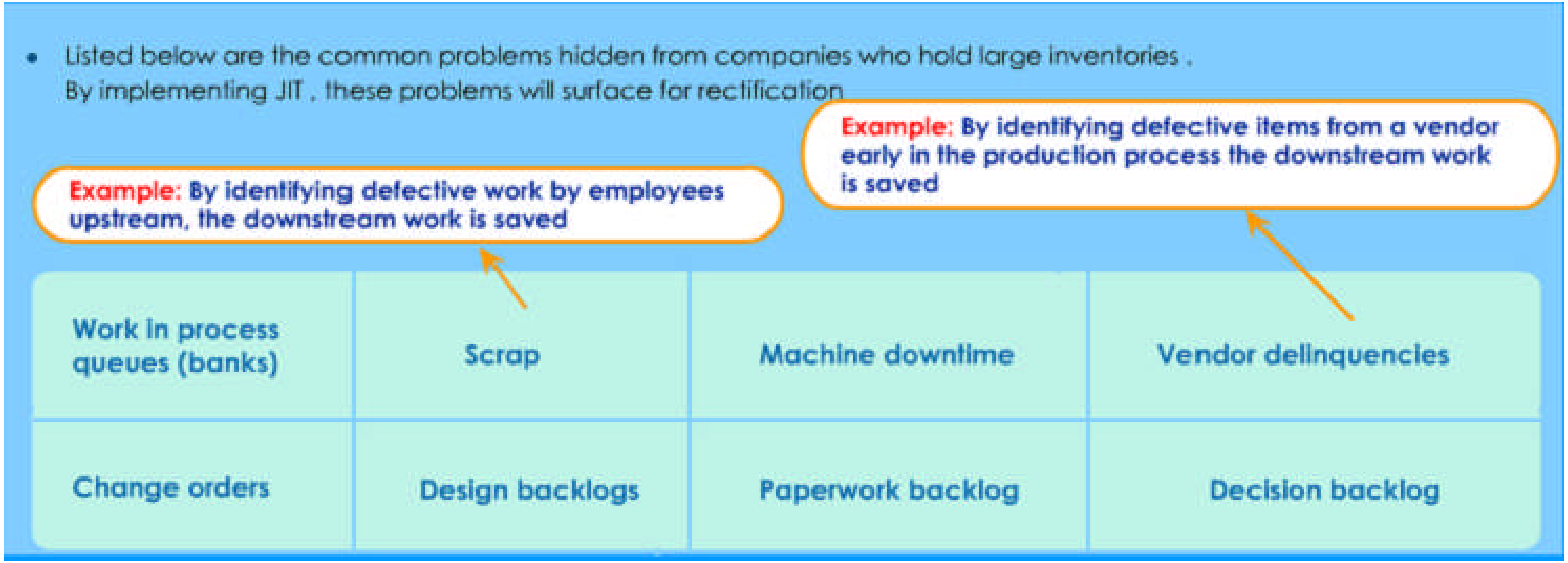
Ways in Minimising Waste



6.2 Just-In-Time Production Systems

Ways in Minimising Waste

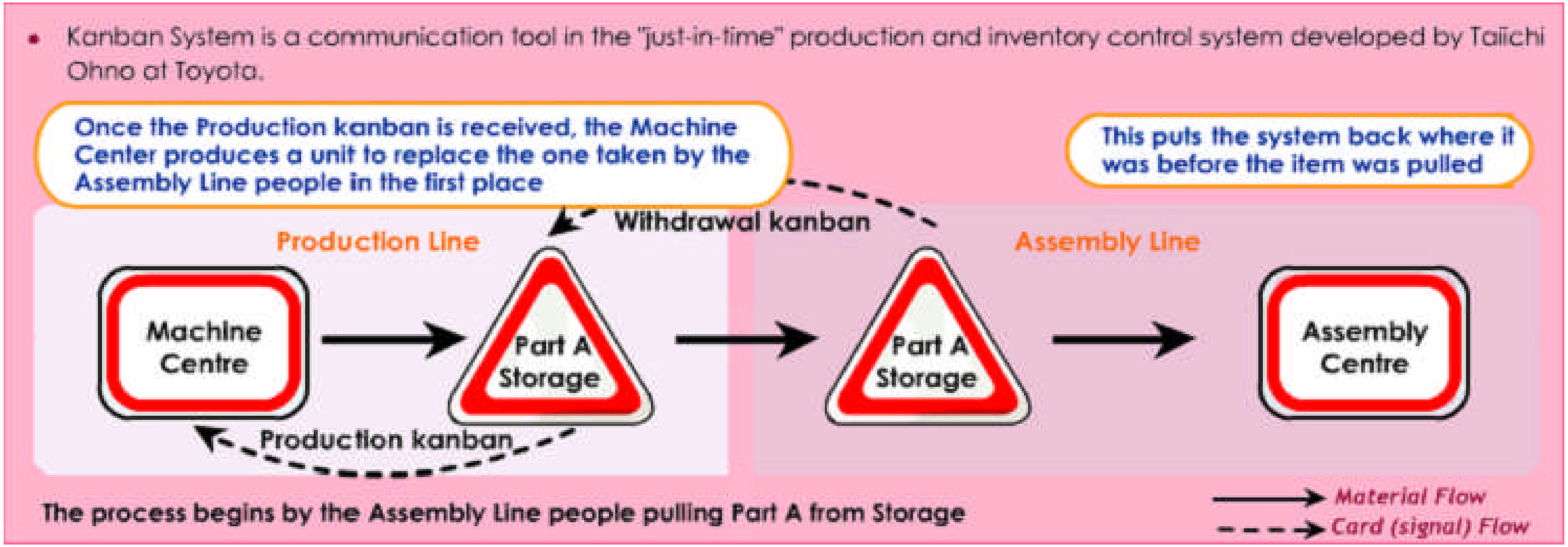
Inventory Hides Problems



6.2 Just-In-Time Production Systems

Ways in Minimising Waste

Kanban System



Kanban

A Kanban or signboard is attached to specific parts in the production line to signify the delivery of a given quantity. When the parts have all been used, the same sign is returned to its origin where it becomes an order for more.

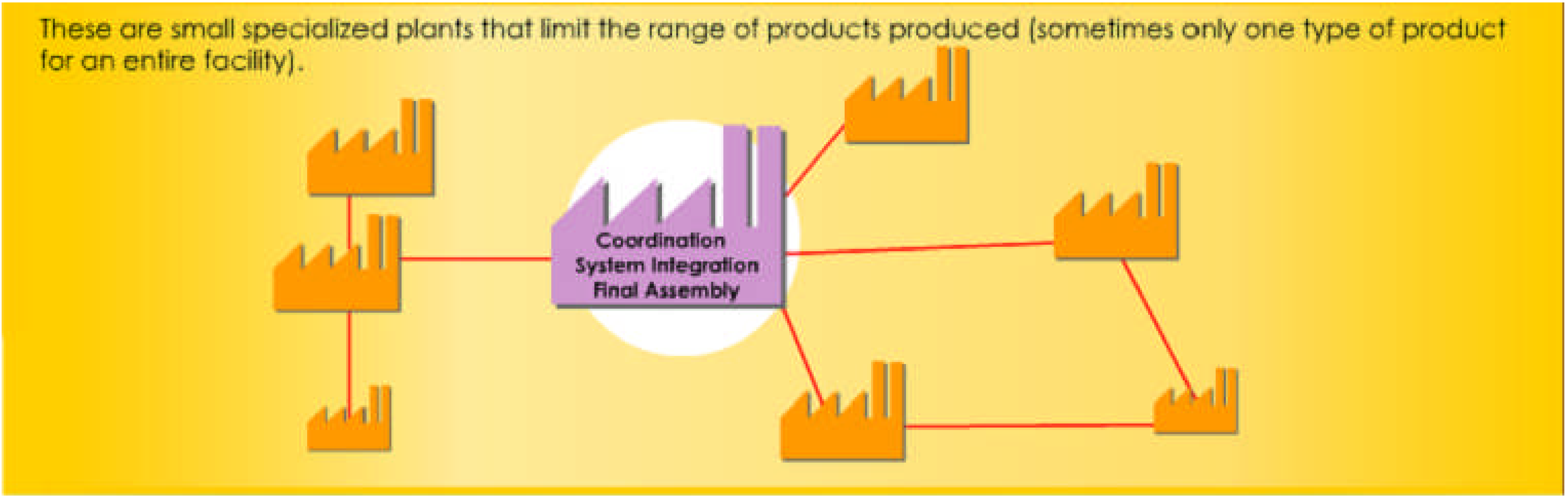
Kanban Signal

A method of signaling suppliers or upstream operations when it is time to replenish limited stocks of components or subassemblies in a just-in-time system. Originally a card system used in Japan, kanban signals now include empty containers, empty spaces and even electronic messages.

6.2 Just-In-Time Production Systems

Ways in Minimising Waste

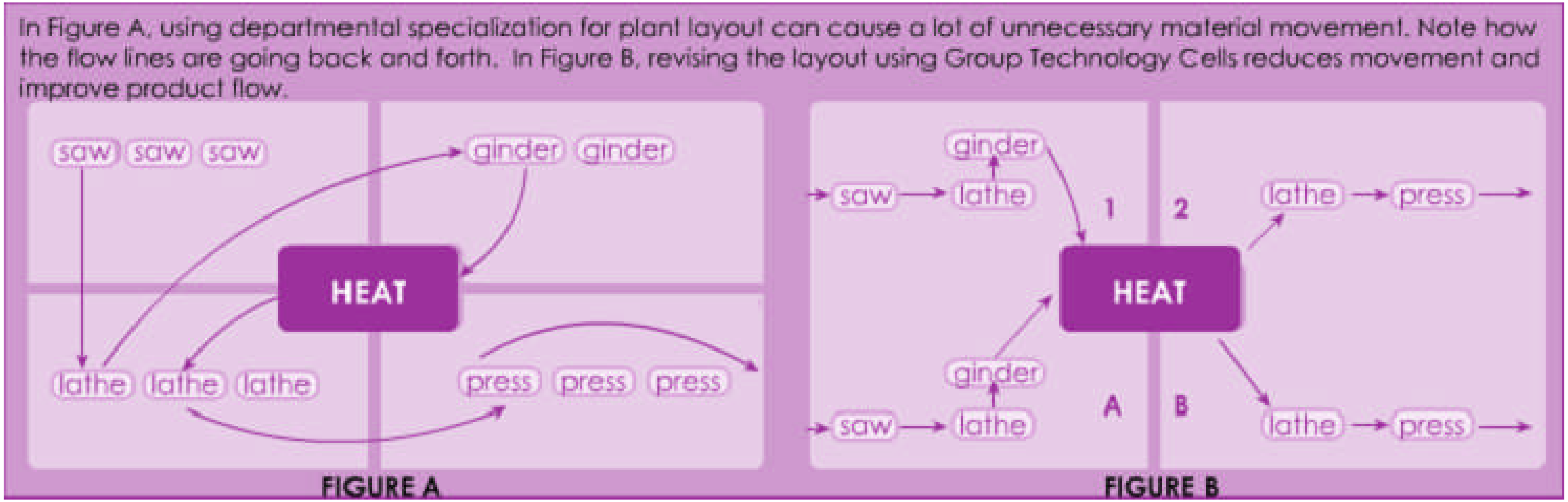
Focused Factory Networks



6.2 Just-In-Time Production Systems

Ways in Minimising Waste

Group Technology



6.2 Just-In-Time Production Systems

Ways in Minimising Waste

Quality at Source

- Self-inspection
- Automated inspection
- Line-stopping empowerment

6.2 Just-In-Time Production Systems

Ways in Minimising Waste

Uniform Plant Loading

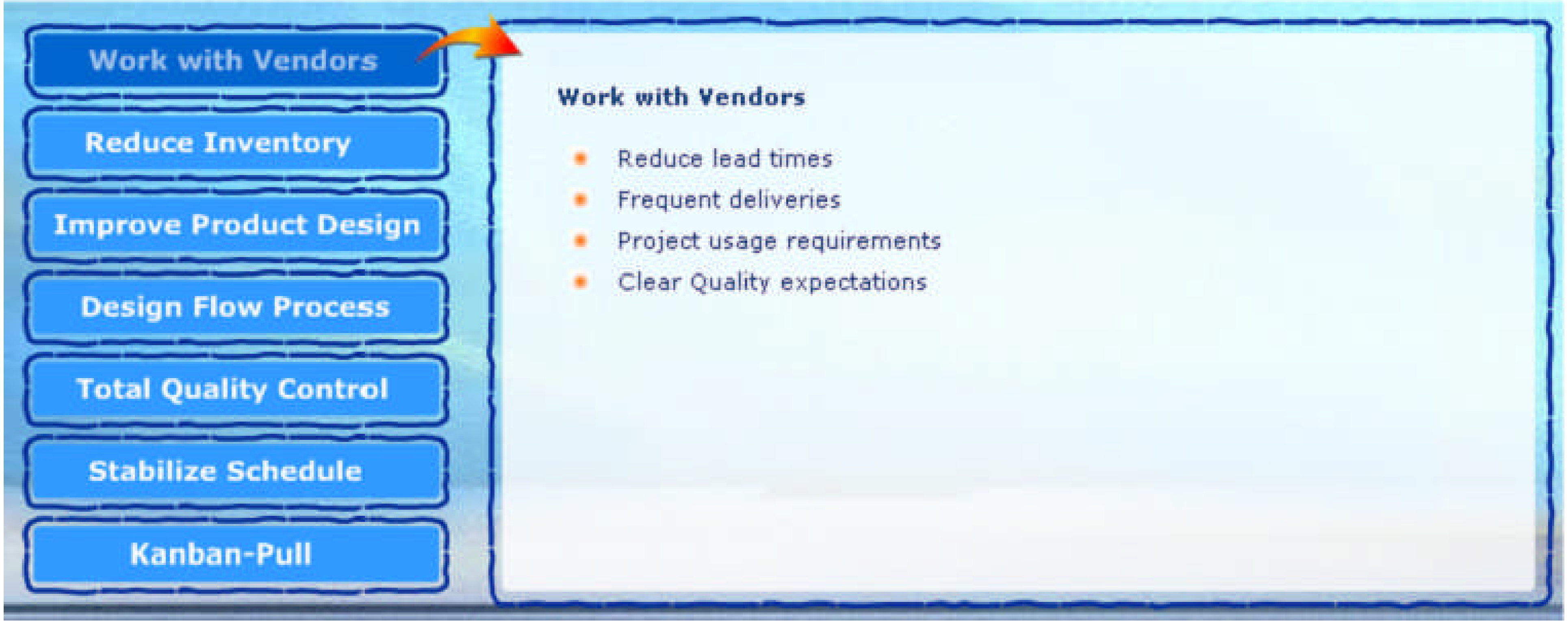
- To maintain a stable mix of products, and firm monthly schedules.
- Suppose we operate a production plant that produces a single product. The schedule of production for this product could be accomplished using either of the two plant loading schedules below. Compare Table A and B. How does the uniform loading help save labor costs?

TABLE A	JAN (UNITS)	FEB (UNITS)	MAR (UNITS)	TOTAL
Not uniform	1,200	3,500	4,300	9,000

TABLE B	JAN (UNITS)	FEB (UNITS)	MAR (UNITS)	TOTAL
Uniform	3,000	3,000	3,000	9,000

6.2 Just-In-Time Production Systems

Methodology



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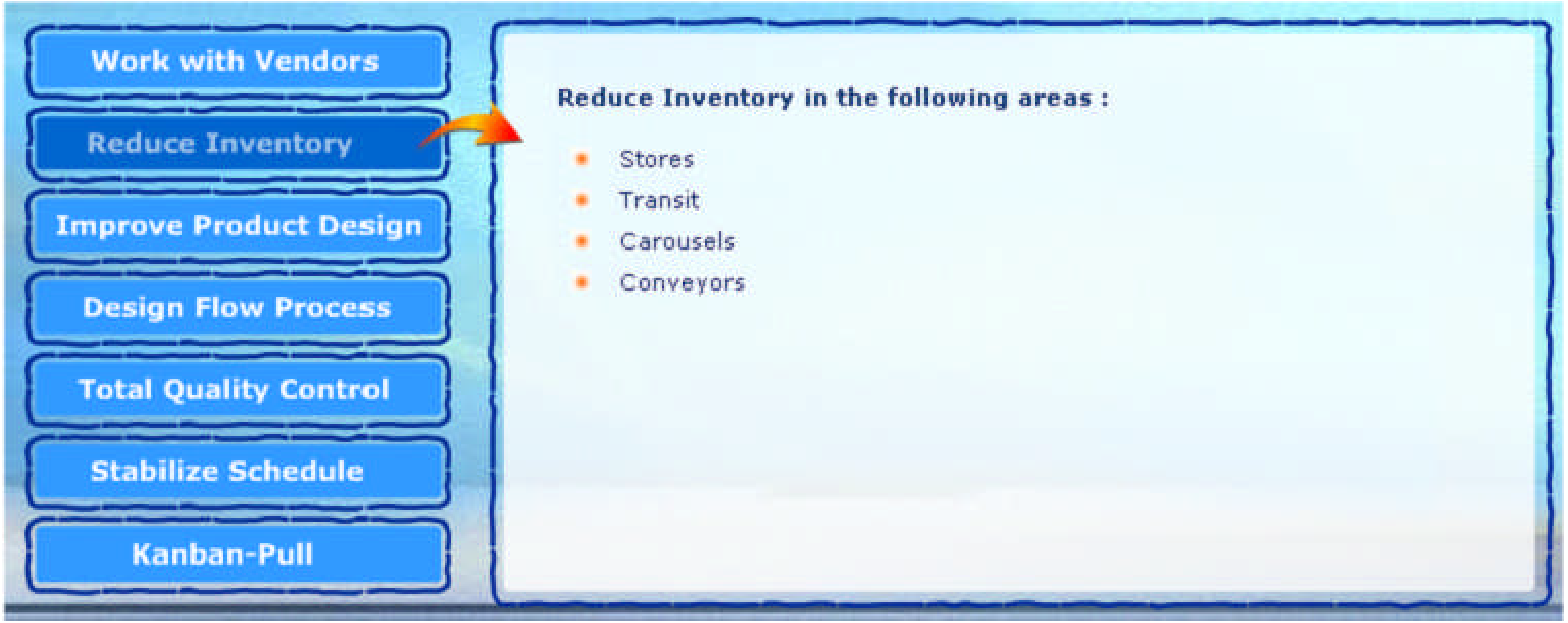

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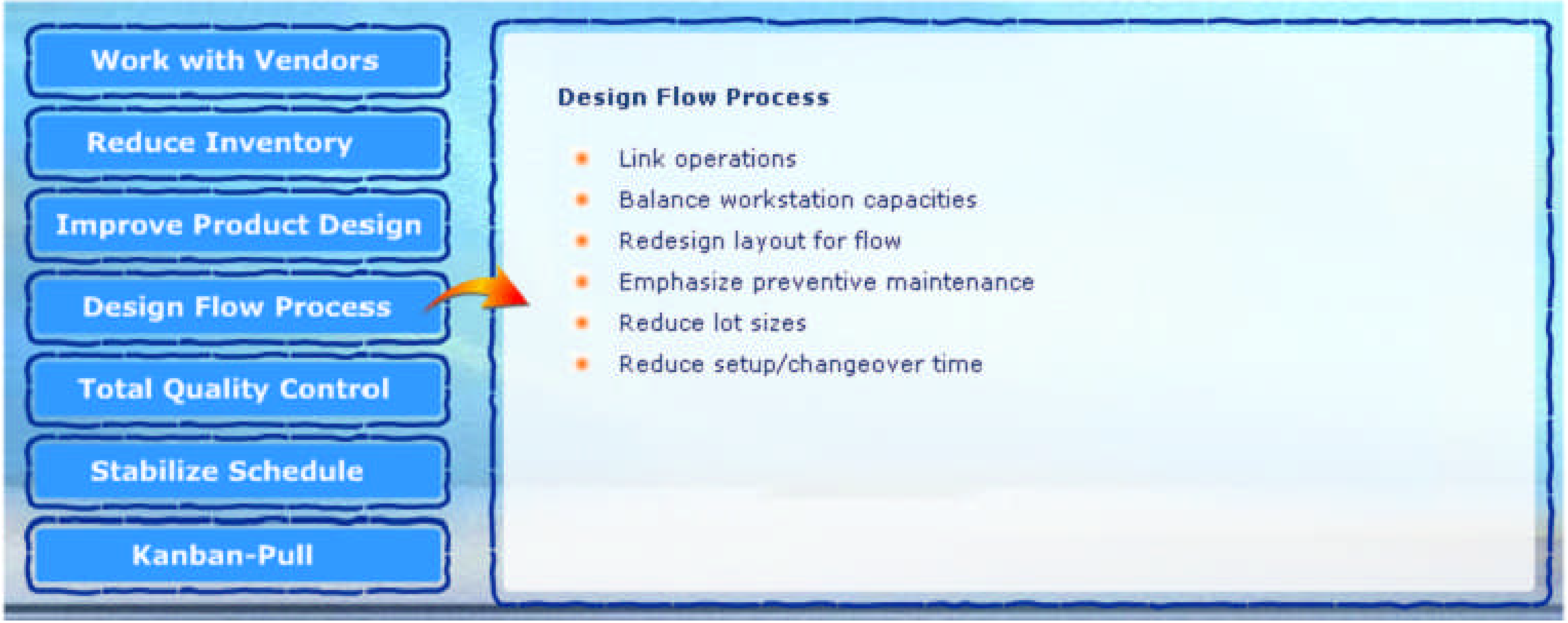

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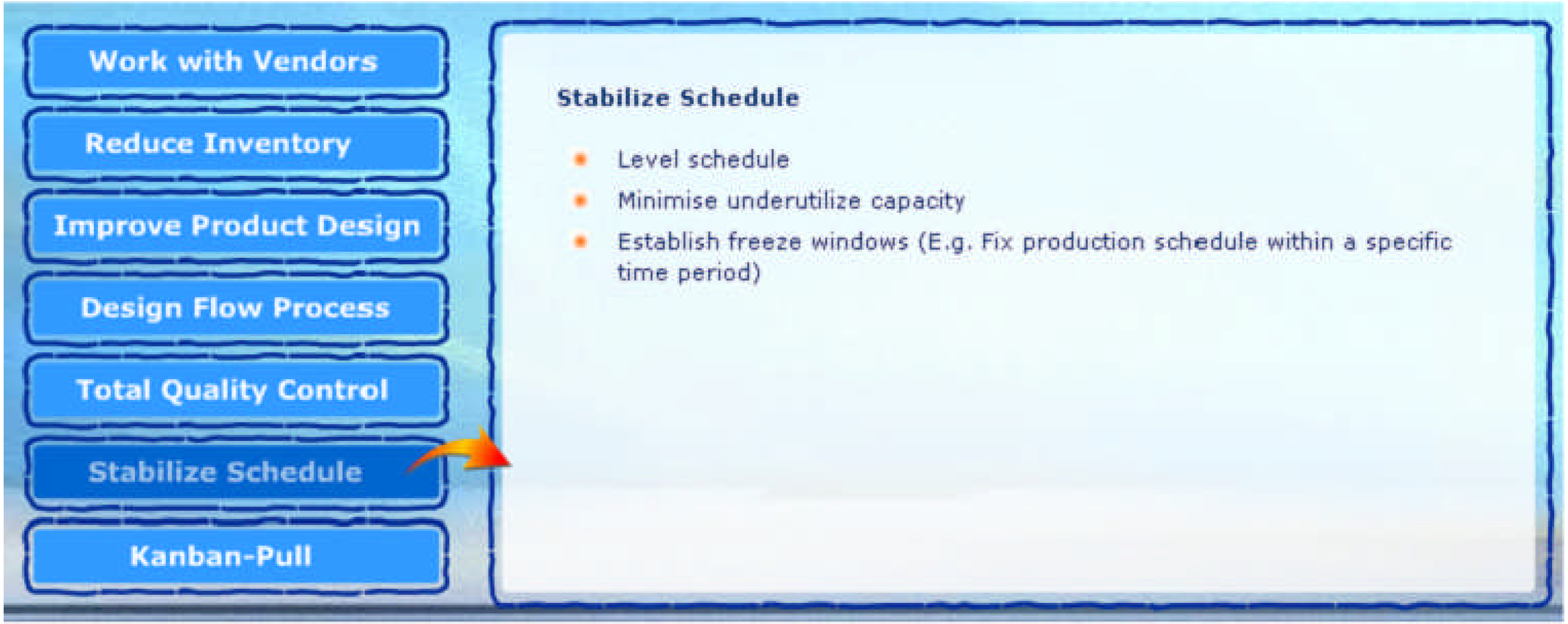

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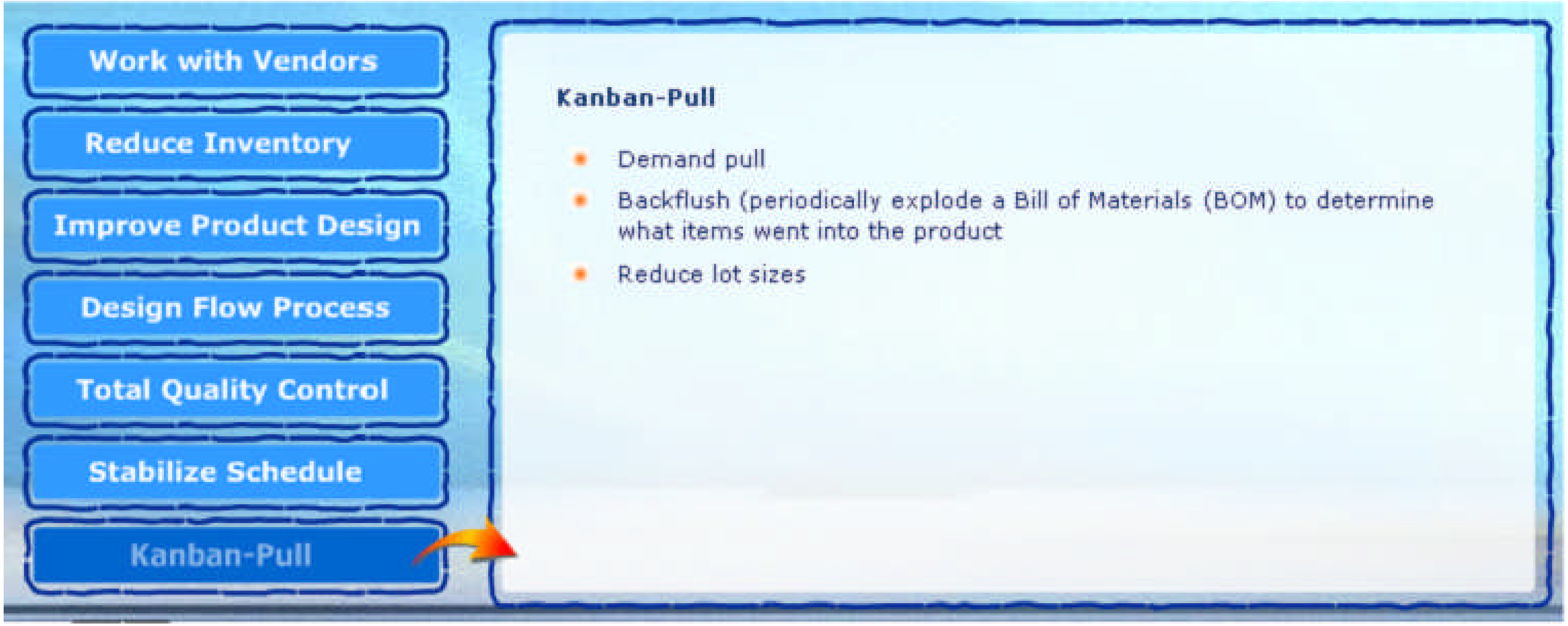

6.2 Just-In-Time Production Systems

Applying JIT Concepts

Some ways of applying JIT concepts include the following:

- Organize Problem-Solving Groups
- Upgrade Housekeeping
- Upgrade Quality
- Clarify Process Flows
- Review Equipment and Process Technologies
- Level the Facility Load
- Eliminate Unnecessary Activities
- Reorganize Physical Configuration
- Introduce Demand-Pull Scheduling
- Develop Supplier Networks

Reference Text

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A Supply Chain Perspective

7th Edition

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