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COURSE NAME	: OPERATIONS MANAGEMENT
SEMESTER	: I
FACULTY NAME	: MR.RAJKUMAR
DESIGNATION	: ASSISTANT PROFESSOR
TOPIC	: INVENTORY MANAGEMENT

LEARNING OBJECTIVES

- After this lecture, students will be able to
  1. Define the term *inventory*
  2. List the different types of inventory
  3. Describe the main functions of inventory
  4. Discuss the main requirements for effective inventory management
  5. Describe the A-B-C approach and explain how it is useful
  6. Describe the basic EOQ model and its assumptions and solve typical problems.
  7. Describe reorder point models and solve typical problems.
  8. Describe situations in which the fixed-order interval model is appropriate, and solve typical problems.
  9. Describe service level and risk of stockout and use Z table to identify the z value for a service level or a risk of stockout

INVENTORY

- An **inventory** is a stock or store of goods.
- Inventories are a vital part of business:
  - necessary for operations
  - contribute to customer satisfaction
    - A “typical” firm has roughly 30% of its current assets and as much as 90% of its working capital invested in inventory
- But
  - Costly
  - May have limited shelf-life
  - Carrier may have limited space

TYPES OF INVENTORY

- Raw materials and purchased parts
- Work-in-process (WIP)
- Finished goods inventories or merchandise
- Tools and supplies
- Maintenance and repairs (MRO) inventory
- Goods-in-transit to warehouses or customers (pipeline inventory)

COSTS OF INVENTORY

- Physical holding costs:
  - out of pocket expenses for storing inventory (insurance, security, warehouse rental, cooling)
  - All costs that may be entailed before you sell it (obsolescence, spoilage, rework...)

- Opportunity cost of inventory: foregone return on the funds invested.

INVENTORY FUNCTIONS

- Inventories serve a number of functions such as:
  1. To meet anticipated customer demand
  2. To smooth production requirements
     - Firms that experience seasonal patterns in demand often build up inventories during preseason periods to meet overly high requirements during seasonal periods.
  3. To decouple operations
     - Buffers between operations
  4. To protect against stockouts
     - Delayed deliveries and unexpected increases in demand increase the risk of shortages.

INVENTORY FUNCTIONS

- Inventories serve a number of functions such as:
  5. To take advantage of order cycles
     - It is usually economical to produce in large rather than small quantities. The excess output must be stored for later use.
  6. To hedge(a limit) against price increases
     - Occasionally a firm will suspect that a substantial price increase is about to occur and purchase larger-than-normal amounts to beat the increase
  7. To permit operations
     - The fact that production operations take a certain amount of time (i.e., they are not instantaneous) means that there will generally be some work-in-process inventory.
  8. To take advantage of quantity discounts
     - Suppliers may give discounts on large orders.

OBJECTIVES OF INVENTORY CONTROL

- Inventory management has two main concerns:
  1. Level of customer service
     - Having the right goods available in the right quantity in the right place at the right time
  2. Costs of ordering and carrying inventories
     - The overall objective of inventory management is to achieve satisfactory levels of customer service while keeping inventory costs within reasonable bounds

MEASURES OF PERFORMANCE

- Measures of performance:
  - Customer satisfaction
    - Number and quantity of backorders
    - Customer complaints

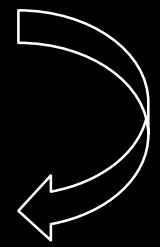
  - Inventory turnover = a ratio of

$$\frac{\text{(average) cost of goods sold}}{\text{(average) inventory investment}}$$

during a period

INVENTORY MANAGEMENT

- Management has two basic functions concerning inventory:
  1. Establish a system for tracking items in inventory
  2. Make decisions about
     - When to order
     - How much to order



EFFECTIVE INVENTORY MANAGEMENT

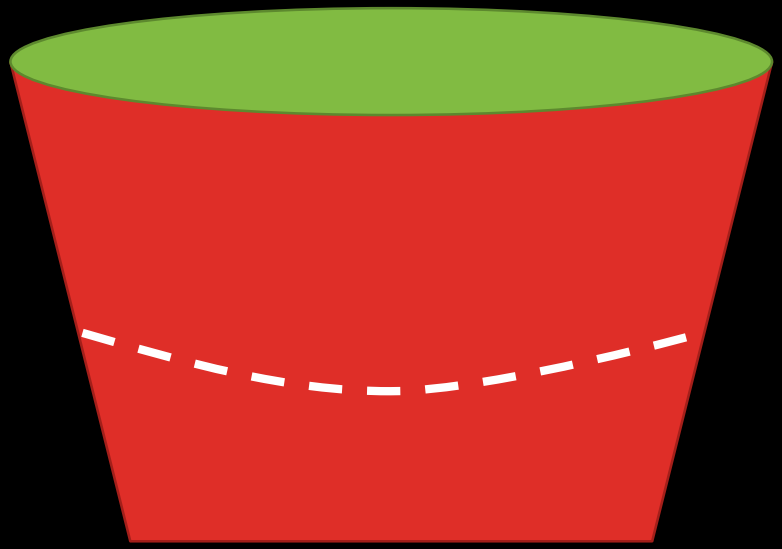
- Requires:
  1. A system keep track of inventory
  2. A reliable forecast of demand
  3. Knowledge of lead time and lead time variability
  4. Reasonable estimates of
     - holding costs
     - ordering costs
     - shortage costs
  5. A classification system for inventory items

INVENTORY COUNTING SYSTEMS

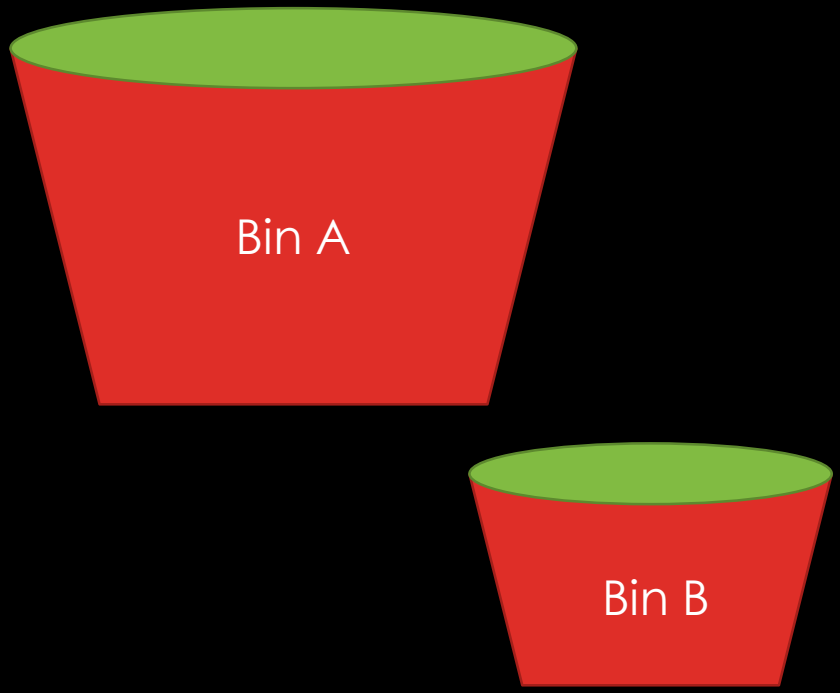
- Periodic System
  - Physical count of items in inventory made at periodic intervals
- Perpetual Inventory System(Occurring repeatedly)
  - System that keeps track of removals from inventory continuously, thus monitoring current levels of each item
  - Point-of-sale (POS) systems
    - A system that electronically records actual sales
  - **Radio Frequency Identification (RFID)**

ONE-BIND & TWO-BIN SYSTEMS

- One-Bin System



- Two-Bin System

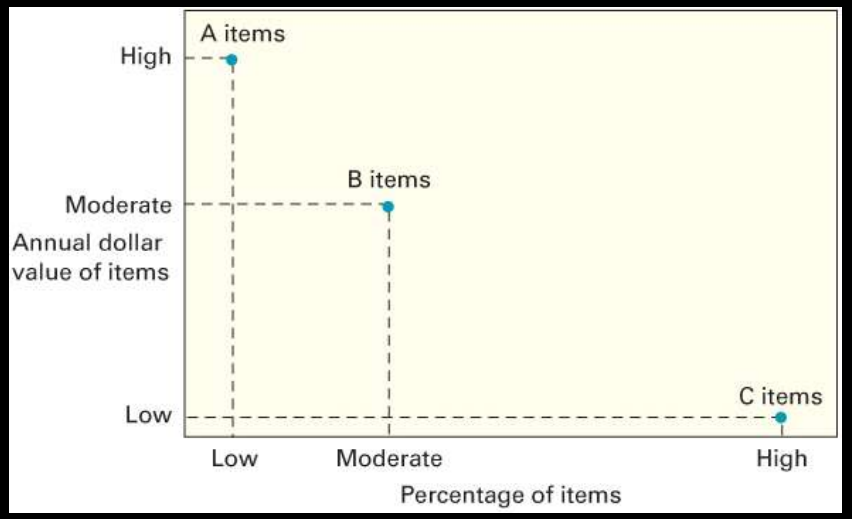


INVENTORY COSTS

- **Purchase cost**
  - The amount paid to buy the inventory
- **Holding (carrying) costs**
  - Cost to carry an item in inventory for a length of time, usually a year
    - Interest, insurance, taxes (in some states), depreciation, obsolescence, deterioration, spoilage, pilferage, breakage, tracking, picking, and warehousing costs (heat, light, rent, workers, equipment, security).
- **Ordering costs**
  - Costs of ordering and receiving inventory
    - determining how much is needed, preparing invoices, inspecting goods upon arrival for quality and quantity, and moving the goods to temporary storage.
- **Shortage costs**
  - Costs resulting when demand exceeds the supply of inventory; often unrealized profit per unit

ABC CLASSIFICATION SYSTEM

- **A-B-C approach**
  - Classifying inventory according to some measure of importance, and allocating control efforts accordingly
  - **A items** (very important)
    - 10 to 20 percent of the number of items in inventory and about 60 to 70 percent of the annual dollar value
  - **B items** (moderately important)
  - **C items** (least important)
    - 50 to 60 percent of the number of items in inventory but only about 10 to 15 percent of the annual dollar value



ABC CLASSIFICATION

- How to classify?
  1. For each item, multiply annual volume by unit price to get the annual dollar value.
  2. Arrange annual values in descending order.
  3. A items: the few with the highest annual dollar value

     C items: the most with the lowest dollar value.

     B items: those in between

#	Annual demand	Unit price	Annual value	Class	% of items	% of value
8	1,000	4,000	4,000,000	A	5.3	52.7
3	2,400	500	1,200,000	B	31.4	40.8
6	1,000	1,000	1,000,000	B		
1	2,500	360	900,000	B		
4	1,500	100	150,000	C	63.3	6.5
10	500	200	100,000	C		
9	8,000	10	80,000	C		
2	1,000	70	70,000	C		
5	700	70	49,000	C		
7	200	210	42,000	C		
	18,800		7,591,000		100	100

ABC CLASSIFICATION: CYCLE COUNTING

- **Cycle counting**
  - A physical count of items in inventory
- Cycle counting management
  - How much accuracy is needed?
    - A items: ± 0.2 percent
    - B items: ± 1 percent
    - C items: ± 5 percent
  - When should cycle counting be performed?
  - Who should do it?

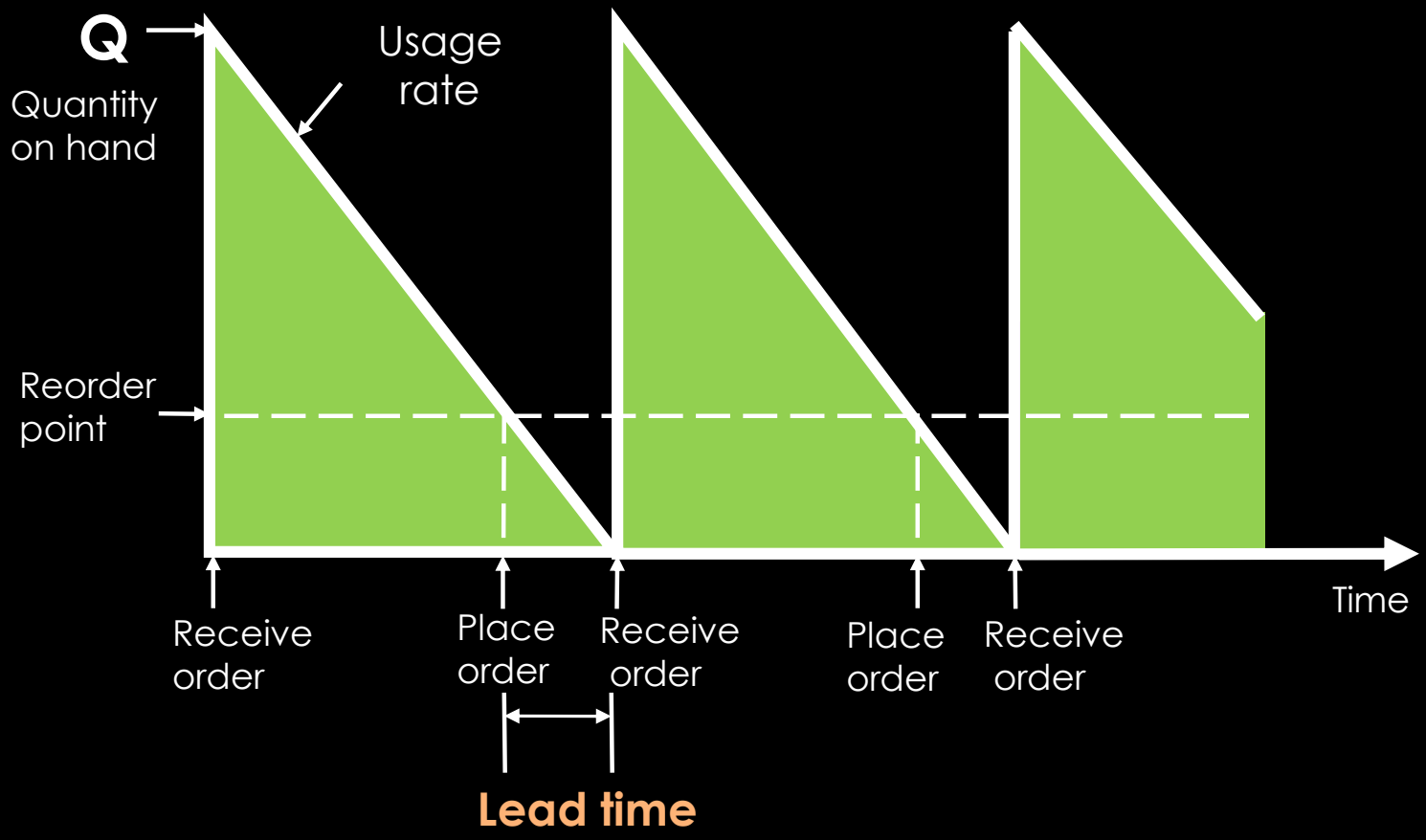
HOW MUCH TO ORDER? ECONOMIC ORDER QUANTITY MODELS

- Economic Order Quantity (EOQ) models:
  - identify the optimal order quantity
    - by minimizing total annual costs that vary with order size and frequency

1. The basic Economic Order Quantity model (EOQ)
2. The Quantity Discount model
3. The Economic Production Quantity model (EPQ)
4. Reorder Point Ordering (uncertainty, when to order)
5. Fixed-Order-Interval model
6. Single Period model (perishable items)

THE INVENTORY CYCLE

Profile of Inventory Level Over Time



TOTAL ANNUAL COST

- Total Cost = Annual Holding Cost + Annual Ordering Cost

$$(TC) = \frac{Q}{2}H + \frac{D}{Q}S$$

$\frac{Q}{2}$: Average number of units in inventory

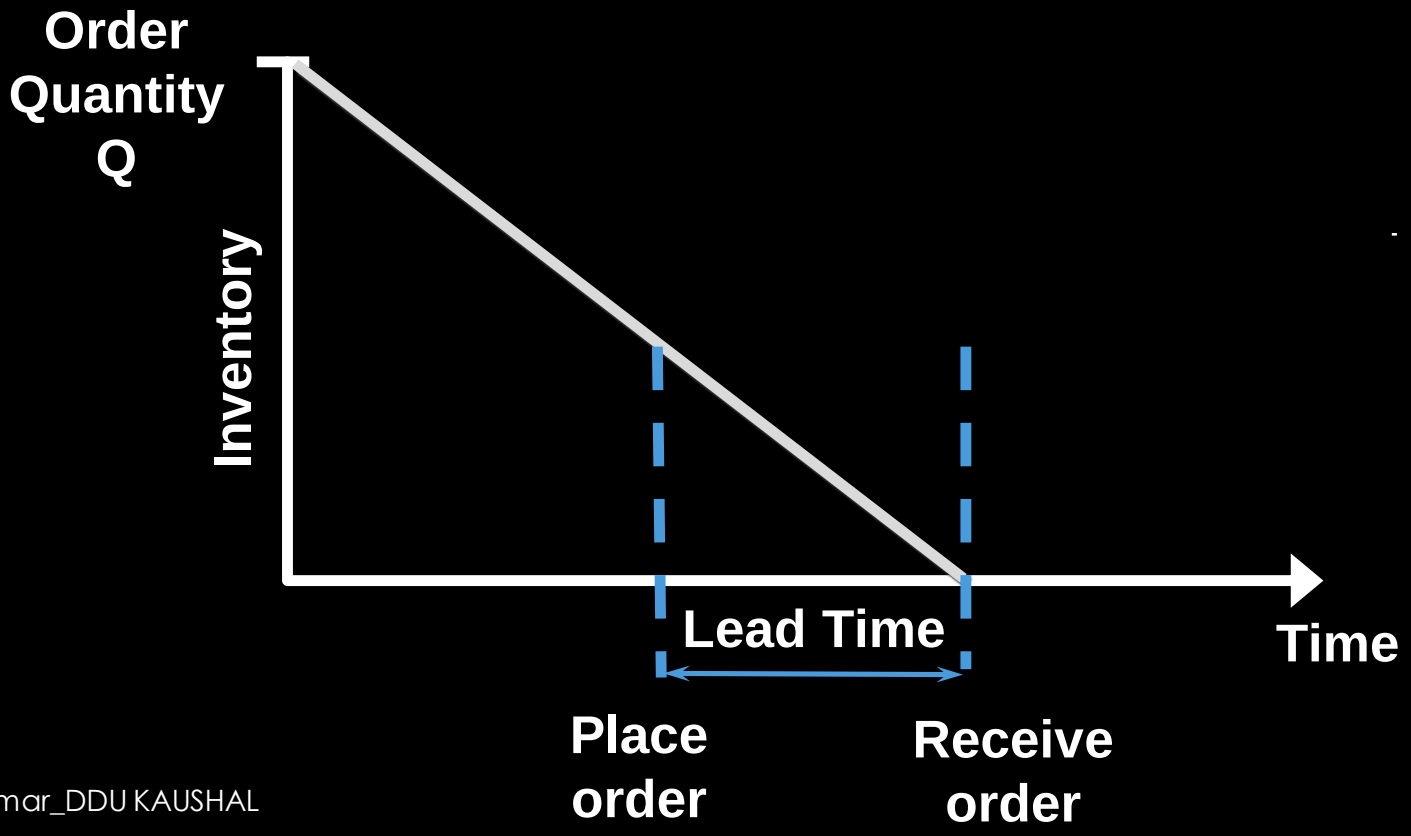
$\frac{D}{Q}$: Number of orders

where

- Q = order quantity in units
- H = holding (carrying) cost per unit, usually per year
- D = demand, usually in units per year
- S = ordering cost per order

WHEN TO REORDER

- If delivery is not instantaneous, but there is a lead time: When to order?



WHEN TO REORDER

- EOQ answers the “how much” question
- The reorder-point (ROP) tells “when” to order

- Reorder-Point
  - When the quantity on hand of an item drops to this amount (quantity-trigger), the item is reordered.

  - Determinants of the Reorder-Point
  1. The rate of demand
  2. The lead time
  3. The extent of demand and/or lead time variability
  4. The degree of stockout risk acceptable to management

REORDER-POINT

ROP = (**Demand per day**) * (**Lead time for a new order in days**)

= **d** * **L**

where

d = (Demand per year) / (Number of working days in a year)

Example:

- Demand = 12,000 iPads per year
- 300 working day year
- Lead time for orders is 3 working days

In other words, the manager should place the order *when* only 120 units left in the inventory.

d = 12,000 / 300 = 40 units

ROP = d * L = 40 units per day * 3 days of leading time = 120 units

THE INVENTORY CYCLE

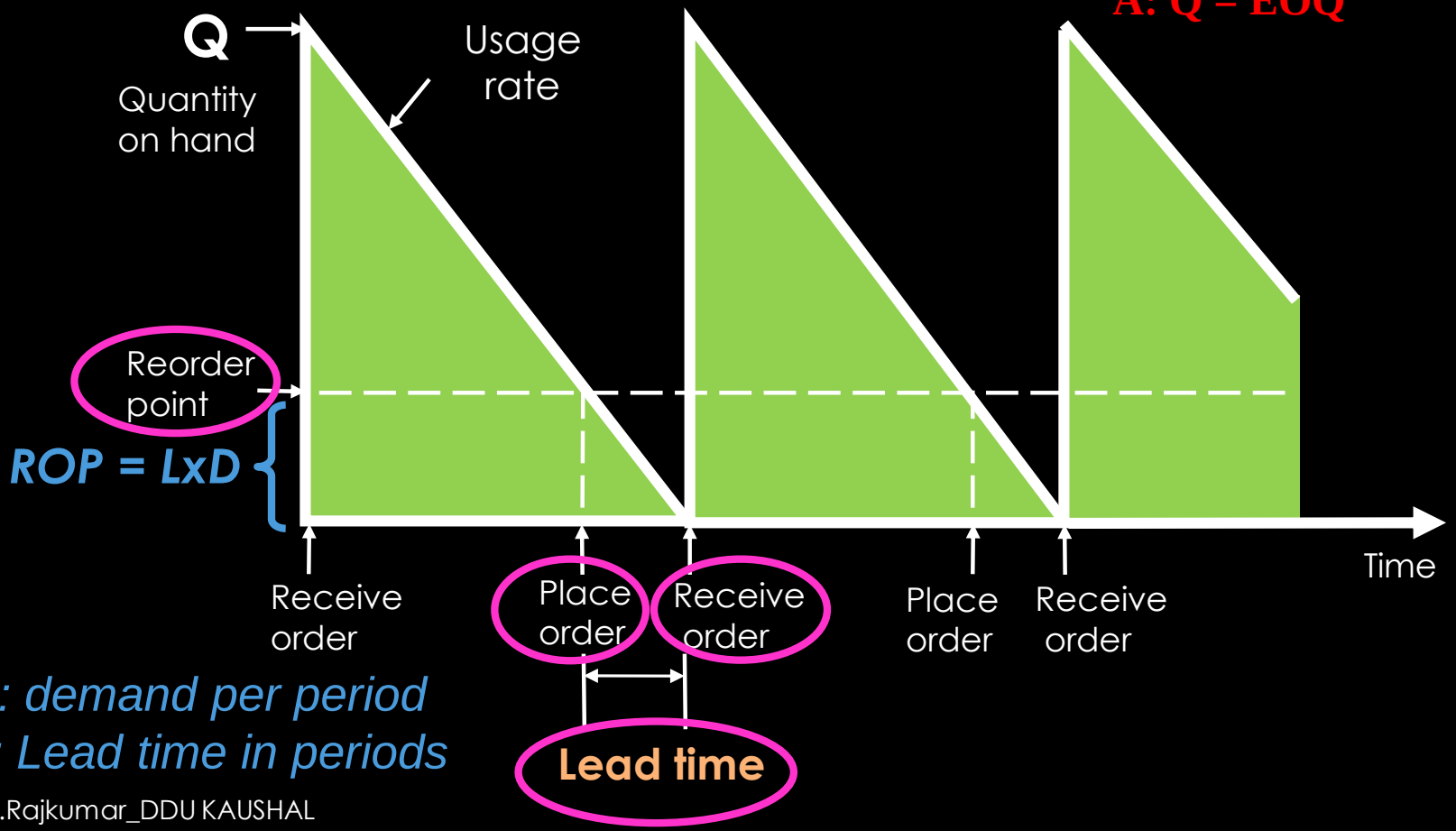
Profile of Inventory Level Over Time

Q: When shall we order?

A: When inventory = ROP

Q: How much shall we order?

A: Q = EOQ

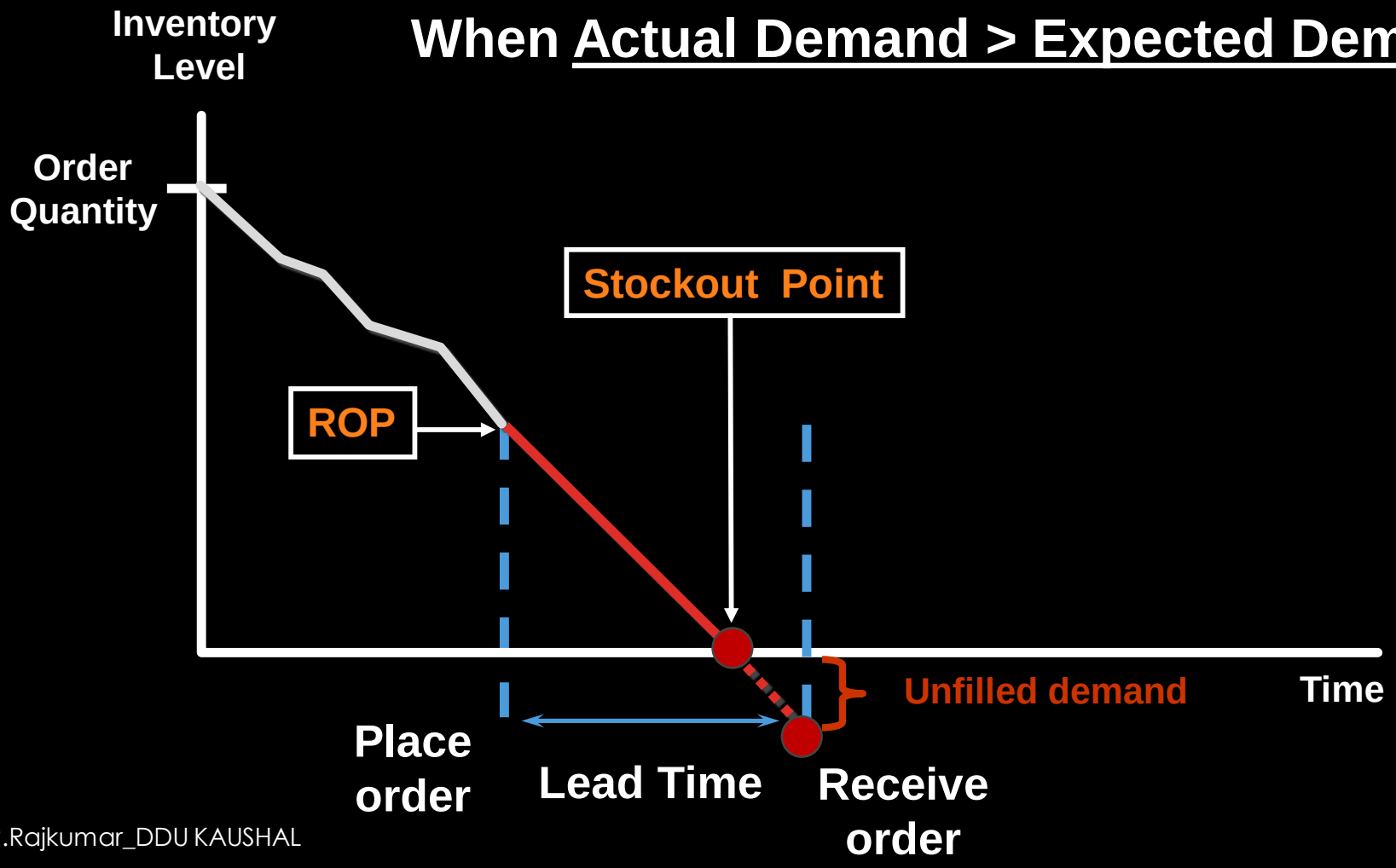


D: demand per period

L: Lead time in periods

BUT DEMAND IS RARELY PREDICTABLE!

When Actual Demand > Expected Demand



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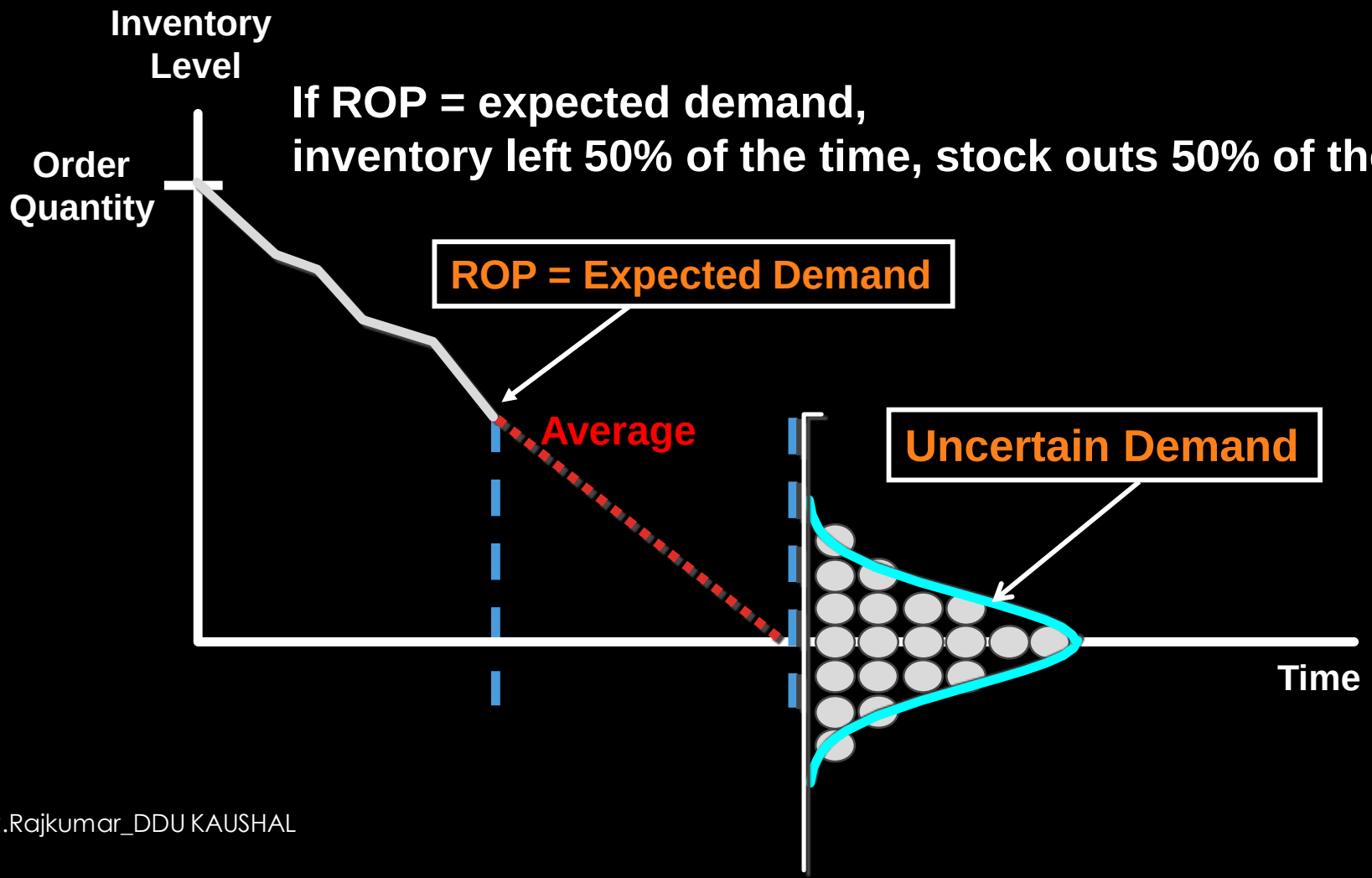
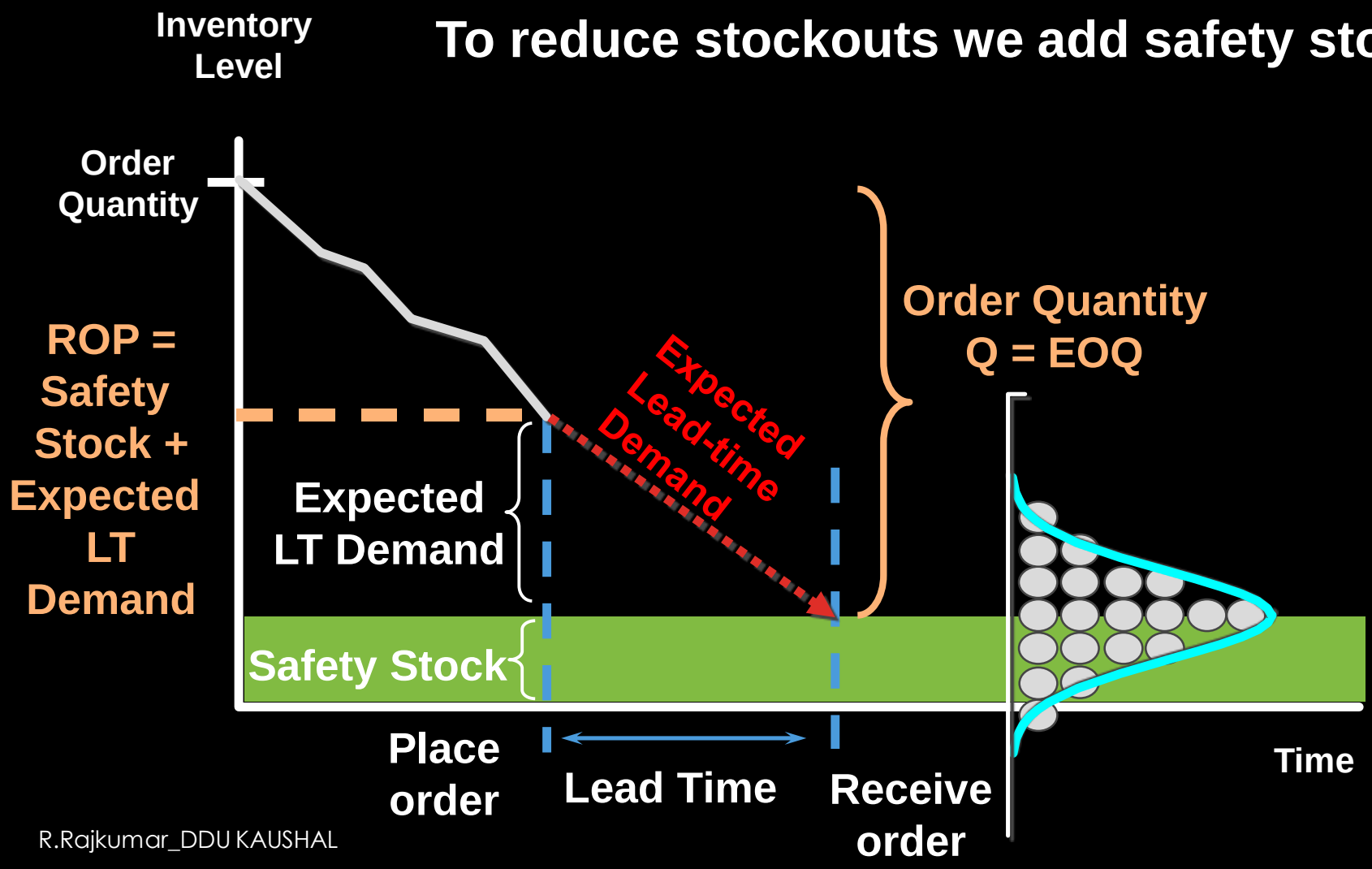


SAFETY STOCK



HOW MUCH SAFETY STOCK?

- The amount of safety stock that is appropriate for a given situation depends upon:
  1. The average demand rate and average lead time
  2. Demand and lead time variability
  3. The desired service level
     - ***Service level = probability of NOT stocking out***

- Reorder point (ROP) =

  Expected demand during lead time + $z*\sigma_{dLT}$

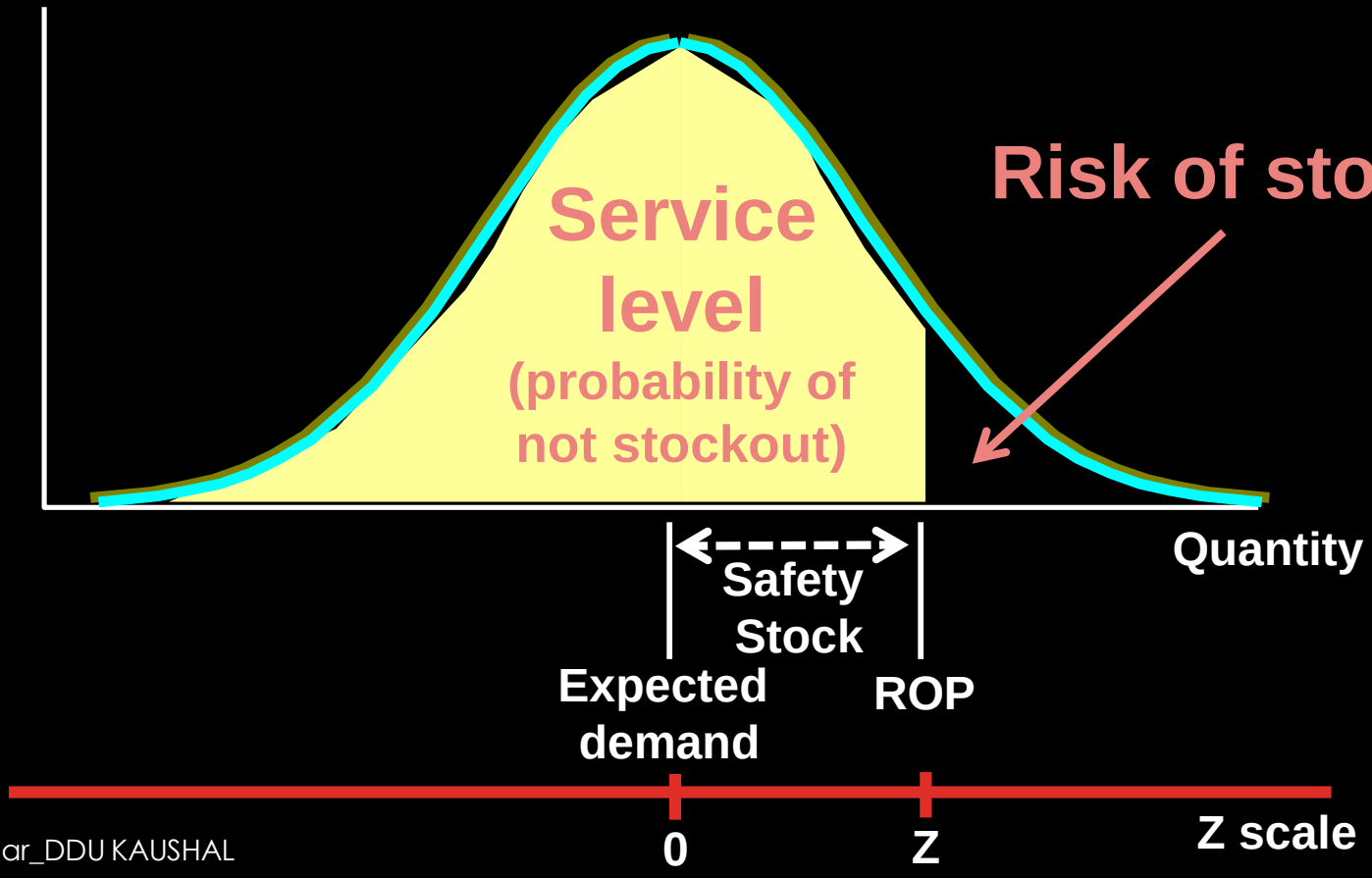
Where

z = number of standard deviations

σ_{dLT} = the standard deviation of lead time demand

REORDER POINT

- The ROP based on a normal distribution of lead time demand



TOYOTA PRODUCTION SYSTEM

- Maximizing production efficiency through the elimination of waste
- The way we make vehicles is defined by the Toyota Production System (TPS). It is an original manufacturing philosophy that aims to eliminate waste and achieve the best possible efficiency – what is often called a “lean” or “just-in-time” system.

TPS IS BASED ON TWO CONCEPTS:

jidoka and just-in-time

- Jidoka, a Japanese term that can be translated as “automation with a human touch” is a method for quickly identifying and correcting any issues that could lead to faulty production.
- Just-in-time is about refining and co-ordinating each production process so that it only produces what is required by the next process in the sequence.

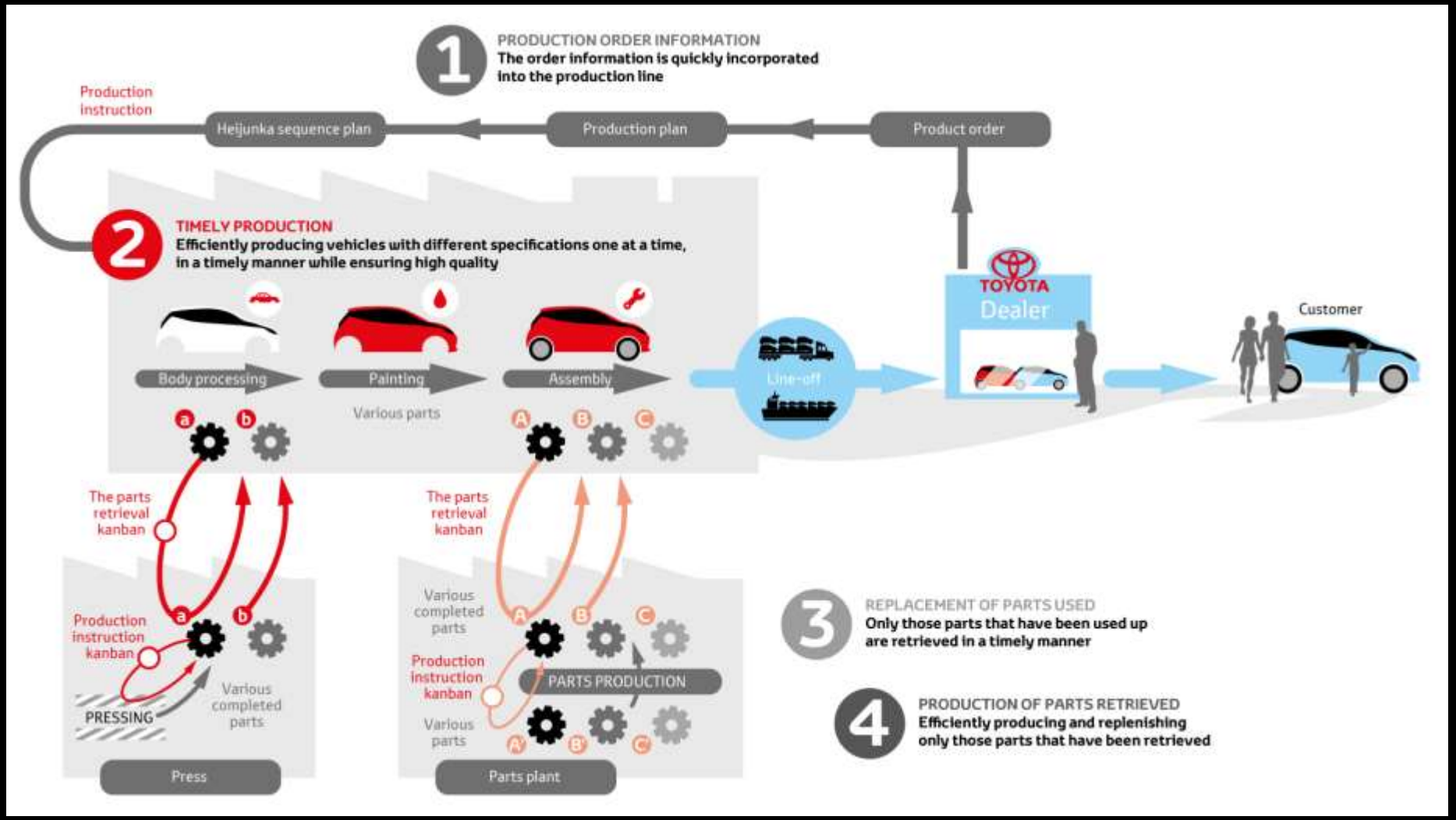
Jidoka

Jidoka is a way of spotting problems and taking prompt action to correct faults at any stage in the production process. Machinery will automatically detect an issue and safely stop so that an inspection and any necessary adjustments can be made. Information is shared with others on the “andon” display board and operators can continue working on other machines. In this way the system helps prevent problems from happening again while maintaining quality and high productivity.

Just-in-time

Just-in-time means making only what is needed, when it is needed, at every stage of production. That means there is no waste, consistent quality and an even production flow. It requires the production line to be stocked with all the right parts, in the right sequence at the moment production begins. As parts are used up, new stock is delivered at the right time, in the right quantity so there is no interruption or slow-down in the production process. The kanban system is central to the just-in-time process, providing an automatic, real-time method to replenish parts at the line side and keep minimal stock.

ILLUSTRATION OF THE TOYOTA PRODUCTION SYSTEM



THANK YOU