CSCP CERTIFIED SUPPLY CHAIN PROFESSIONAL

# MODULE 4: INTERNAL OPERATIONS AND INVENTORY

## SECTION A: PLANNING OPERATIONS

APICS

ASCM

# Section A Introduction

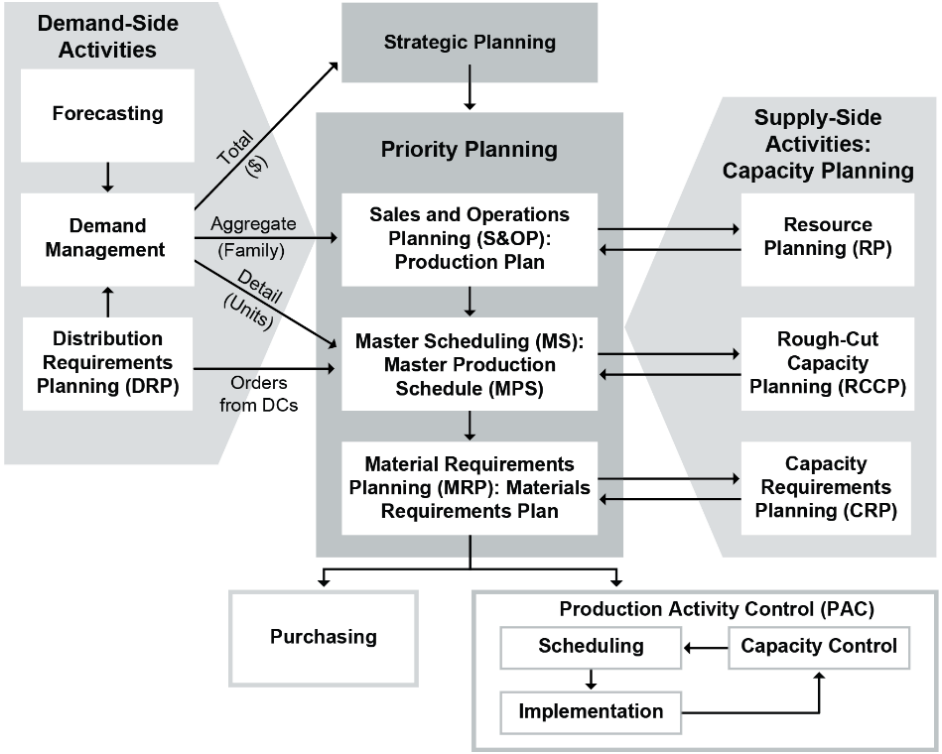
## Section A Key Processes:

- Plan operations.
  - Develop master schedule.
  - Determine material requirements.

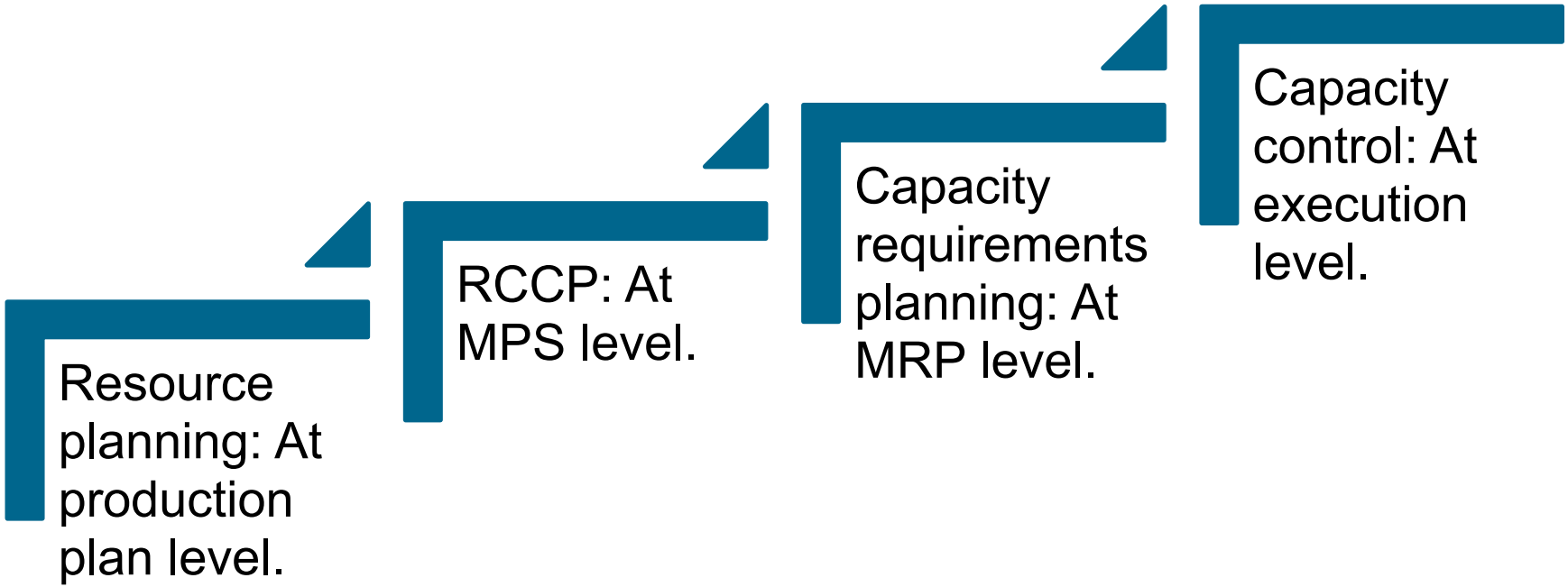
## Section A Topics:

- Make-Versus-Buy, Outsourcing, and Offshoring
- Sourcing Requirements and Total Costs

# Manufacturing Planning and Control



## Stages of Verifying Capacity



# Master Scheduling Grid and Time Fences

| Period | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Forecast | | 20 | 22 | 21 | 25 | 24 | 23 | 21 | 21 | 25 | 25 |
| Customer orders | | 19 | 17 | 15 | 11 | 9 | 5 | 2 | 1 | 0 | 0 |
| Project available balance (PAB) | 50 | 31 | 14 | 49 | 24 | 0 | 27 | 6 | 35 | 10 | 35 |
| Available-to-promise (ATP) | | 14 | | 15 | | | 43 | | 49 | | |
| Master production schedule (MPS) | | | | 50 | | | 50 | | 50 | | 50 |

**Demand Time Fence**

**Planning Time Fence**




Source: APICS Master Planning of Resources, Version 3.1.

# Projected Available Balance (PAB)

PAB Prior to DTF = Prior Period PAB + MPS − Customer Orders
Period 1 PAB = 50 Units + 0 Units − 19 Units = 31 Units

PAB After DTF = Prior Period PAB + MPS − Greater of Forecast or Customer Orders
Period 6 PAB = 0 Units + 50 Units − 23 Units = 27 Units

| | | Frozen Zone | | | Slushy Zone | | | | | Liquid Zone | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Forecast | | 20 | 22 | 21 | 25 | 24 | 23 | 21 | 21 | 25 | 25 |
| Customer orders | | 19 | 17 | 15 | 11 | 9 | 5 | 2 | 1 | 0 | 0 |
| Project available balance (PAB) | 50 | 31 | 14 | 49 | 24 | 0 | 27 | 6 | 35 | 10 | 35 |
| Available-to-promise (ATP) | | | | | | | | | | | |
| Master production schedule (MPS) | | | | 50 | | | 50 | | 50 | | 50 |

**Demand Time Fence**

**Planning Time Fence**




Source: APICS Master Planning of Resources, Version 3.1.

# Available-to-Promise (ATP)

First Period ATP = Inventory + MPS − ∑Customer Orders Before Next MPS
Period 1 ATP = 50 Units + 0 Units − (19 Units + 17 Units) = 14 Units

Following Period ATP = MPS − ∑Customer Orders Before Next MPS
Period 3 ATP = 50 Units − (15 Units + 11 Units + 9 Units) = 15 Units

| | | Frozen Zone | | | Slushy Zone | | | | | Liquid Zone | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Forecast | | 20 | 22 | 21 | 25 | 24 | 23 | 21 | 21 | 25 | 25 |
| Customer orders | | 19 | 17 | 15 | 11 | 9 | 5 | 2 | 1 | 0 | 0 |
| Project available balance (PAB) | 50 | 31 | 14 | 49 | 24 | 0 | 27 | 6 | 35 | 10 | 35 |
| Available-to-promise (ATP) | | 14 | | 15 | | | 43 | | 49 | | 50 |
| Master production schedule (MPS) | | | | 50 | | | 50 | | 50 | | 50 |

Demand Time Fence

Planning Time Fence

Source: APICS Master Planning of Resources, Version 3.1.

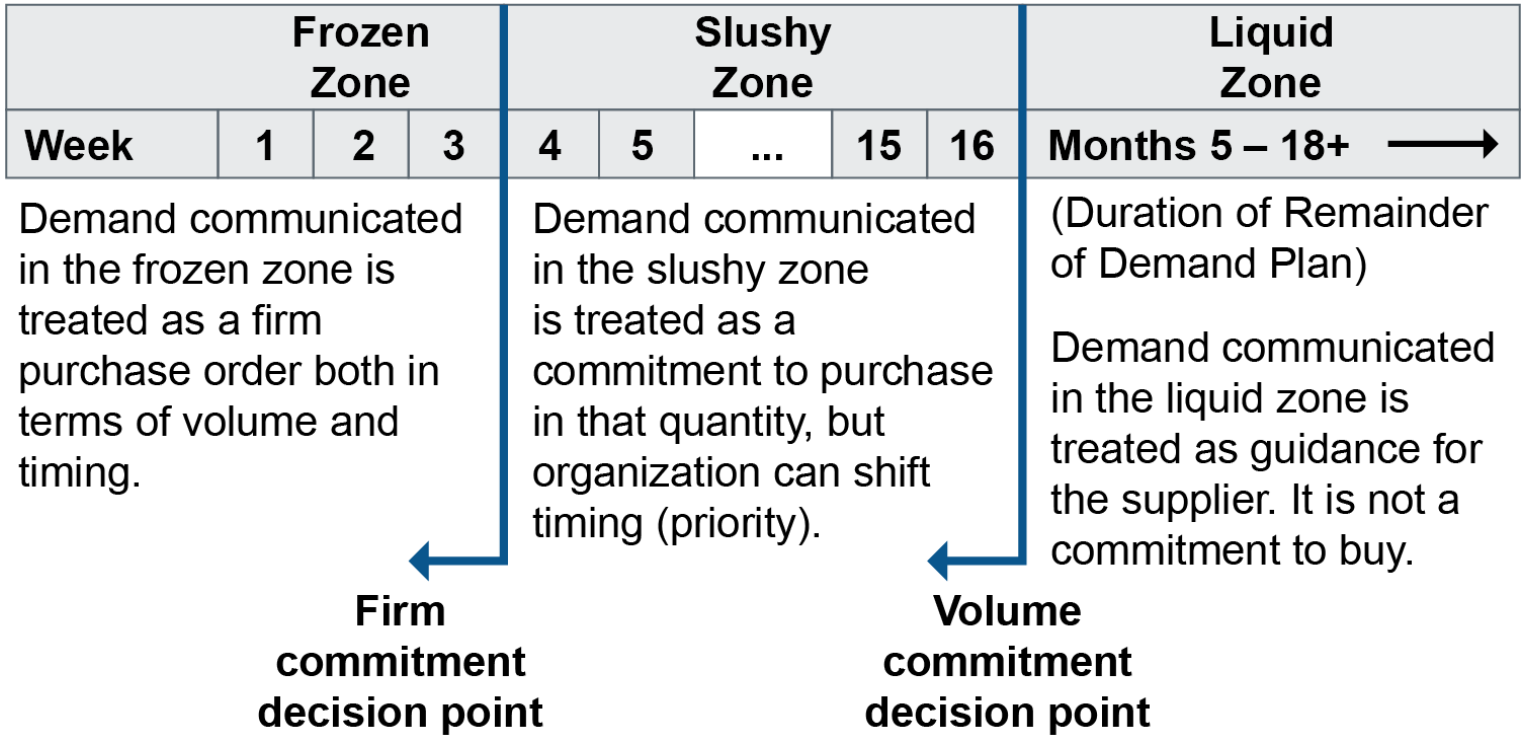
# Purposes of the Master Production Schedule

- Provide sales-operations “contract.”
  - Assure sales force of product availability.
  - Assure operations of sales force commitment.
- Balance supply with demand for:
  - Low inventory costs
  - Fewer stockouts
  - More efficient production.

# Weekly Dates for Specific Products

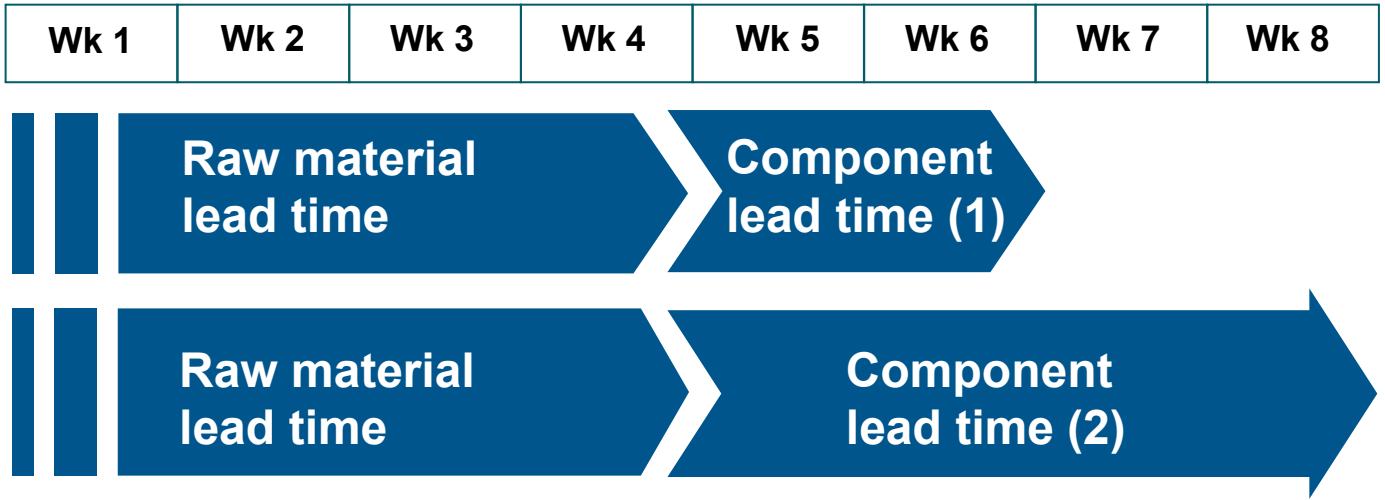
| Months | July | | | | August | | | |
|---|---|---|---|---|---|---|---|---|
| Aggregate production plan (S&OP) | 1,000 | | | | 1,200 | | | |
| **Weeks** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| MPS: Weekly production of specific products | | | | | | | | |
| LX30—30-ppm | 50 | 50 | 50 | 75 | 75 | 75 | 50 | 100 |
| LX21—21-pp | 75 | 25 | 100 | 75 | 100 | 100 | 100 | 100 |
| LX50—15-pp | 50 | 150 | 150 | 150 | 75 | 125 | 150 | 150 |

# Commitment Decision Points



# Planning Horizon

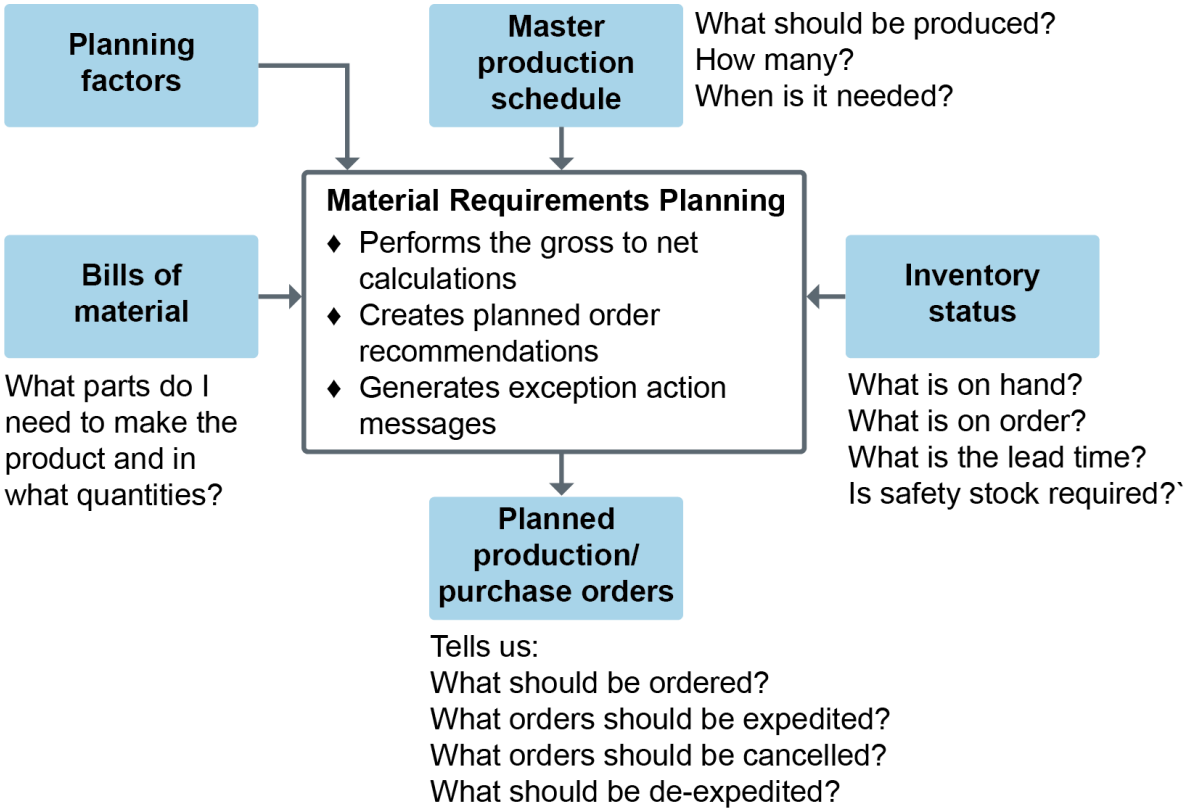
- Amount of time plan extends into future
- At least equal to cumulative lead time for product



## Materials Requirements Planning

- MRP plans production/purchase orders for dependent demand items only.
- Dependent demand doesn’t require estimation, only calculation.
- Some items can have both independent and dependent demand.

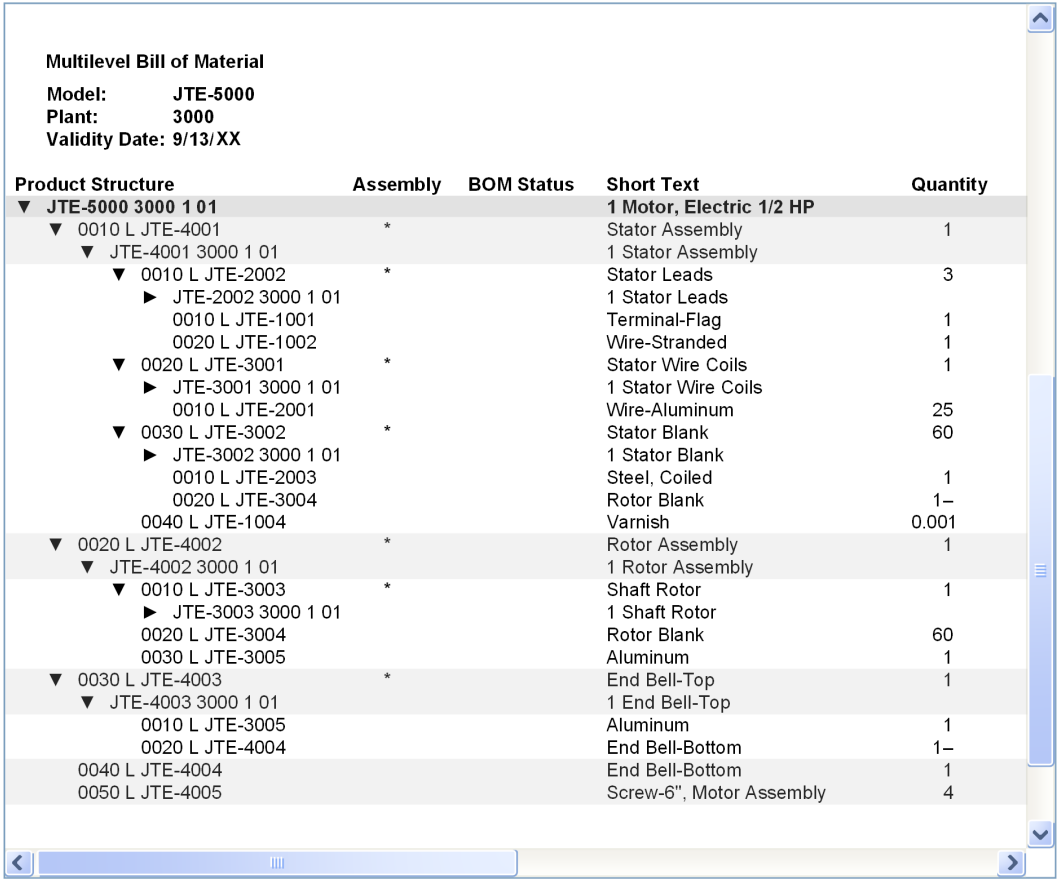
# Materials Requirements Planning



# Materials and Inventory

## Bill of Material

- Complete list of components for a manufactured or assembled item.
- “Explode” multilevel BOMs: expand to drill down into details.
- Modular (planning) BOMs are used for planning modular components.

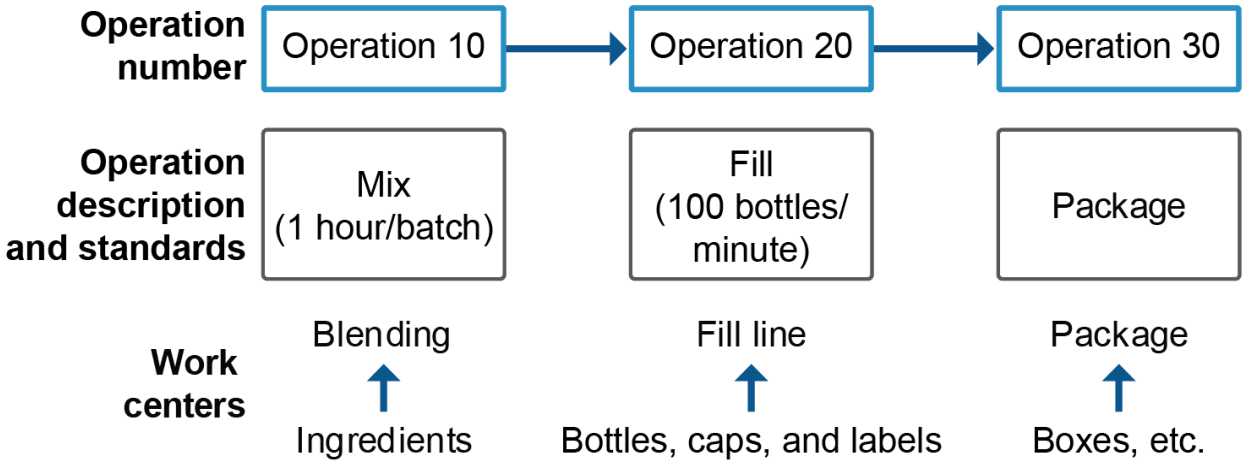


**Multilevel Bill of Material**

**Model:** JTE-5000
**Plant:** 3000
**Validity Date:** 9/13/XX

| Product Structure | Assembly | BOM Status | Short Text | Quantity |
|---|---|---|---|---|
| ▼ JTE-5000 3000 1 01 | | | 1 Motor, Electric 1/2 HP | |
| ▼ 0010 L JTE-4001 | * | | Stator Assembly | 1 |
| ▼ JTE-4001 3000 1 01 | | | 1 Stator Assembly | |
| ▼ 0010 L JTE-2002 | * | | Stator Leads | 3 |
| ► JTE-2002 3000 1 01 | | | 1 Stator Leads | |
| 0010 L JTE-1001 | | | Terminal-Flag | 1 |
| 0020 L JTE-1002 | | | Wire-Stranded | 1 |
| ▼ 0020 L JTE-3001 | * | | Stator Wire Coils | 1 |
| ► JTE-3001 3000 1 01 | | | 1 Stator Wire Coils | |
| 0010 L JTE-2001 | | | Wire-Aluminum | 25 |
| ▼ 0030 L JTE-3002 | * | | Stator Blank | 60 |
| ► JTE-3002 3000 1 01 | | | 1 Stator Blank | |
| 0010 L JTE-2003 | | | Steel, Coiled | 1 |
| 0020 L JTE-3004 | | | Rotor Blank | 1– |
| 0040 L JTE-1004 | | | Varnish | 0.001 |
| ▼ 0020 L JTE-4002 | * | | Rotor Assembly | 1 |
| ▼ JTE-4002 3000 1 01 | | | 1 Rotor Assembly | |
| ▼ 0010 L JTE-3003 | * | | Shaft Rotor | 1 |
| ► JTE-3003 3000 1 01 | | | 1 Shaft Rotor | |
| 0020 L JTE-3004 | | | Rotor Blank | 60 |
| 0030 L JTE-3005 | | | Aluminum | 1 |
| ▼ 0030 L JTE-4003 | * | | End Bell-Top | 1 |
| ▼ JTE-4003 3000 1 01 | | | 1 End Bell-Top | |
| 0010 L JTE-3005 | | | Aluminum | 1 |
| 0020 L JTE-4004 | | | End Bell-Bottom | 1– |
| 0040 L JTE-4004 | | | End Bell-Bottom | 1 |
| 0050 L JTE-4005 | | | Screw-6", Motor Assembly | 4 |

# Routing File



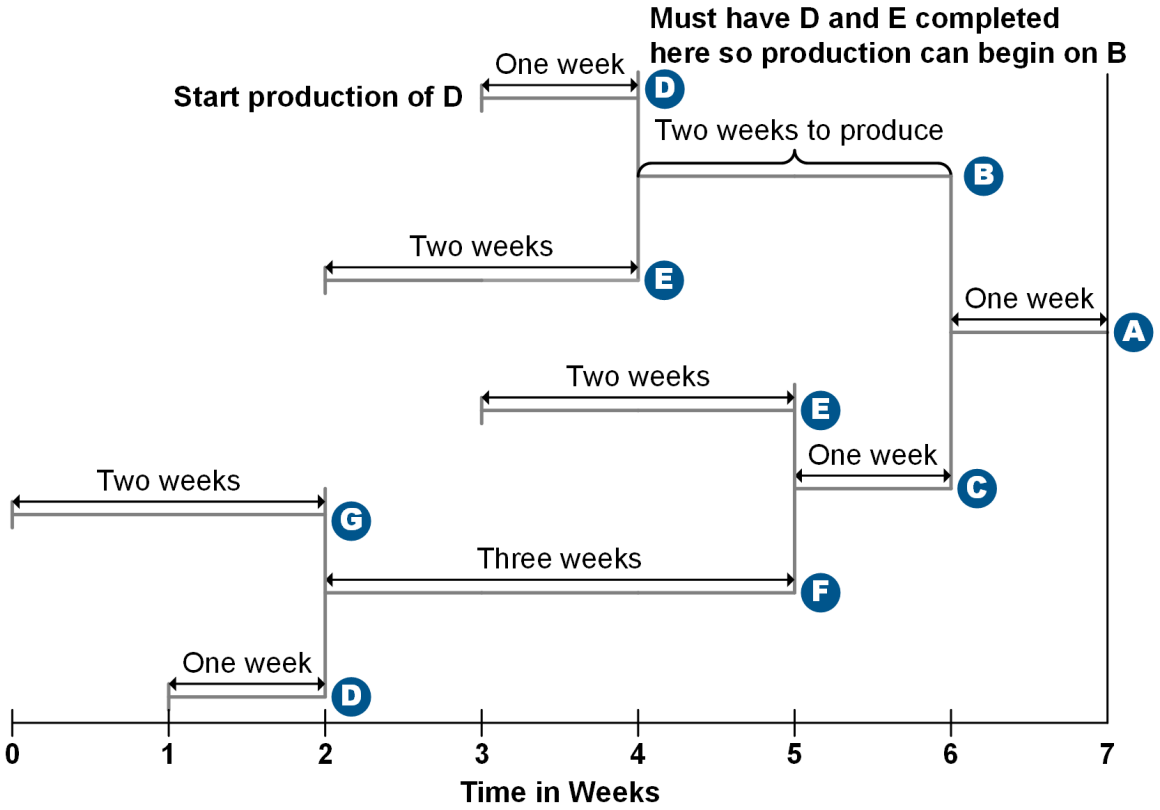

A **routing** for a product shows how it is manufactured in one or more operations. Each operation is identified by a sequence number and a description. The sequence number places the operations in the proper manufacturing sequence. The operations also identify where that process occurs and the standard setup and run times for the product. Tooling and testing requirements can also be included in the routing definition.

# Lot-for-Lot and FOQ Replenishment

- Lot-for-lot
  - Exact number needed for production is number to make/buy
  - Often used for dependent demand items
- Fixed order quantity (FOQ)
  - Used in MRP when operations require fixed batch sizes and order quantities.

| MRP Lot-Sizing Problem: Lot-for-Lot Technique | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Week | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Gross Requirements | | 35 | 30 | 40 | | 10 | 40 | 30 | | 30 | 55 |
| Scheduled Receipts | | | | | | | | | | | |
| Projected Available Balance (PAB) | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Net Requirements | | | 30 | 40 | | 10 | 40 | 30 | | 30 | 55 |
| Planned Order Receipts | | | 30 | 40 | | 10 | 40 | 30 | | 30 | 55 |
| Planned Order Releases | | 30 | 40 | | 10 | 40 | 30 | | 30 | 55 | |

# Offsetting



## Managing MRP

- Avoiding system “nervousness”
  - Net change (not plan regeneration)
  - Time fences (rescheduling only with authorization)
  - Pegging components to end products in bill of material
- Is nervousness a red flag?
- Reconciling JIT/lean with MRP
  - Small bucket or bucketless
  - Balanced flow

# Evolution of MRP Software

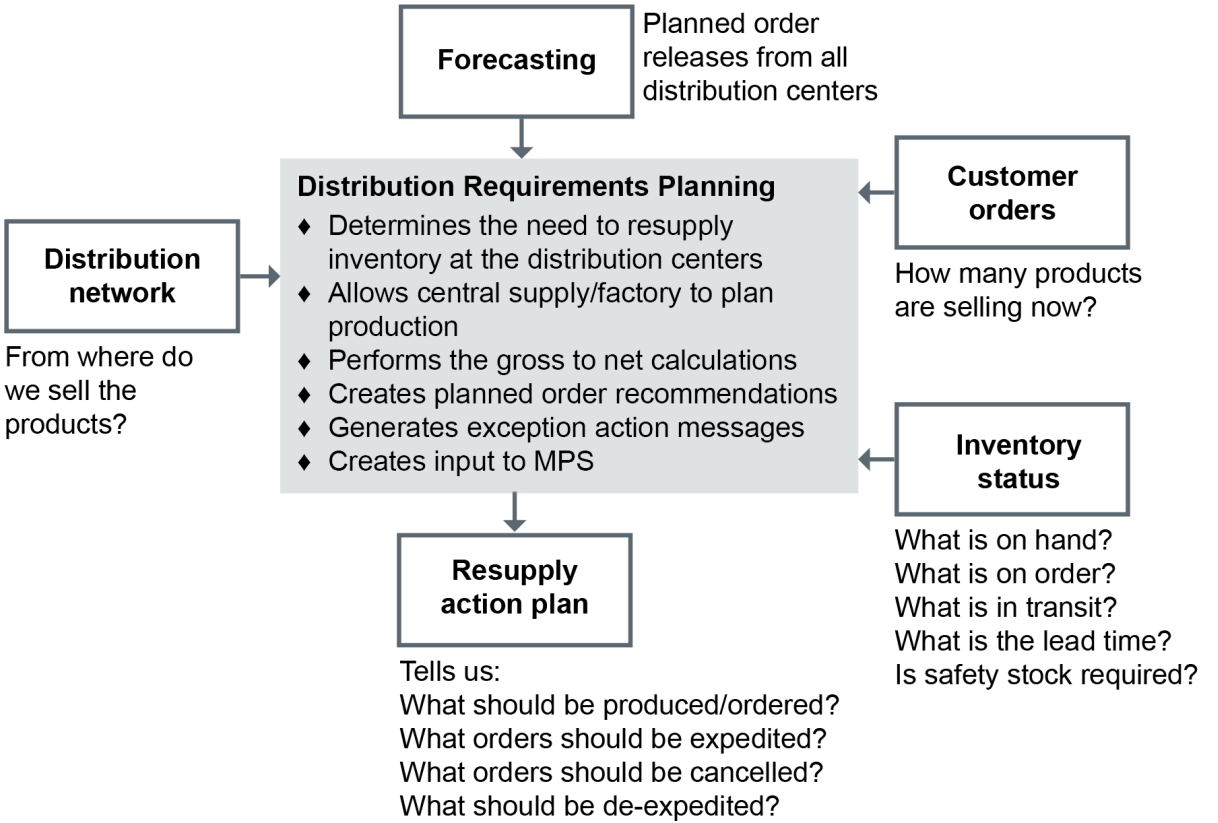
| MRP | Closed-Loop MRP | MRP II (often just called MRP) | DDMRP |
|---|---|---|---|
| • Automates BOM<br>• Improves on-time delivery; frees up time to plan<br>• Assumes infinite capacity—hence, impossible schedules | • Refinement of MRP: provides feedback on capacity available<br>• Tradeoff: installation and training costs | • Includes financials (crosses boundaries)<br>• Makes capacity more visible<br>• Translates detailed information to financial statements<br>• Helps realign with plan | • Priority on what can and will be sold (not made)<br>• Minimize cumulative lead time and cost<br>• Some long-lead time materials held<br>• Strategically placed, continually monitored buffer inventories |

# Distribution Requirements Planning

| Push systems | Hybrid systems (e.g., DRP) | Pull systems |
|---|---|---|
| ▪ Forecasts and schedules centrally coordinated.<br>▪ Drawbacks:<br>– Customers don't determine own orders.<br>– Doesn't account for local conditions. | ▪ Push to given echelon, pull from there, use retail demand data.<br>▪ Benefits:<br>– From push: Coordination and control<br>– From pull: Local demand responsiveness | ▪ Each partner sets own orders.<br>▪ Drawbacks:<br>– Bullwhip effect if partners are not collaborating.<br>– Ignores needs of other SC partners.<br>– Ignores supplier's ability. |

# DRP Components

- DC demand forecasts determine gross requirement
- Safety stock for customer service
- Accurate lead time information
- Distribution system map



# DRP Logic

| DC A: Week | | ~ | 6 | 7 |
|---|---|---|---|---|
| Gross Reqs. | | | | 300 |
| PAB | 170 | | 170 | 270 |
| Net Requirements | | | | 200 |
| Planned Order Receipts | | | | 400 |
| Planned Order Releases | | | 400 | |

| DC B: Week | | ~ | 6 | 7 | 8 |
|---|---|---|---|---|---|
| Gross Reqs. | | | | | 500 |
| PAB | 200 | | 200 | 200 | 200 |
| Net Requirements | | | | | 400 |
| Planned Order Receipts | | | | | 500 |
| Planned Order Releases | | | 500 | | |

| Central Supply: Wk. | | ~ | 3 | ~ | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Gross Reqs. | | | | | | 900 | |
| PAB | 500 | | 500 | | 500 | 200 | 200 |
| Net Requirements | | | | | | 600 | |
| Planned Order Rec. | | | | | | 600 | |
| Planned Order Rel. | | | 600 | | | | |

| MS Grid: Week | ~ | 2 | 3 | 4 |
|---|---|---|---|---|
| Gross Reqs. | | | 600 | |
| PAB | | 0 | 200 | 200 |
| MPS | | | 800 | |

| | Lot Size | Lead | SS |
|---|---|---|---|
| DC A | 400 | 1 wk | 70 |
| DC B | 500 | 2 wks | 100 |
| Central | 600 | 3 wks | 200 |
| MS Grid | 800 | n/a | n/a |

Source: APICS CPIM Basics of Supply Chain Management.

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# SECTION B: CAPACITY AND PRODUCTION ACTIVITY CONTROL

APICS

ASCM

# Section B Introduction

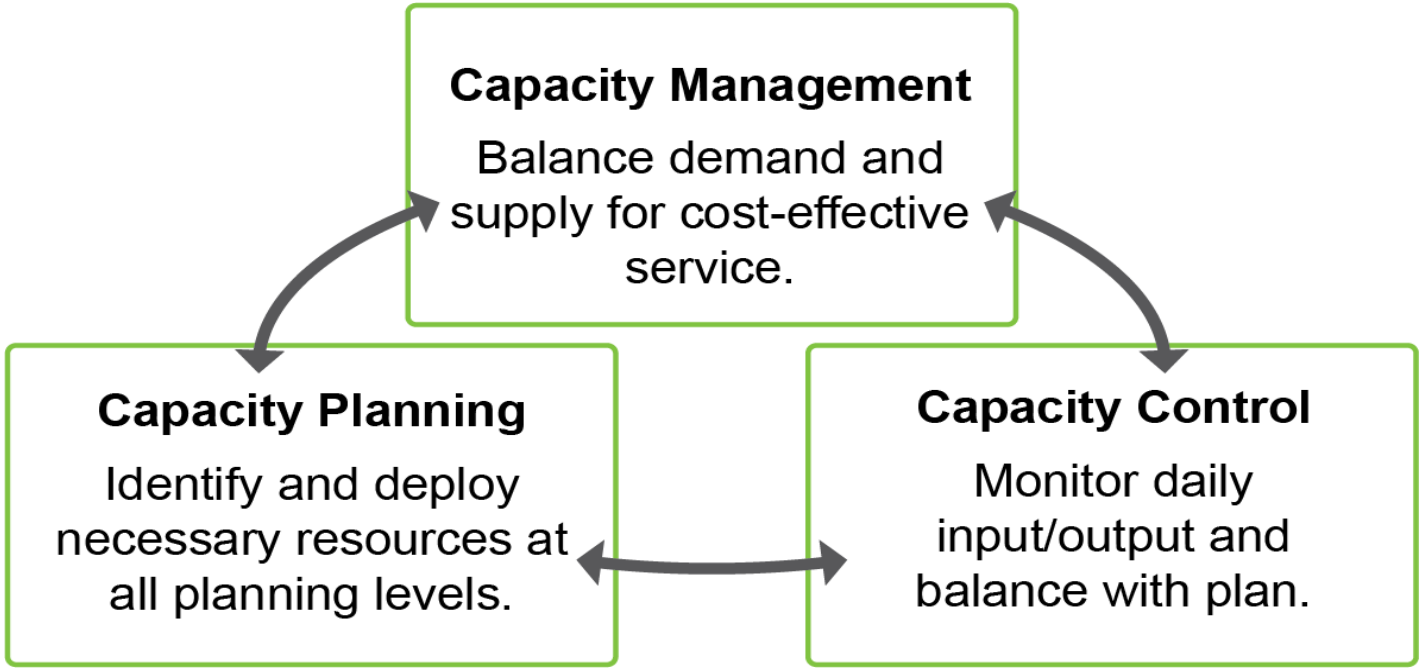
**Section B Key Process:**

- Evaluate capacity requirements.

**Section B Topics:**

- Capacity
- Production Activity Control

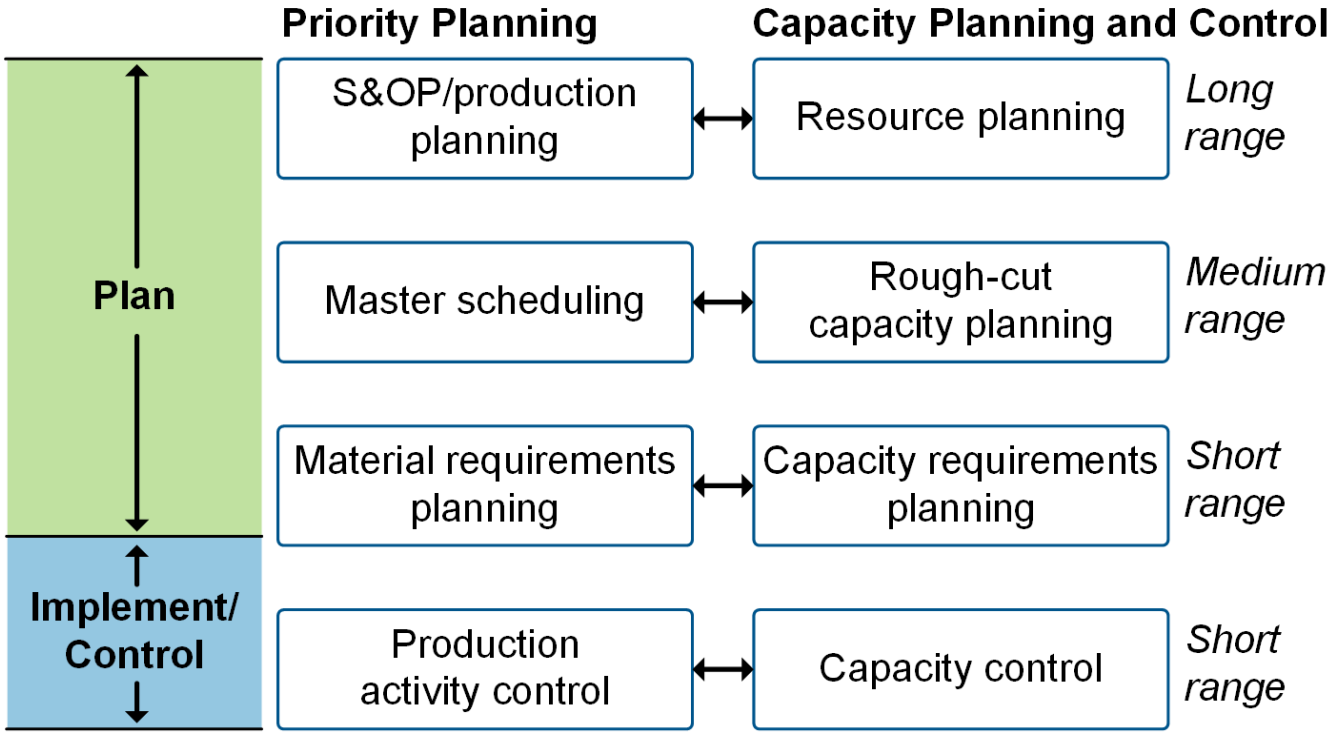
# Capacity Management, Planning, and Control



## Capacity Objectives

| Too much | Just right | Too little |
| --- | --- | --- |
| • Supply > demand<br>• Layoffs, idle machines, unused storage<br>• Excess inventory | • On-time fulfillment<br>• Quality items<br>• Optimal use of resources | • Demand > supply<br>• Stockouts, broken orders, overtime, temps, work shifts, etc. |

# Planning Horizons



# Resource Planning

This long-term plan may specify certain long-term capacity goals requiring capital investments.

**Business plan**

**Production plan**

This is the long-range production plan in terms of product families. It was created through the S&OP process.

**Resource profile**

For each product family, it identifies the amount of the resource required to make one unit of the average product family.

**Resource Planning**

This is the long-range capacity planning process. It calculates the load that will be placed on the resource, which needs to be compared to the capacity for the following key resources:

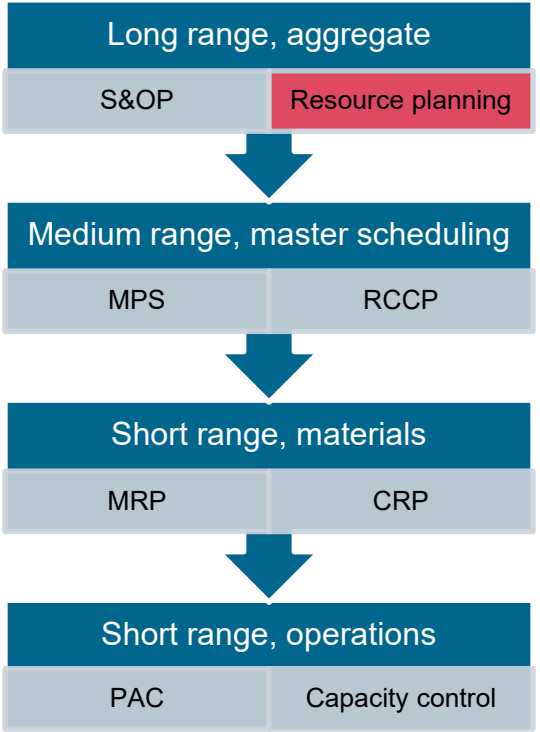
- Plant
- Equipment
- Workforce

**Critical resources**

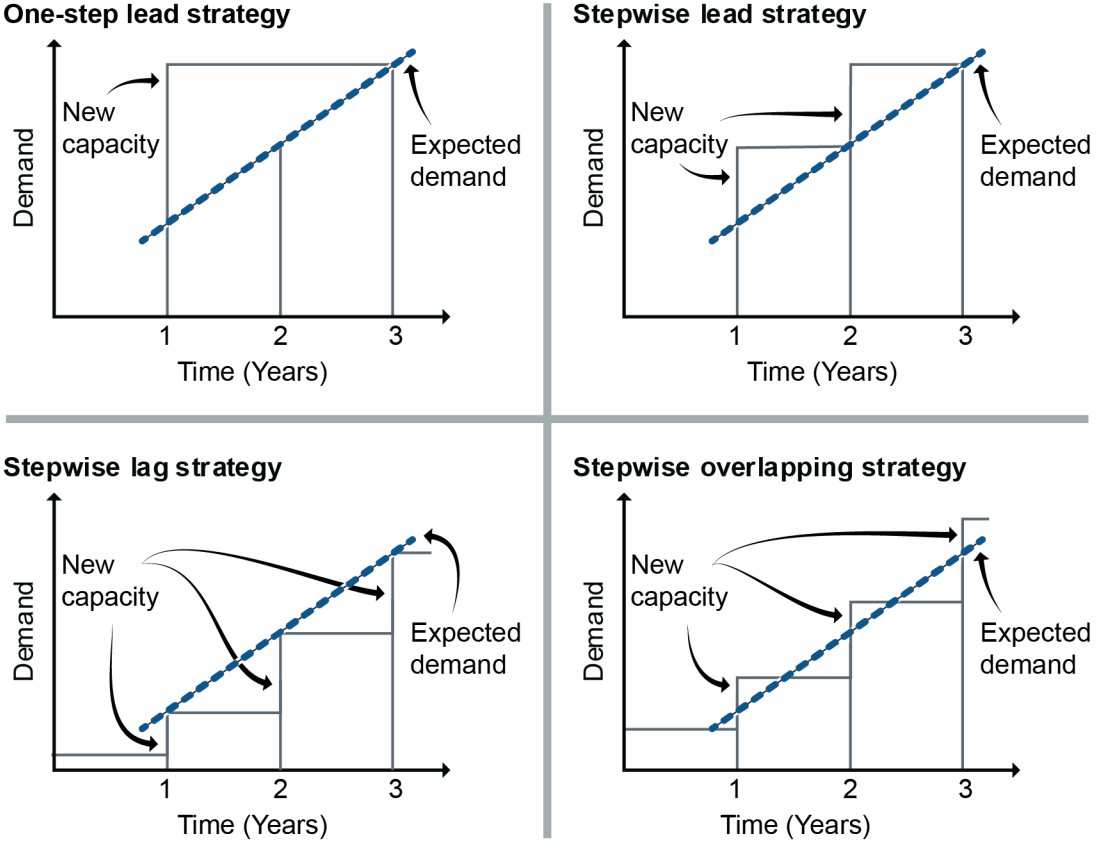
These are the bottlenecks that are currently restricting overall capacity at the product family level.

**Action plan**

The resource plan is evaluated against the available resources. When bottlenecks are identified, an action plan has to be put in place, i.e., modify the production plan or plan for the availability of additional resources, etc.



# Four Ways to Stage Capacity Growth



# Rough-Cut Capacity Planning

**Preliminary master production schedule**

The master scheduling software creates this proposed item-level schedule of production based on product demand and inventory balances.

**Bill of resources**

For each end item, it identifies the key raw materials for critical resources based on the resources required to make one unit of the specific models or types of end items.

**Rough-Cut Capacity Planning**

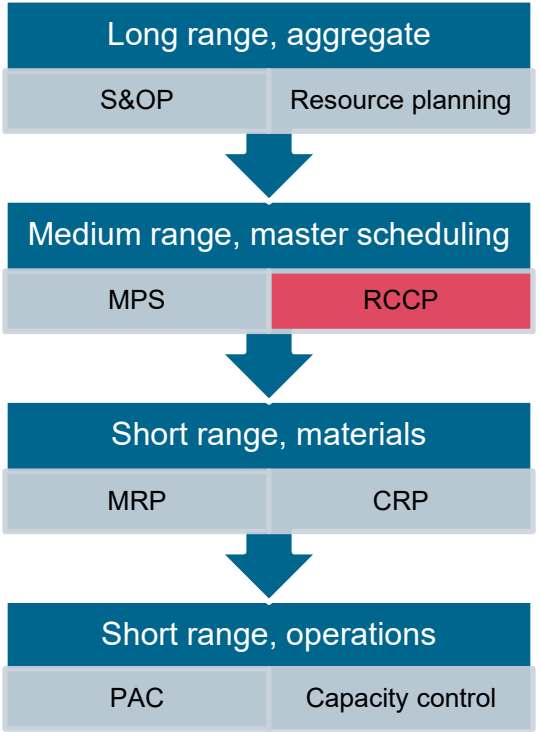
This is the mid-range capacity planning process. It validates critical resource (bottleneck) availability for the MPS.

**Critical resources**

These are the bottleneck operations, labor, or critical materials that are currently restricting overall capacity at the item level.

**Master production schedule**

If sufficient capacity is available in bottlenecks, the MPS is considered workable. If not, the master scheduler explores ways to increase capacity (e.g., overtime, use of alternate work centers, contracting out work). If these are not possible/ economical, the master scheduler will revise the MPS to be feasible.

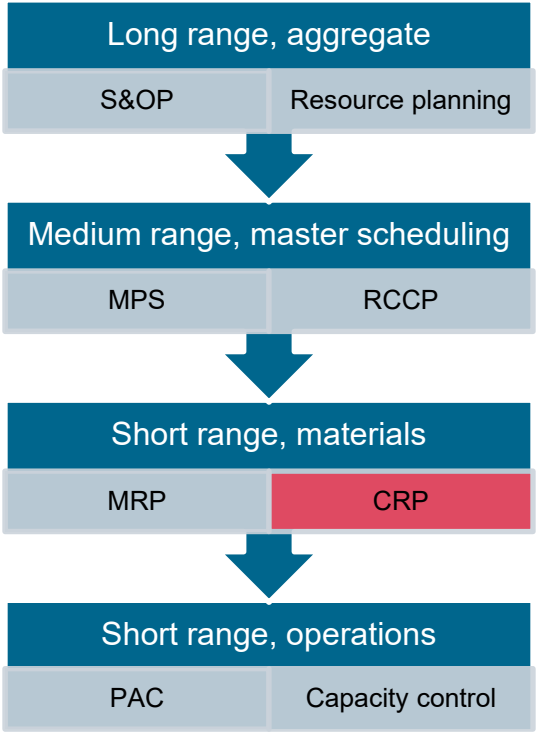


## Rough-Cut Capacity Planning

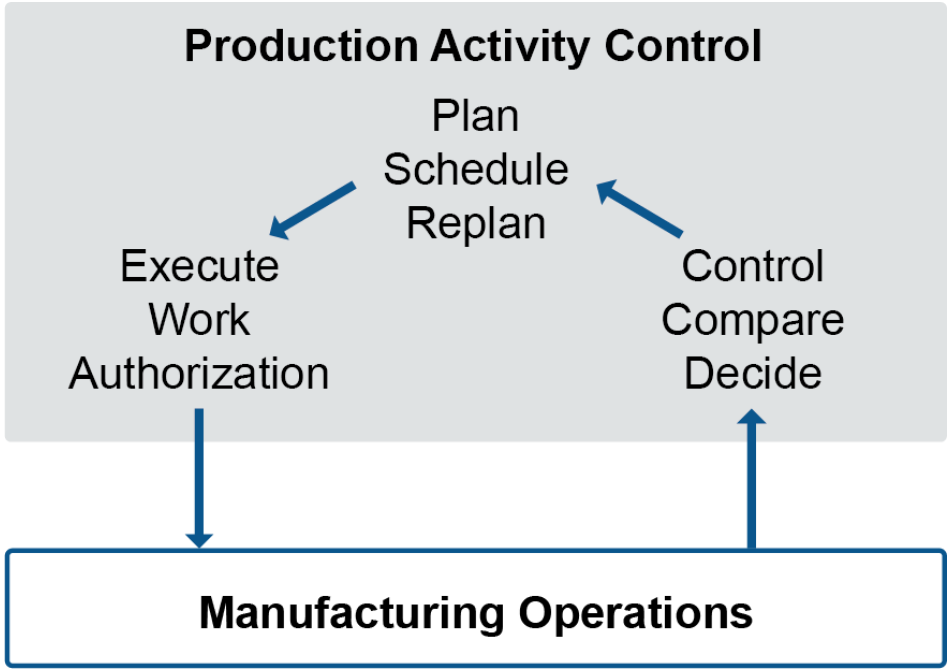
- Process of converting MPS into key resource requirements
- Comparison of load vs. available or demonstrated capacity for each key resource
- Medium-term
- Bottlenecks, gateway work centers, critical suppliers only

# Capacity Requirements Planning (CRP)

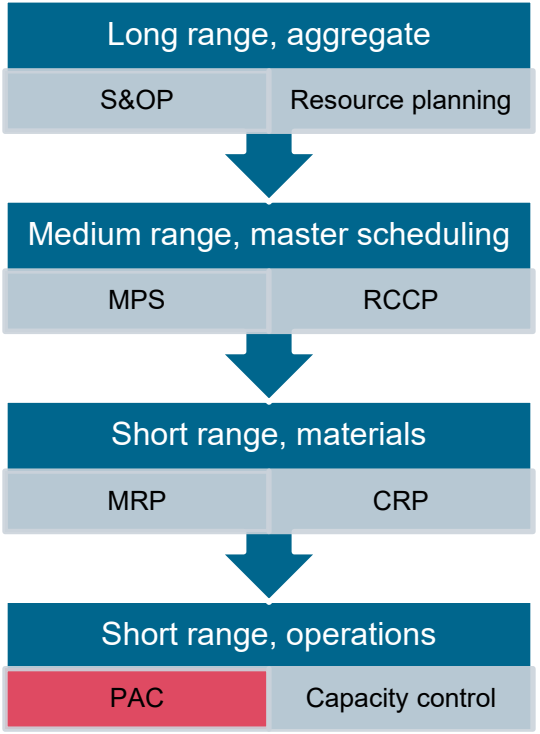
- CRP takes place at level of MRP.
- Assigns each facility, work center, and operation a load and does load leveling.
- Steps to determine site capacity:
  - Check open order file.
  - Check planned order releases.
  - Check routing file.
  - Check work center file.
- Output: adjustment of load or capacity (or both) to meet plan, as required.



# Production Activity Control (PAC)




Source: CPIM Workbook.

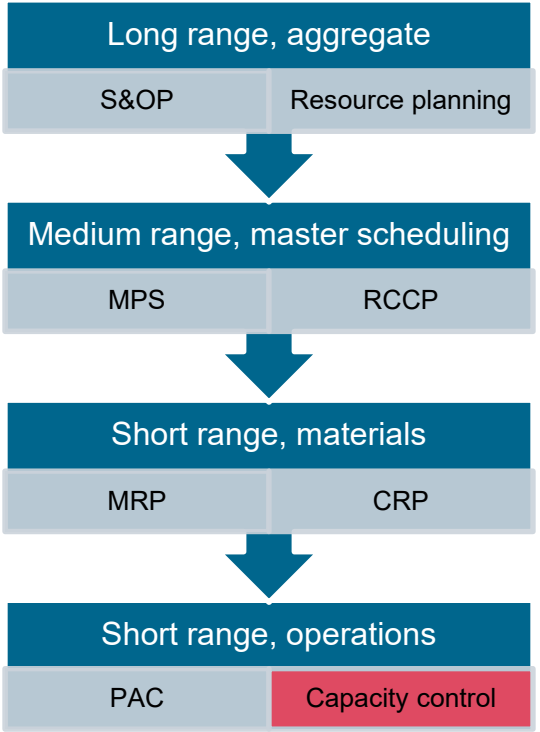


## Measuring Capacity

- Available Time = Hours of Operation × Number of Workers or Equipment
- $\text{Utilization} = \frac{\text{Hours Worked}}{\text{Available Hours}} \times 100$
- $\text{Efficiency} = \frac{\text{Standard Hours of Work}}{\text{Hours Worked}} \times 100$
- Rated Capacity = Available Time × Utilization × Efficiency
- $\text{Demonstrated Capacity} = \frac{\text{Output for } n \text{ Periods}}{n}$

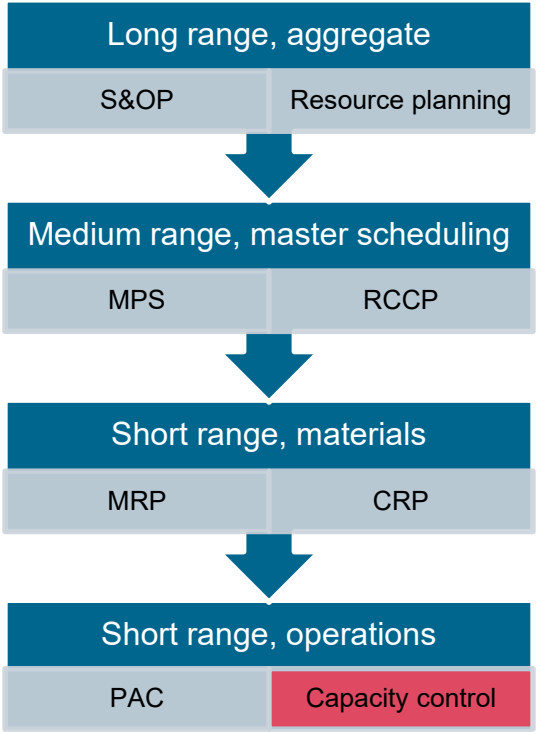
# When Load and Capacity Are Out of Balance

- Change capacity to match load:
  - Add or reduce work hours.
  - Hire or lay off workers.
  - Shift workers to understaffed sites.
  - Change routings.
  - Hire subcontractors or temporary workers.
- Change load to match capacity:
  - Change lot sizes or schedule.



# Continuous Improvement of PAC

- Concentrate on constraints.
- Use visual signals.
- Develop pull partnerships.
- Learn to be lean.



# CSCP

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# SECTION C: INVENTORY

APICS

ASCM

# Section C Introduction

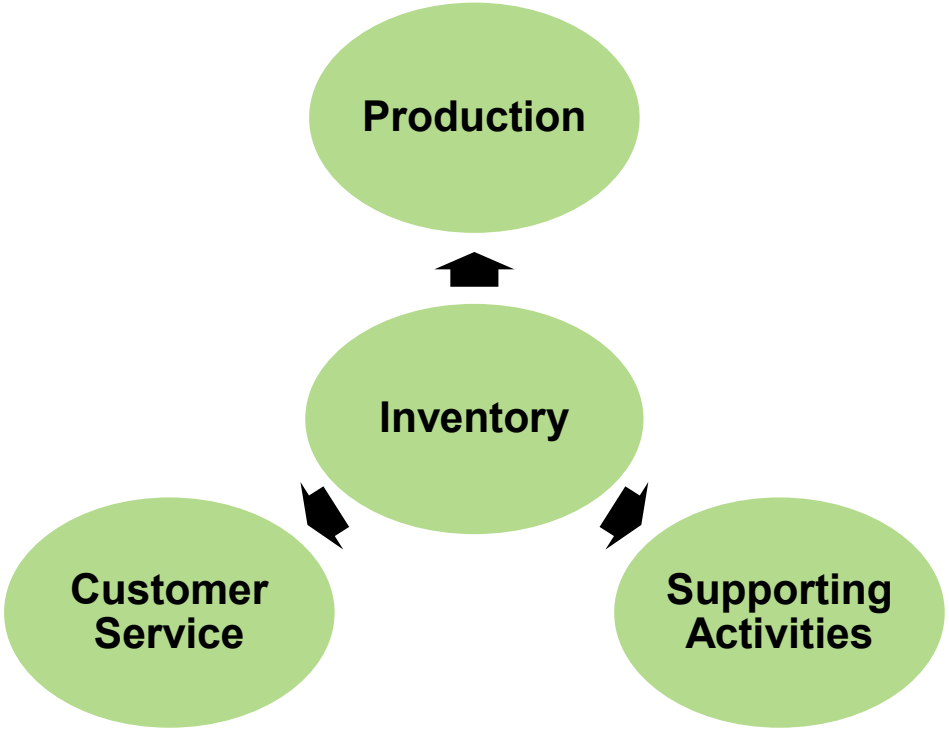
## Section C Key Processes:

- Manage inventory.
  - Align inventory requirements with demand.
  - Manage MRO supplies.
  - Develop replenishment strategy.
  - Manage product traceability and chain of custody.
  - Define and execute physical inventory and cycle counting.
  - Manage product disposition and obsolescence.

## Section C Topics:

- Inventory
- Replenishment Strategies
- Traceability, Accuracy, and Disposition

# The Need for Inventory




- Production
  - Raw materials
  - Work-in-process items
- Customer service
  - Finished goods
  - Spare parts
- Supporting activities
  - Maintenance
  - Repair
  - Operating supplies

# Types of Inventory

**1)** Raw materials

**2)** Work-in-process (WIP)

**3)** Finished goods (FG

Raw materials supplier → Component supplier → Manufacturer → Distributor → End customer

**4)** MRO

**5)** In-transit

## Why Have Inventory?

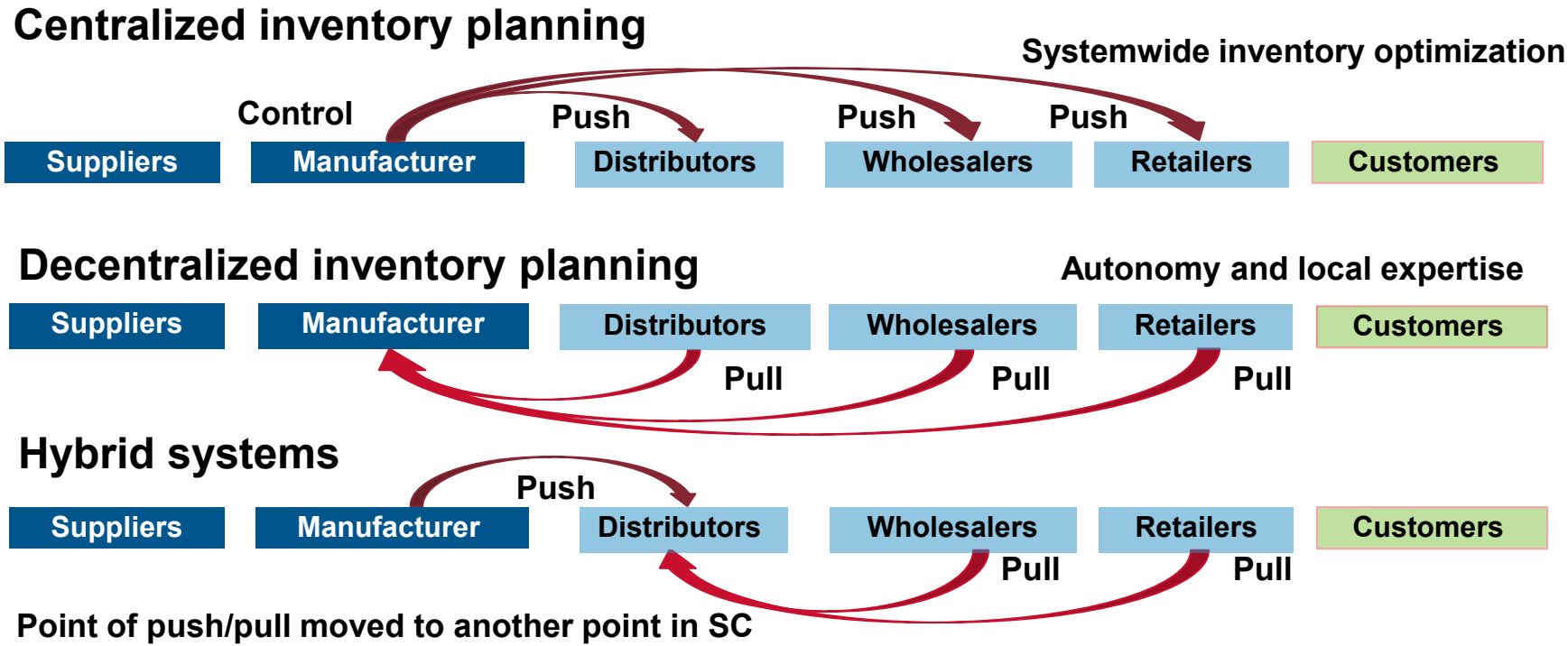
| | |
|---|---|
| Inventory Functions | Cycle stock/lot size inventory |
| | Anticipation inventory |
| | Buffer inventory |
| | Safety stock |
| | Hedge inventory |
| | Decoupling |

# Inventory Costs

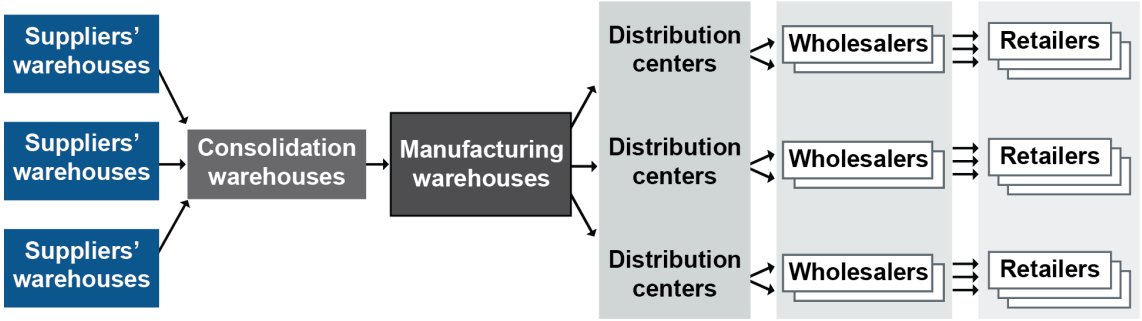
- Acquisition costs: order quantity × unit cost
- Landed costs: product cost plus logistics costs
- Carrying (holding) costs: storage, capital, and risk costs

- Storage costs
  - Rent, equipment leases, depreciation
  - Operating costs, material-handling expenses, power
  - Taxes
- Capital costs
  - Interest, financing, payments to creditors and investors
- Risk costs
  - Insurance, inventory value reductions, write-offs

# Inventory Planning



# Echelons and Echelon Inventory




- Echelons
  - Add costs.
  - Are a buffer for later echelons.
  - May provide consolidation or break-bulk to reduce total inventory/costs.
- Echelon inventory aggregates demand for more accurate order calculation.
  - Inventory at a node = all inventory at that echelon + all inventory at later SC points + in transit

## Inventory Management Roles

Purchasing and materials management: adequate raw materials at low inventory cost

Manufacturing and finance: efficient and low-cost production balanced against low inventory cost

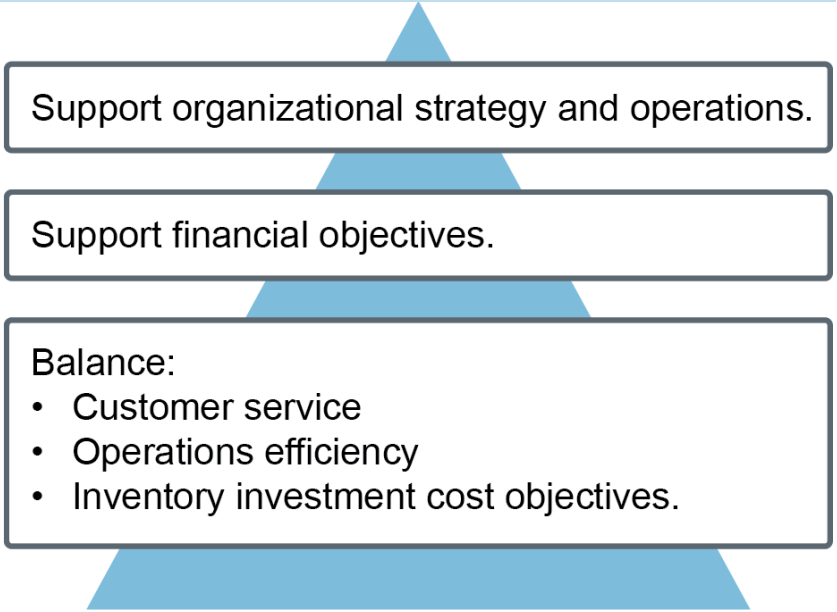
Sales and marketing: sufficient inventory to meet customer delivery requests and service levels

# Factors Influencing Inventory Policies

| | | |
|---|---|---|
| Customer demand | Planning horizon | Replenishment lead time |
| Product variety | Inventory costs | Customer service requirements |

# Aggregate Inventory Management

## Aggregate Inventory Management Objectives

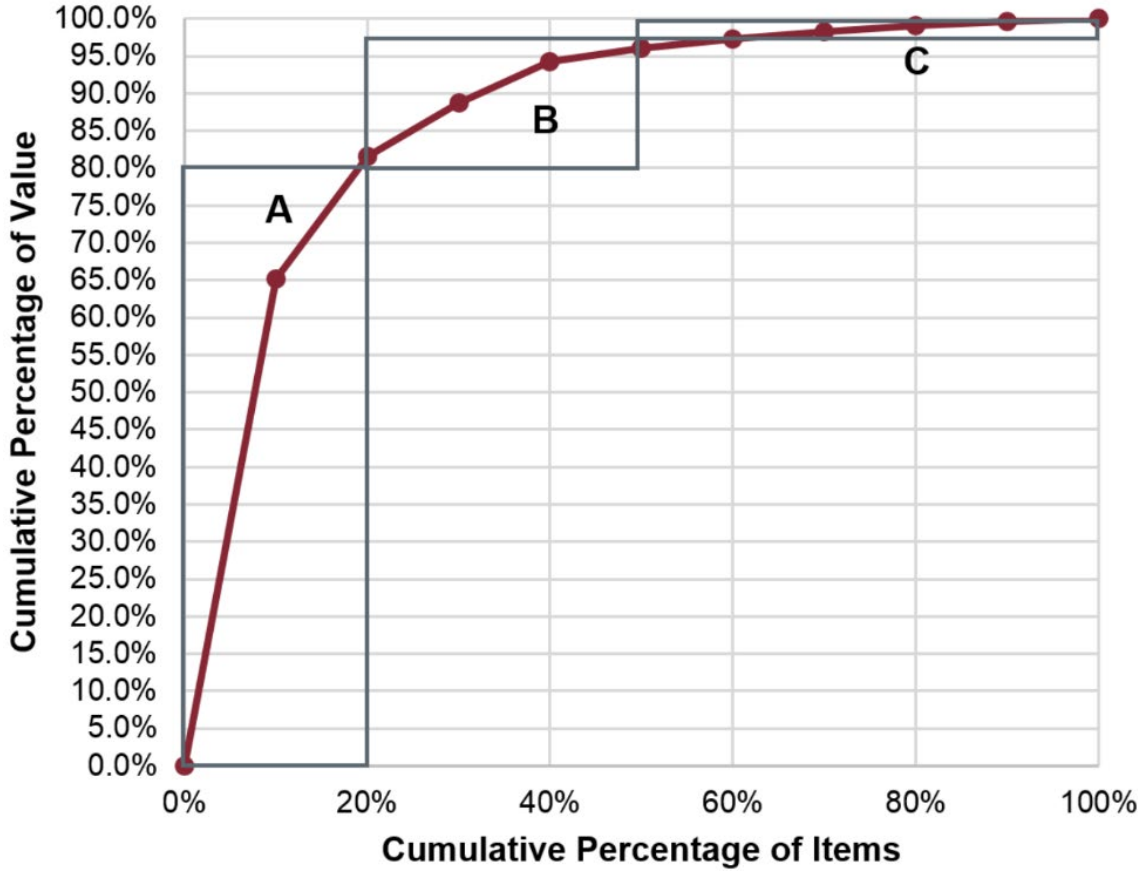



## Ways to Aggregate Inventory

- Demand pattern
- Production process
- Stage of production flow
- Relative value to organization
- Product or SKU family or type
- Distribution pattern

# ABC Inventory Classification: Pareto Analysis

- A: Better treatment, tighter controls
- B: Moderate treatment and control
- C: Looser controls, may not get safety stock



## Item Inventory Management

- Goal is to enable planners to translate strategic inventory goals into measurable results (proper production and distribution of each SKU).
- Inventory rules
  - When to order inventory
  - How to determine order size per order
  - Relative importance of each inventory item
  - Inventory control procedures for individual items

# Effects of Inventory on Financial Statements

| Balance Sheet | Income Statement | Cash Flows |
|---|---|---|
| ▪ Unsold inventory is current asset.<br>▪ Only profit margin portion contributes to net income when sold.<br>▪ Can determine average inventory from balance sheet. | ▪ COGS: Product expenses booked when units sold.<br>▪ Operating expenses: Period expenses booked when incurred.<br>▪ Reducing costs is more effective than increasing sales volume. | ▪ Decrease in inventory increases cash position.<br>▪ Inventory write-offs reduce owners' equity and may require reducing debts to maintain covenants. |

# Balance Sheet for Two Years (Assets)

What the organization owns

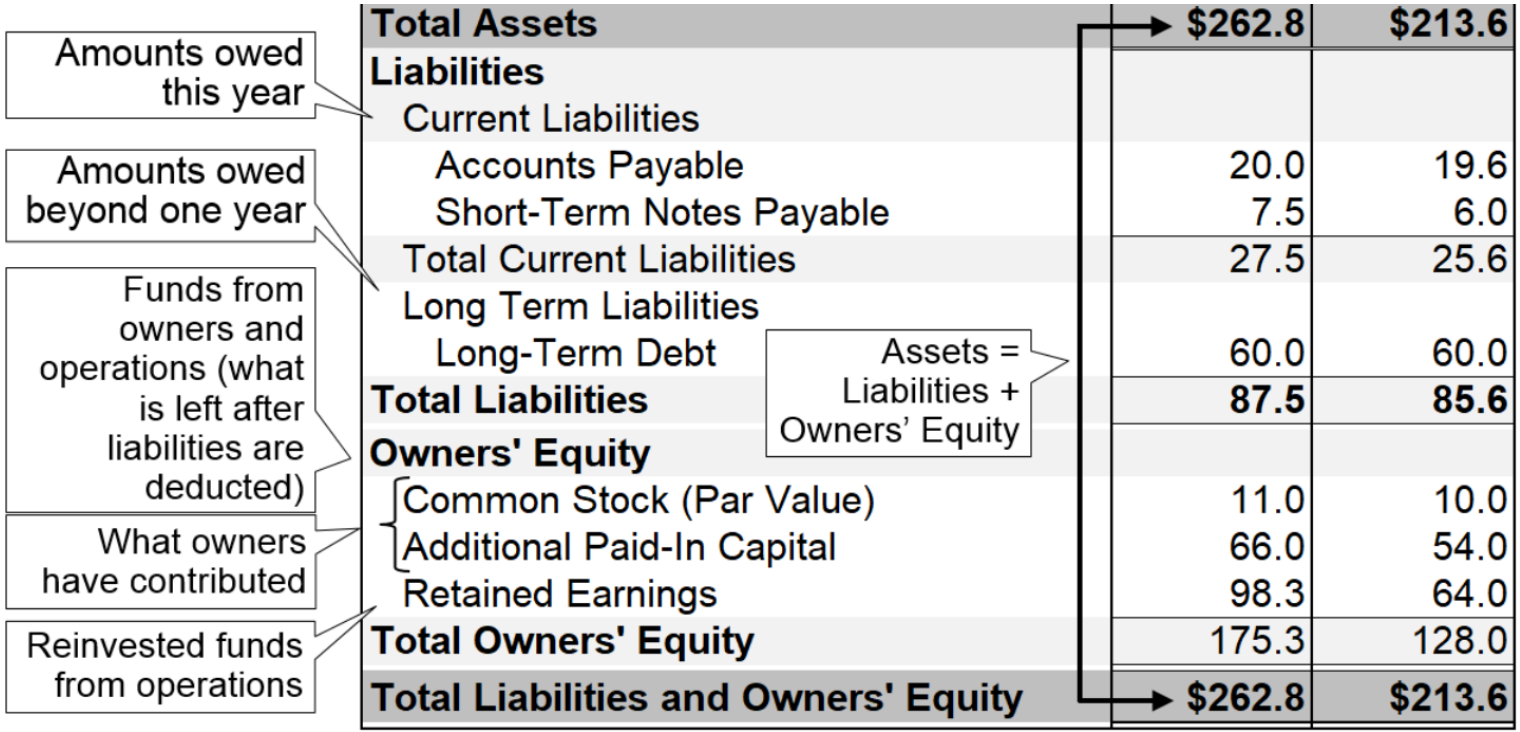
Assets expected to be converted to cash within one year

Long-term assets not easily converted to cash

Statement of financial value at a point in time (end of year)

| BALANCE SHEETS<br>December 31, | In Millions (000,000)<br>Year 2 | <br>Year 1 |
|---|---|---|
| **Assets** | | |
| Current Assets | | |
| Cash and Cash Equivalents | $96.5 | $56.3 |
| Inventory | 59.9 | 60.4 |
| Accounts Receivable | 48.4 | 44.3 |
| **Total Current Assets** | **204.9** | **161.1** |
| Fixed Assets | | |
| Gross Property, Plant, and Equipment | 70.0 | 60.0 |
| Less: Accumulated Depreciation | 12.1 | 7.5 |
| Net Property, Plant, and Equipment | 57.9 | 52.5 |
| **Total Assets** | **$262.8** | **$213.6** |

# Balance Sheet for Two Years (Liabilities)




| | | |
|---|---|---|
| **Total Assets** | **$262.8** | **$213.6** |
| **Liabilities** | | |
| Current Liabilities | | |
| Accounts Payable | 20.0 | 19.6 |
| Short-Term Notes Payable | 7.5 | 6.0 |
| Total Current Liabilities | 27.5 | 25.6 |
| Long Term Liabilities | | |
| Long-Term Debt | 60.0 | 60.0 |
| **Total Liabilities** | **87.5** | **85.6** |
| **Owners' Equity** | | |
| Common Stock (Par Value) | 11.0 | 10.0 |
| Additional Paid-In Capital | 66.0 | 54.0 |
| Retained Earnings | 98.3 | 64.0 |
| **Total Owners' Equity** | 175.3 | 128.0 |
| **Total Liabilities and Owners' Equity** | **$262.8** | **$213.6** |

# Income Statement for Two Years

Reduce costs:

- Increase profit margin without needing to raise prices

| INCOME STATEMENTS<br>For the Years Ending | In Millions (000,000s) except per share amts.<br>Year 2 | <br>Year 1 |
|---|---|---|
| **Revenue (Sales)** | **$302.6** | **$276.9** |
| Less: Cost of Goods Sold (COGS) | | |
| Direct Labor | 38.3 | 37.6 |
| Direct Materials | 101.5 | 99.7 |
| Factory Overhead | 26.6 | 26.1 |
| Less: Total Cost of Goods Sold (COGS) | 166.4 | 163.4 |
| **Gross Profit** | **136.2** | **113.5** |
| Less: Operating Expenses | | |
| Selling Expenses | 30.3 | 24.9 |
| General and Administrative | 27.2 | 22.2 |
| Lease Expense | 12.1 | 8.3 |
| Less: Total Operating Expenses | 69.6 | 55.4 |
| Less: Depreciation | 4.6 | 4.0 |
| Less: Interest Expense | 3.9 | 3.9 |
| **Net Income (Profit) Before Taxes** | **58.1** | **50.3** |
| Less: Income Taxes | 16.3 | 14.1 |
| **Net Income (Profit)** | **$41.8** | **$36.2** |
| Net Income (as a Pct. of Revenue) | 14% | 13% |
| **Net Income Per Share-Basic** | **$3.95** | **$3.78** |

Profit or loss over a period of time

Product expenses: these expenses are booked when the related units of inventory are sold.

Period expenses: these expenses are recorded in the period in which they are incurred.

# Inventory

## Statement of Cash Flows for Two Years

- Beware too much capital tied up in inventory
- Need sufficient cash

A viable firm needs positive cash flow from operations in most years.

Increase in inventory or accounts receivable reduces cash; a decrease will grow cash on hand.

Increase in accounts payable increases cash, while a decrease reduces cash.

Extra cash from financing means more debt or equity investments were issued; reduced cash means debt was paid down or dividends were paid to owners.

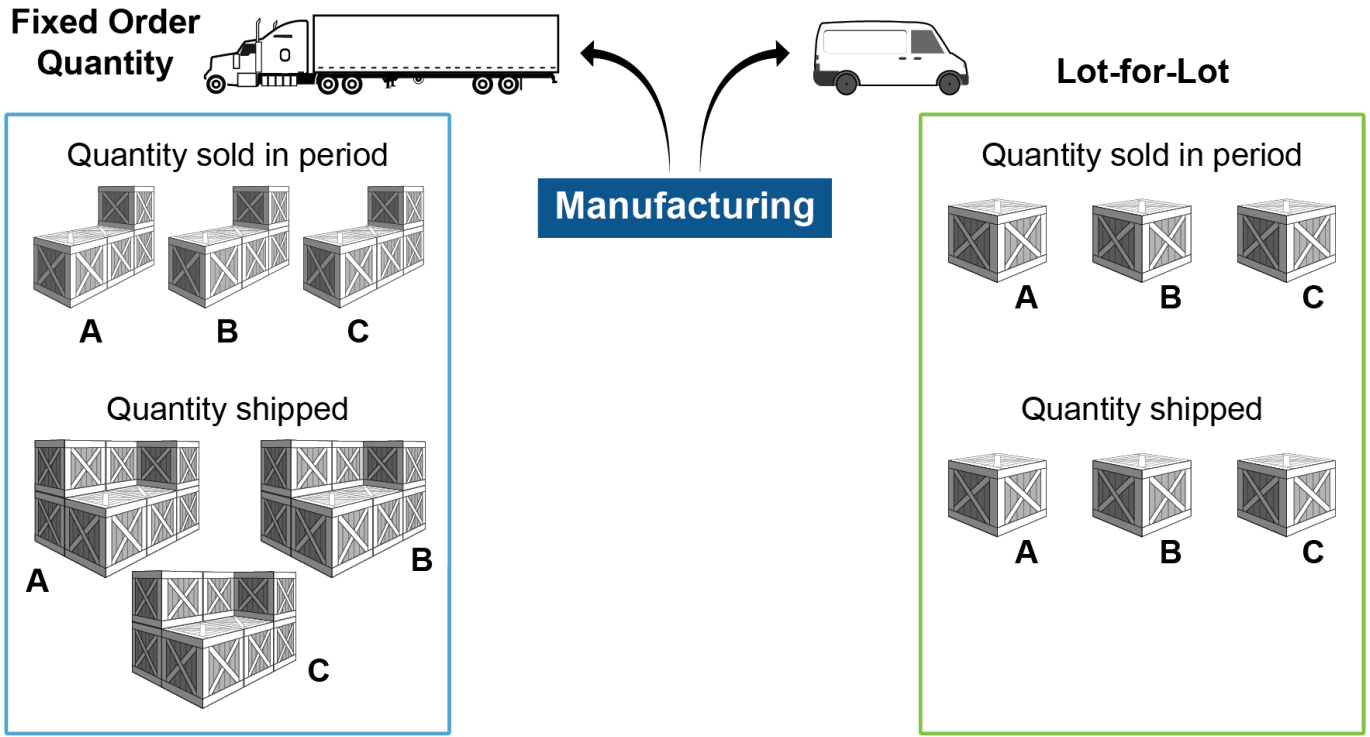
Net Income
+/– Change in (Δ) Operating
+/– Δ Investing
+/– Δ Financing
+ Beginning Cash
= Ending Cash

| CASH FLOW STATEMENTS<br>Year | In Millions (000,000)<br>Year 2 | Year 1 |
|---|---|---|
| **Operating Section** | | |
| After-Tax Net Income | $41.8 | $36.2 |
| Depreciation Add-Back | 4.6 | 4.0 |
| (Increase)/Decrease in Inventory | 0.5 | (8.6) |
| (Increase)/Decrease in Accounts Receivable | (4.1) | (4.1) |
| Increase/(Decrease) in Accounts Payable | 0.4 | 1.8 |
| **Cash Flow from Operations** | **43.2** | **29.3** |
| **Investing Section** | | |
| Capex Spend (Capital Expenditures) | (10.0) | (10.0) |
| **Cash Flow from Operations and Investment** | **33.2** | **19.3** |
| **Financing Section** | | |
| Additional Equity Capital | 13.0 | 7.0 |
| Less Dividends Paid | (7.5) | (5.0) |
| Increase/(Decrease) in Long-Term Debt | - | - |
| Increase/(Decrease) in Short-Term Notes | 1.5 | (1.5) |
| **Cash Flow from Operations, Investments, and Financing** | **40.2** | **19.8** |
| Beginning Cash Balance | 56.3 | 36.5 |
| **Ending Cash Balance** | **$96.5** | **$56.3** |

Change in cash balance over a period of time

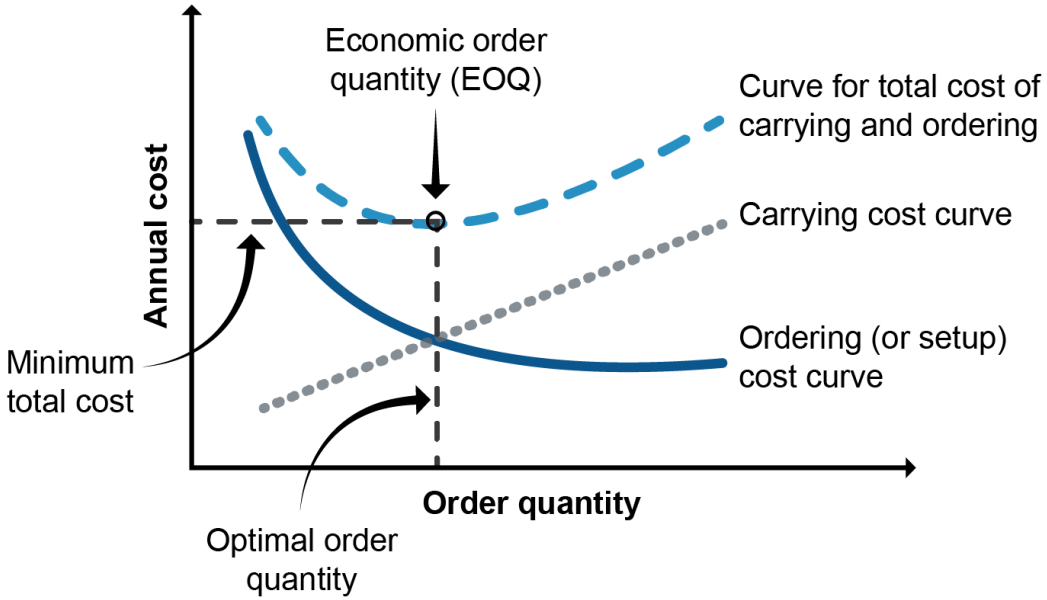
Investments in extra capacity reduce cash.

# Lot-for-Lot versus Fixed Order Quantity (FOQ)



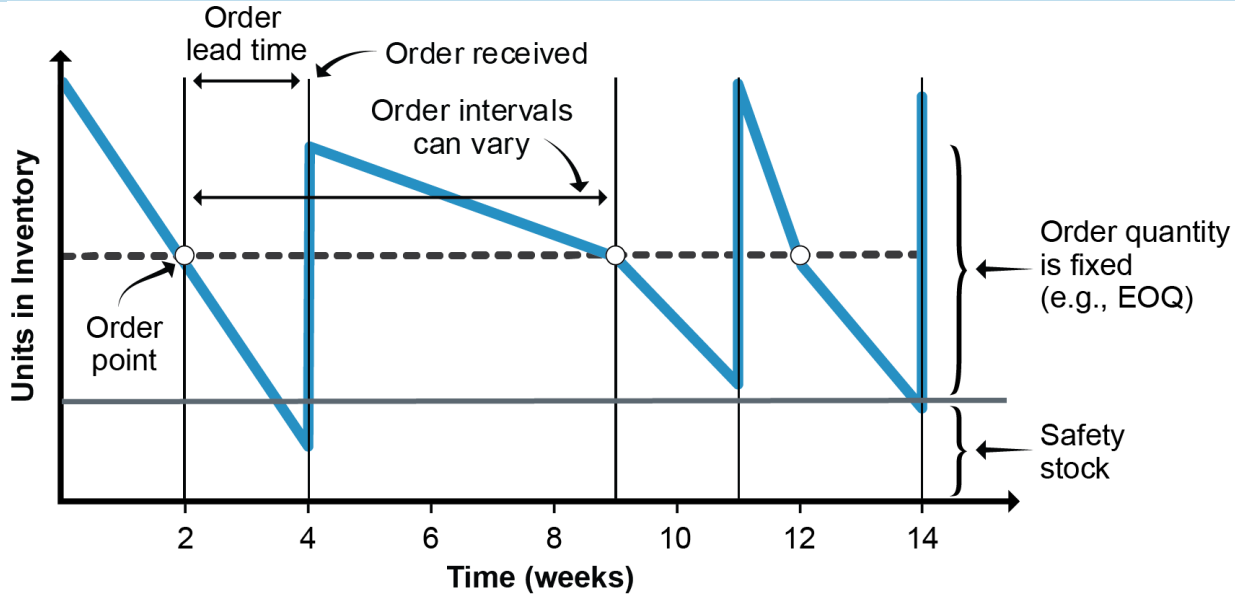
# Economic Order Quantity (EOQ)

- Minimum cost: carrying costs = ordering costs
- $EOQ = \sqrt{\frac{2 \times A \times S}{i \times c}}$
  - Q = Order quantity in units
  - *i* = Annual carrying cost %
  - *c* = Unit cost in $
  - A = Annual usage in units
  - S = Ordering Cost in $/order



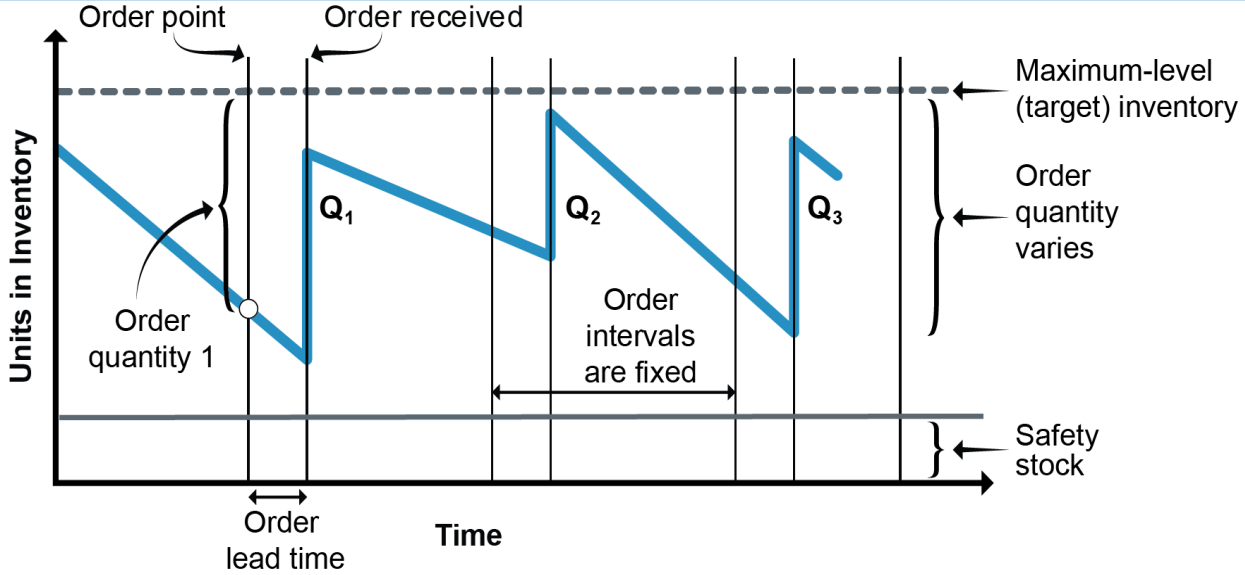
# Ordering Systems: Order Point System

- Order Point = Demand During the Lead Time + Safety Stock
- Order Point = (50 Units/Week × 2 Weeks) + 100 Units = 200 Units



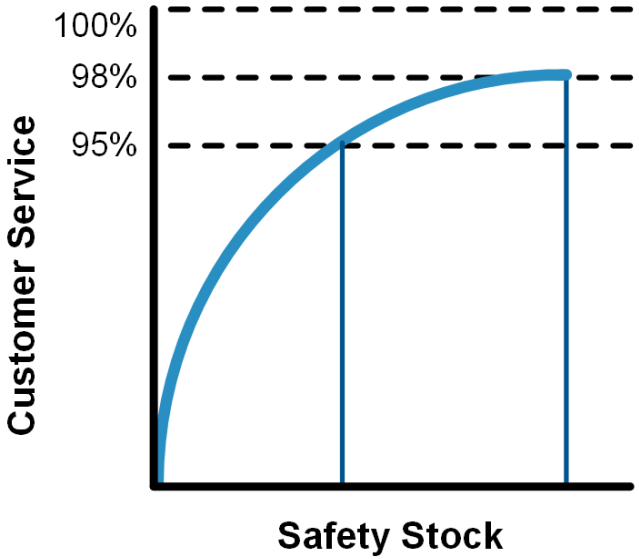
# Ordering Systems: Periodic Review System

- Maximum-Level Inventory = D × (T + L) + SS
- Order Quantity = Maximum-Level Inventory − Inventory On Hand
- D = Demand/unit of time, T = Order interval, L = Lead time, SS = Safety stock



## Safety Stock

- Inventory to protect against demand and lead time variations.
- Set/review target frequency for use.
- Methods for setting level: fixed amount, coverage, statistical.
- Need to balance cost of safety stock and cost of stockouts.
- To decrease: less frequent orders, less demand variability, shorter lead time, more accurate forecasts
- Organizational, regulatory, or industry requirements may mandate a minimum level of safety stock.



## Safety Lead Time

- Replenishment orders placed before (or after) normal order point.
- Could result in overstocks.
- Can impact bullwhip effect.
- Large orders with long lead times, e.g., on container ships, could result in significant overstocks (or stockouts).

## Product Traceability and Configuration Management

- Reduces size of recalls
- Differentiates for region-specific bans
- Compliance audits
- Compliance with free trade zone agreements and labels such as “Made in U.S.A.”
- Customs inspections

# Assessing Inventory Accuracy

## Periodic Count

- Necessary for, e.g., retail.
- Traditional method, requires store shutdown.
- Annual count of all items.
- Often done by temporary employees.
- Disruptive, expensive, error-prone.

## Cycle Count

- Count some items each day.
- Count all items a set number of times annually.
- Count A items more often than B or C items.
- Timely correction of errors, no store shutdown.

| May | Jun | July | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|---|---|---|---|---|---|---|---|---|---|---|---|

# Assessing Inventory Accuracy

## Cycle Counting Example

| Class | Qty. | Policy | Items/Day |
|---|---|---|---|
| A | 1,000 | Per month 20 days | 1,000/20 = 50/day |
| B | 3,500 | Per quarter 60 days | 3,500/60 = 58/day |
| C | 5,500 | Semi-annually 120 days | 5,500/120 = 46/day |
| | | | 154/day |

## Improving Tracking and Counting

- Keep it secure.
- Keep it neat.
- Make labels easily visible and put on everything.
- Use bins and arrangements to ease counting.
- Treat A, B, C items suitably.
- Use technology.

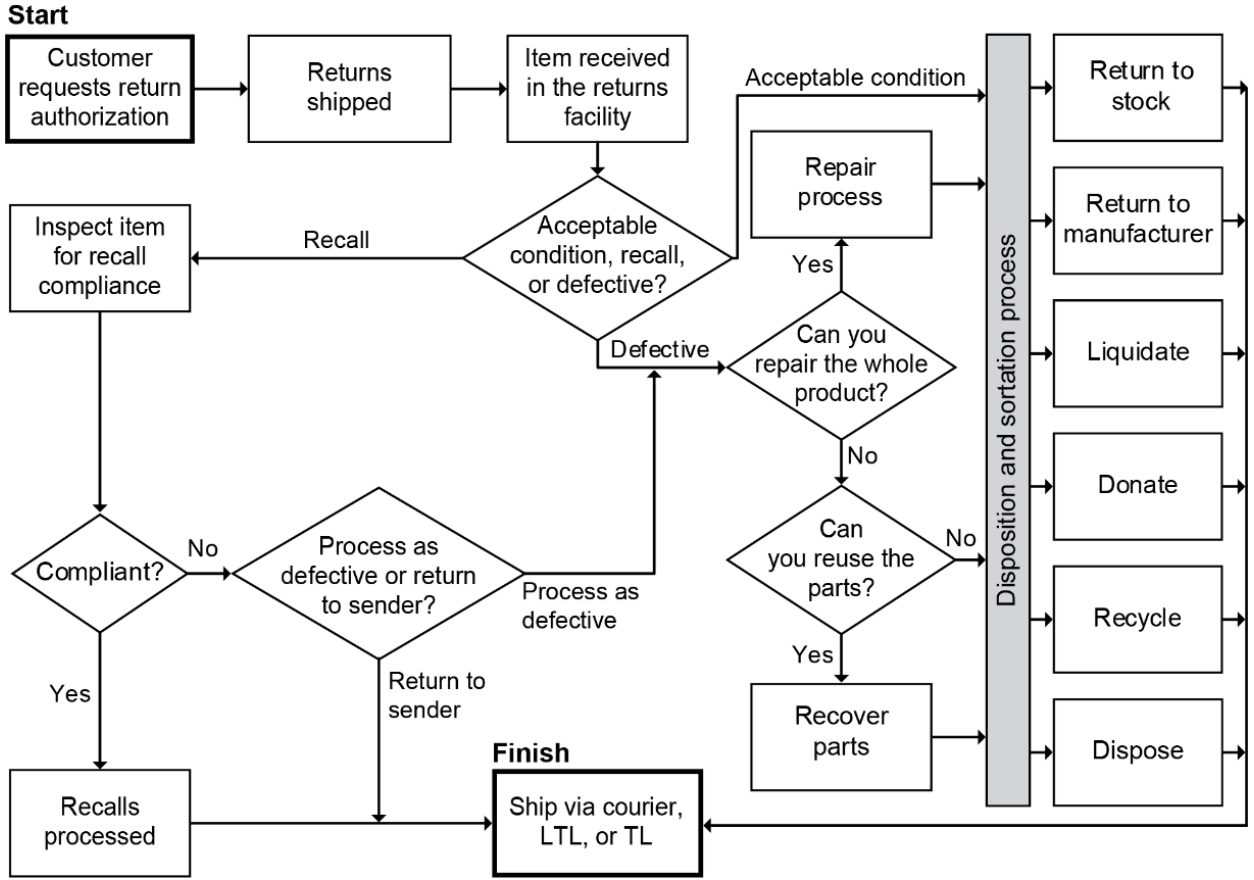
## Product End-of-Life

- Use end-of-life management for phase-out and phase-in plan.
- Set end-of-sales strategy.
  - Official communication needed so as not to ruin sales
  - May need time for supply chain inventory to sell
- Set end-of-service strategy.
  - Could stay profitable or be loyalty generator
  - Provide less expensive services
- Revisit equipment and space use.
- Consider backward compatibility.
- Accept product at end of life.
- Do risk and crisis management.

# Traceability, Accuracy, and Disposition

## Disposition of Returned Products

- Assess and categorize
- Return material authorization or policy
- Centralize







Adapted from © "Reverse Logistics Process Flow," Greve-Davis. Used with permission.

CSCP CERTIFIED SUPPLY CHAIN PROFESSIONAL

# SECTION D: PERFORMANCE AND CONTINUOUS IMPROVEMENT

APICS

ascm

# Section D Introduction

## Section D Key Processes:

- Measure and assess performance.
  - Report against KPIs and other objectives.
  - Compare operational performance against the plan.
  - Evaluate inventory accuracy.
  - Compare financial performance against the plan.
- Analyze and utilize applicable continuous improvement philosophies.

## Section D Topics:

- Operations, Inventory, and Financial Performance
- Continuous Improvement
- Quality Tools
- Continuous Improvement Methods

# Metrics and KPIs

## Metrics

You get what you measure.

1. Determine objectives and define success criteria.
2. Select metrics.
3. Set challenging but feasible targets.
4. Ensure measurements occur.
5. Consolidate, analyze, and report.

## Key Performance Indicators (KPIs)

- All KPIs are metrics but not all metrics are KPIs.
- Use balanced scorecard (e.g., learning and growth for SC improvements).
- Limit KPIs to be workable.
- Set baselines/targets.
- Assess impact on customers and bottom line.
- Monitor KPI performance.

# Key Performance Indicators (KPIs)

Apply KPIs only to processes and activities that directly enable organizational and supply chain strategies.

## New Product KPIs

- Internal failure rate
- External failure rate
- Introduction lead time

## Merchandise KPIs

- Market share
- Volume growth
- Total SC inventory turns (across chain)

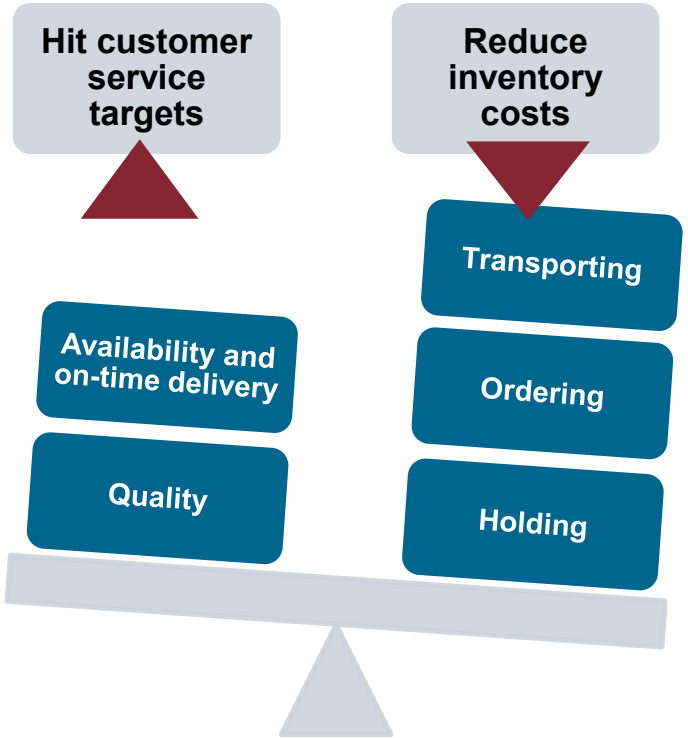
## Replenishment KPIs

- Order fill rate
- On-time delivery
- Order fulfillment lead time

# Operations KPIs

- % MPS completed as scheduled
- # of time fence violations
- Standard vs. actual production yield
- Quality metrics
- Inventory turnover by raw material turns, WIP turns, etc.

# Inventory Management KPIs



## Methods of Tracking Inventory

Order of steps is important:

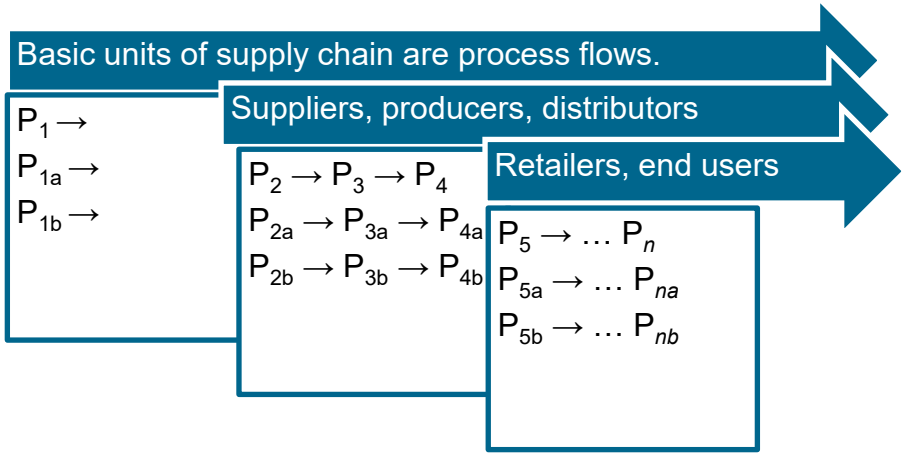
1. Identify the item by SKU.
2. Verify the quantity.
3. Request and get approval for move or get order.
4. Execute the inventory movement.
5. Create a record of the transaction completion.

## Total Quality Management (TQM)

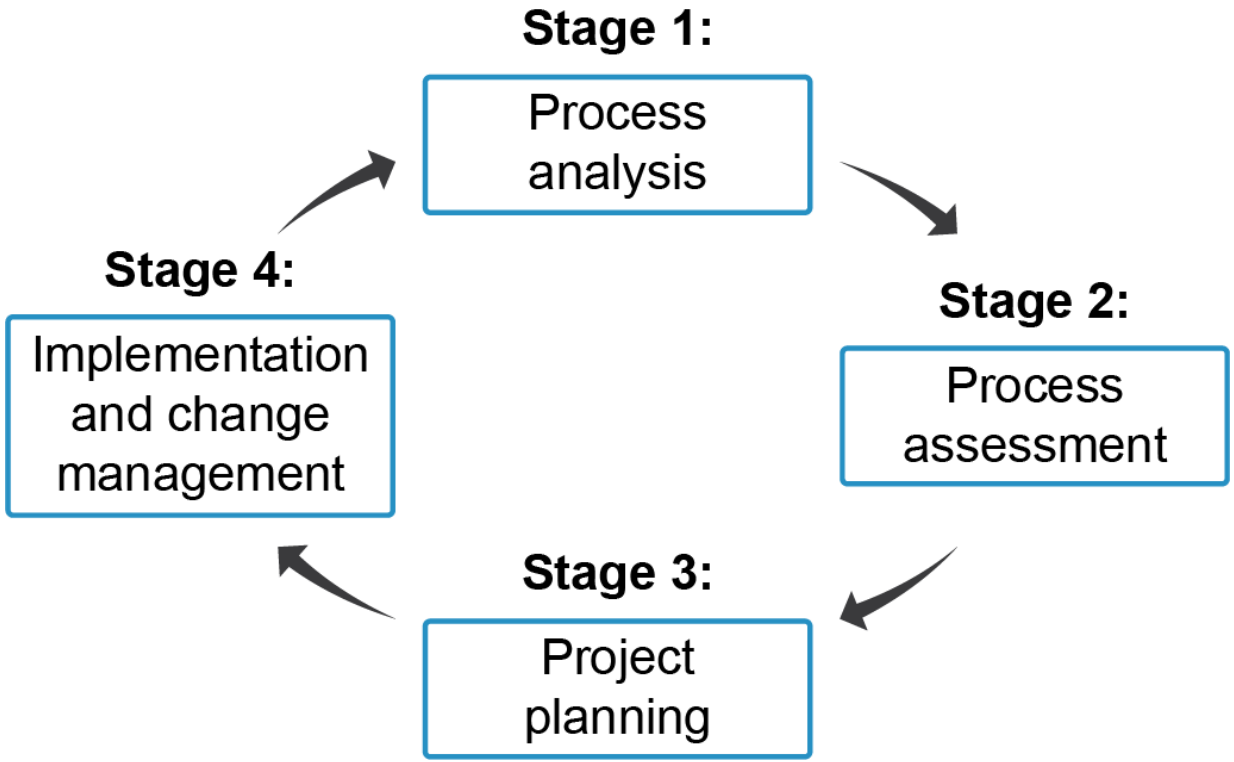
- Management approach to long-term success through customer satisfaction.
- Guiding principles:
  - Actions show management commitment.
  - Fix processes rather than assigning blame.
  - Place customer at center of improvement discussions.
  - Suppliers are partners, not adversaries.
  - Standard performance measures enable tracking over time.

# Reasons to Adopt Continuous Improvement

- Supply chain management is process-oriented.
- Supply chains are dynamic.
- Supply chains evolve.
- Continuous improvement of supply chain design can reduce costs of poor quality.




# Continuous Improvement Model



# Improvement Initiatives

## Personnel Improvement Initiatives

- Developing knowledge, skills and abilities.
- Consider individual learning styles: visual, tactile, and auditory.

## Process Analysis and Improvement

- Top-down direction
- Bottom-up implementation
- Strategic alignment and prioritization
- “As is” state
- “To be” can start with “low hanging fruit”

# Process Analysis and Improvement: Visibility

***"You can't fix what you can't see."***

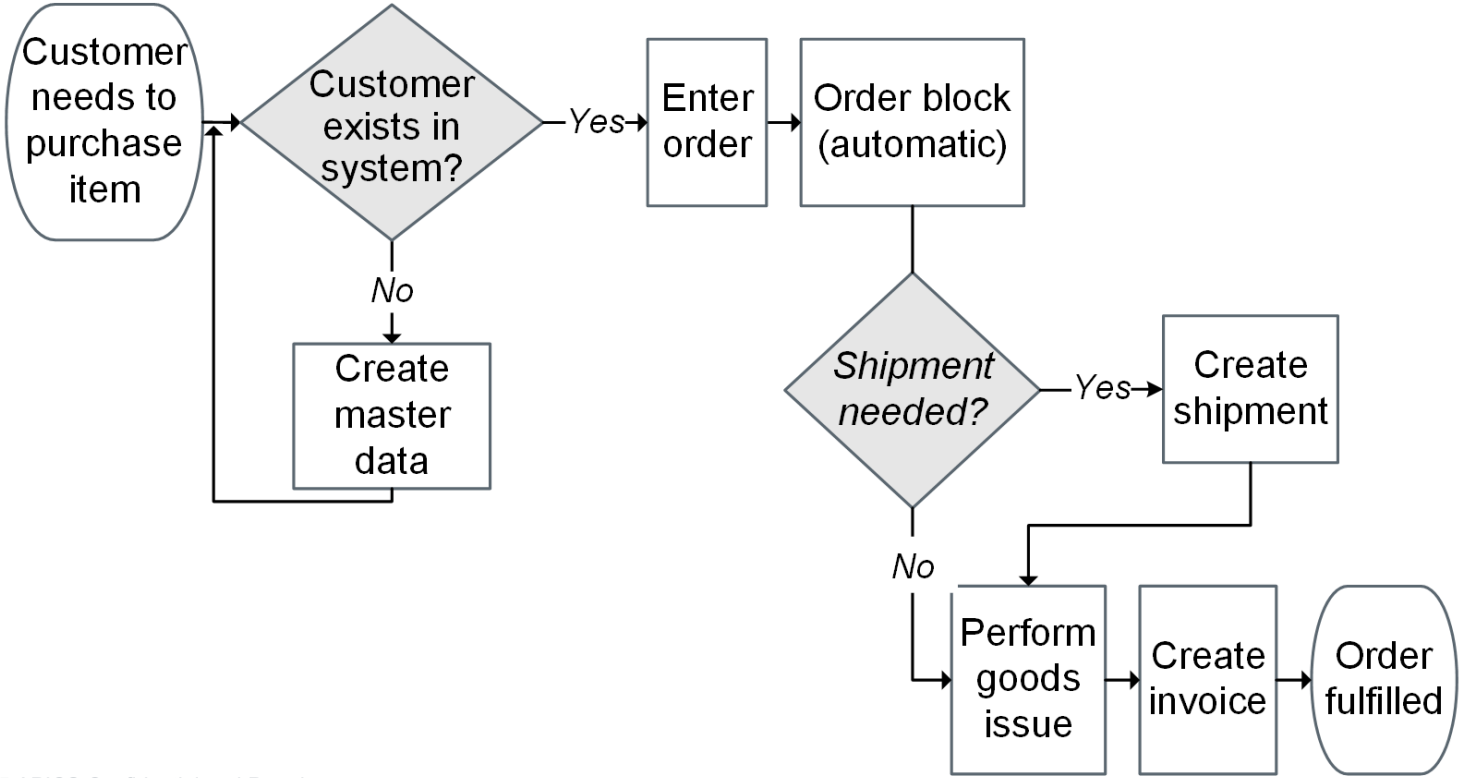

***"Facts Are Your Friends"***

# Benchmarking

Setting goals by comparison to another entity or authoritative definition of excellence

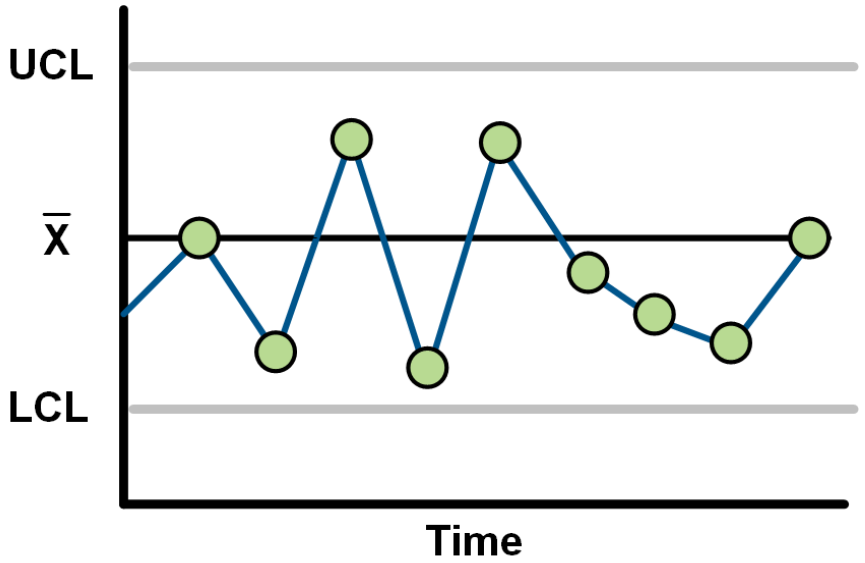
| Competitive Benchmarking | Best-in-Class Benchmarking | Process Benchmarking |
|---|---|---|
| Setting goals by reference to a competitor | Setting goals by reference to the best performer | Setting process goals by reference to an authoritative process description |

# Seven Basic Tools of Quality: Process Map



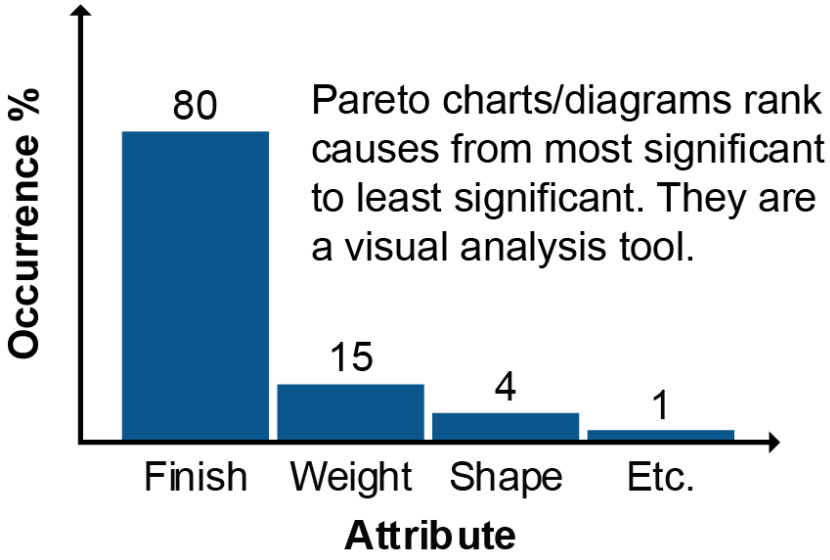
# Seven Basic Tools of Quality: Control Chart

- Makes variance visible
- Statistical process control
- Contains samples from sequences
- Reveals spikes indicating process control problems
- Examples
  - Component measurement conformance
  - Wait time for service
  - Percentage of event occurrence

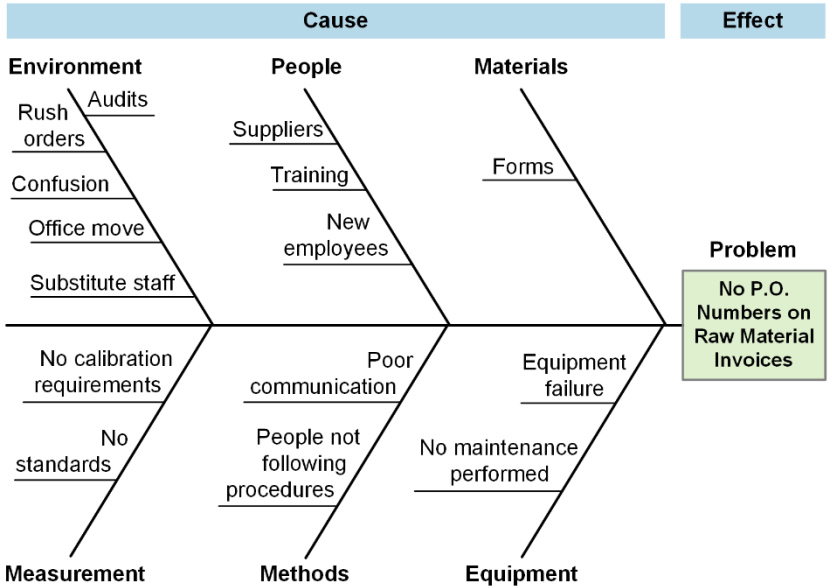


# Seven Basic Tools of Quality

## Pareto Chart

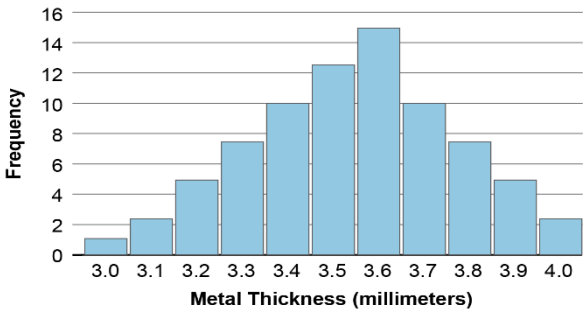



## Cause-and-Effect Diagram



# Seven Basic Tools of Quality

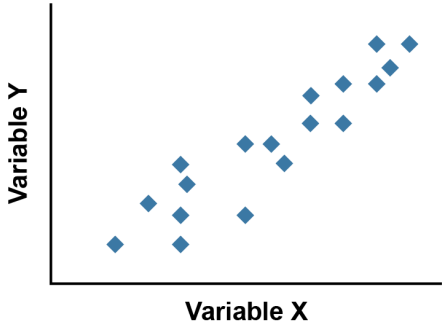
## Histogram




## Check Sheet

| Defect | February | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Total |
| Too pink | 𝍸 I | III | I | 𝍸 II | 17 |
| Too red | I | I | — | II | 4 |
| No fragrance | II | — | I | III | 6 |
| Wrong size | IIII | II | I | 𝍸 | 12 |
| **Totals** | **13** | **6** | **3** | **17** | **39** |

## Scatter Chart

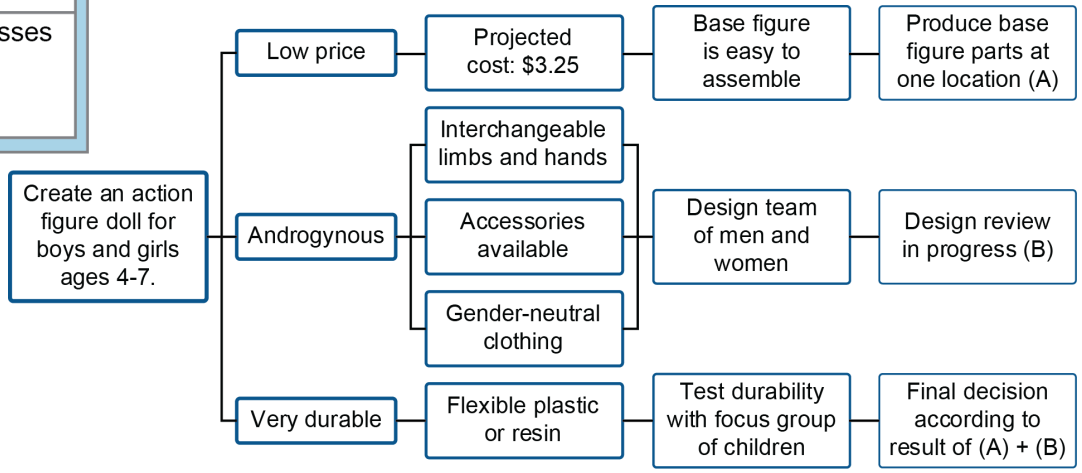


# Seven New Tools

## Affinity Diagram

| Issue: Product recall causes | | |
|---|---|---|
| Inspection | Customer feedback | Product materials |
| Frequency | Costs | Return processes |

## Tree Diagram

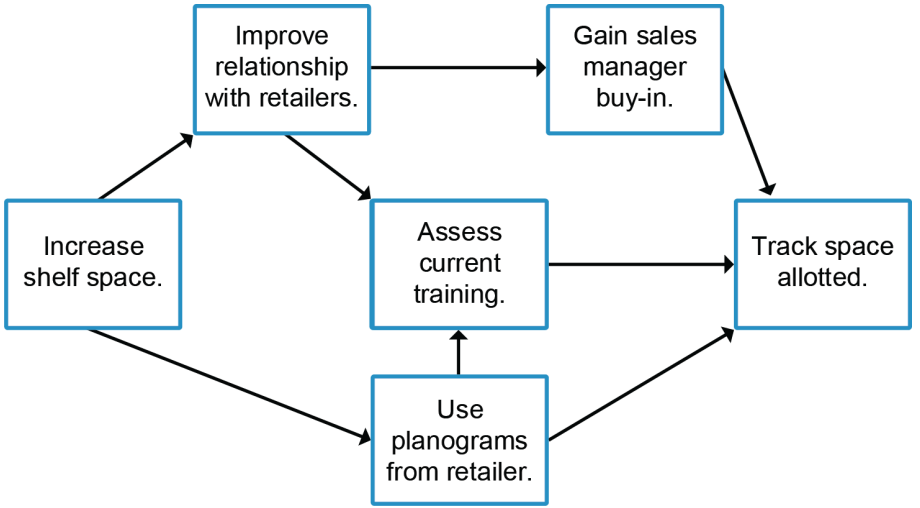


# Seven New Tools

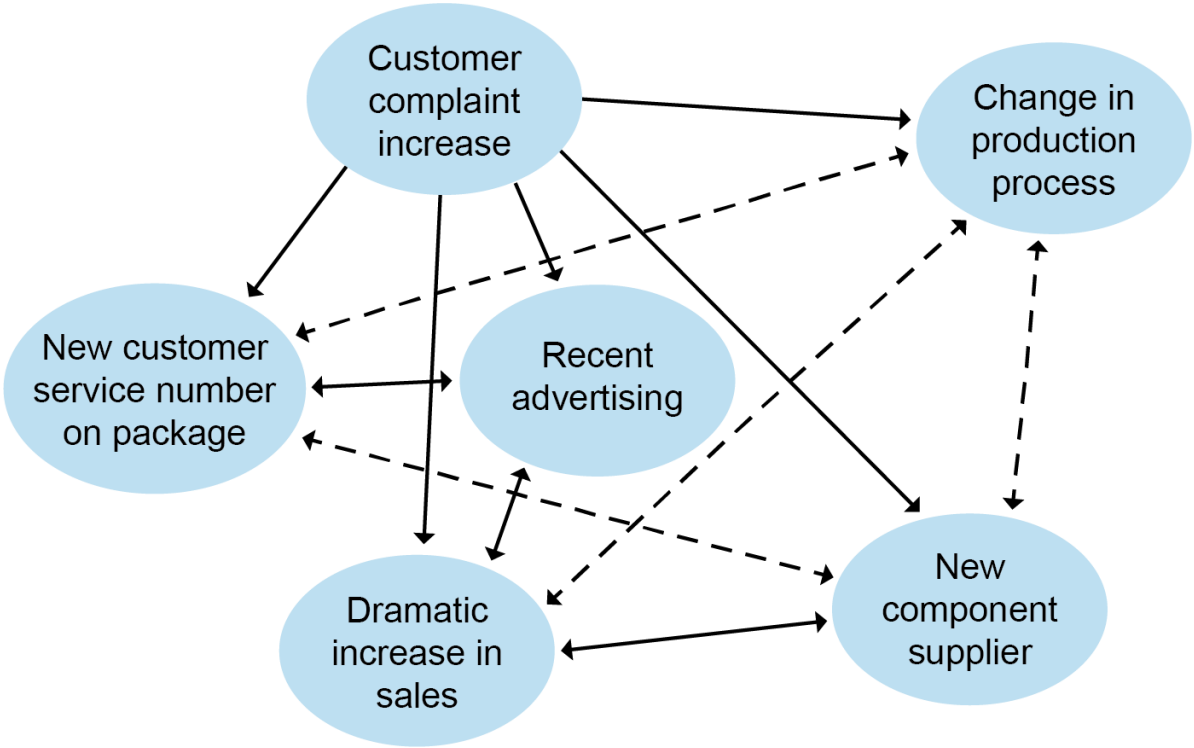
## Matrix Diagram

| Specification | Customer A | Customer B | Customer C |
|---|---|---|---|
| Width | ≤.789 inch | ≤.790 inch | ≤.785 inch |
| Length | ≤1.11 inch | ≤1.20 inch | ≤1.01 inch |
| Thickness | ≤.55 inch | ≤.575 inch | ≤.545 inch |
| Color (Pantone) | #127 | #130 | #129 |

## Process Decision Program Chart

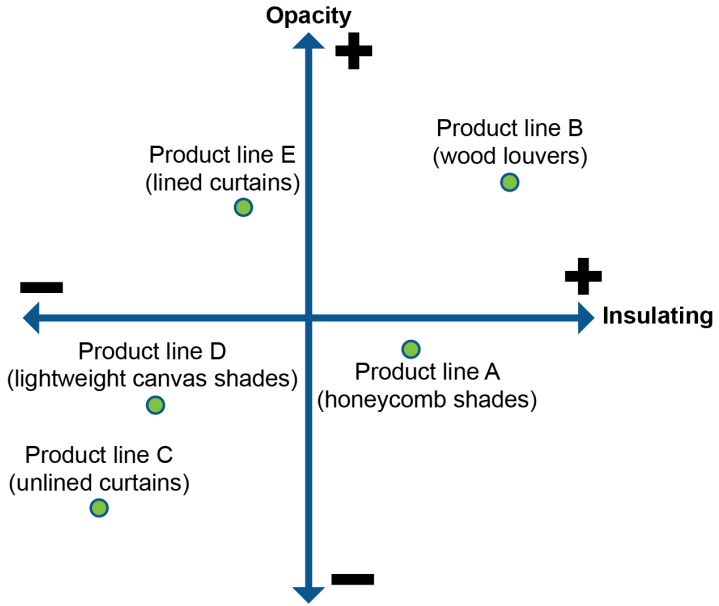


# Seven New Tools: Relationship Diagram

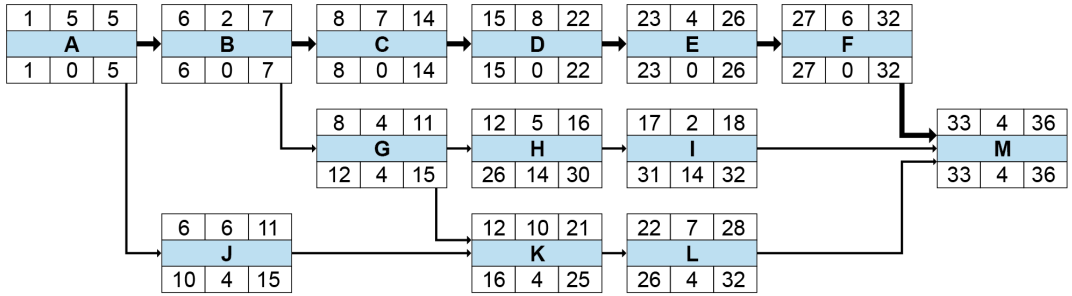


# Seven New Tools

## Matrix Data Analysis Chart




## Activity Network Diagram



# Eight Types of Waste

- Any activity that adds no value in eyes of customer
- Byproduct of process or task needing special control

| Type | Description |
|---|---|
| **Process** | Taking unneeded steps in work; inefficiencies |
| **Movement (transportation)** | Moving products unnecessarily |
| **Methods (motion)** | Wasted time or efforts by operators |
| **Product defects** | Products/services that do not meet specifications |
| **Waiting time** | Queuing delays |
| **Overproduction** | Making more product than required |
| **Excess inventory** | Holding stock not required to fulfill customer orders |
| **Unused people skills** | Waste of knowledge or capabilities |

# Lean Supply Chain Thinking

## Lean Objectives

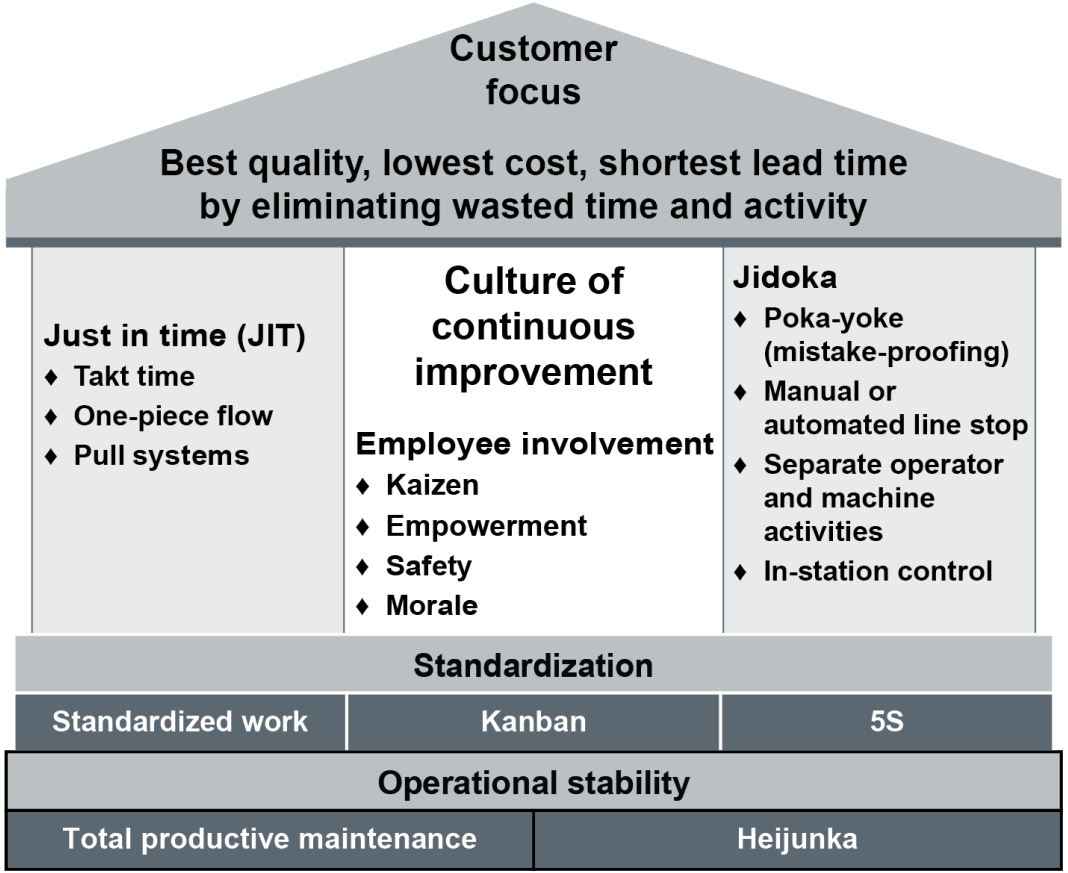
- Eliminate waste in value streams.
- Meet customer demand.
- Increase velocity.
- Reduce need for working capital.
- Increase inventory turns.
- Gain market share.
- Increase profitability.
- Develop the workforce.
- Produce perfect quality.

## Five Lean Principles

- Create value for the customer.
- Identify all steps across a value stream.
- Create value flow.
- Pull products based upon customer demand.
- Strive for perfection by continually removing successive layers of waste.

# Continuous Improvement Methods

## House of Toyota




Source: APICS Lean Enterprise Workshop Series.

# Additional Lean Considerations

## Value stream mapping

- Map
  - Steps for broad range of SC processes
  - Management and information systems
- Current vs. future state
- Value-added versus non-value-added

## Kaizen event/ Kaizen blitz(sm)

- Event
  - Time-boxed
  - Embed in long-term plans
- Blitz
  - Rapid improve-ment of limited process area
  - Implement in week or less

## Five Ss

- Sort (seiri)
- Simplify (set in order) (seiton)
- Scrub (seiso)
- Standardize (seiketsu)
- Sustain (shitsuke)

Source: Adapted from *Five Pillars of the Visual Workplace* by Hiroyuki Hirano.

# Additional Lean Considerations (continued)

## Setup time reduction

- Major impact on cost and product variety.
- Reduction in time and materials.

## Total productive maintenance

- Preventive maintenance.
- Efforts to adapt, modify, or refine equipment to:
  - Increase flexibility
  - Reduce material handling
  - Promote continuous flows.

## Three major areas of waste

- **Muda** (consumes resources, creates no value).
- **Mura** (unevenness).
- **Muri** (over-burdening).

# Just in Time (JIT)

## Just-in-Time (JIT) Elements

1. Have inventory only when needed.
2. Quality at zero defects level.
3. Reduce lead times by:
   - Reducing setup times.
   - Reducing queue lengths.
   - Reducing lot sizes.
4. Review and revise operations.
5. Strong supplier relationships.
6. Multiskilled labor force.
7. Move toward cellular manufacturing environment.

## JIT Philosophy

- Eliminate all waste.
- Strive for continuous productivity improvements.

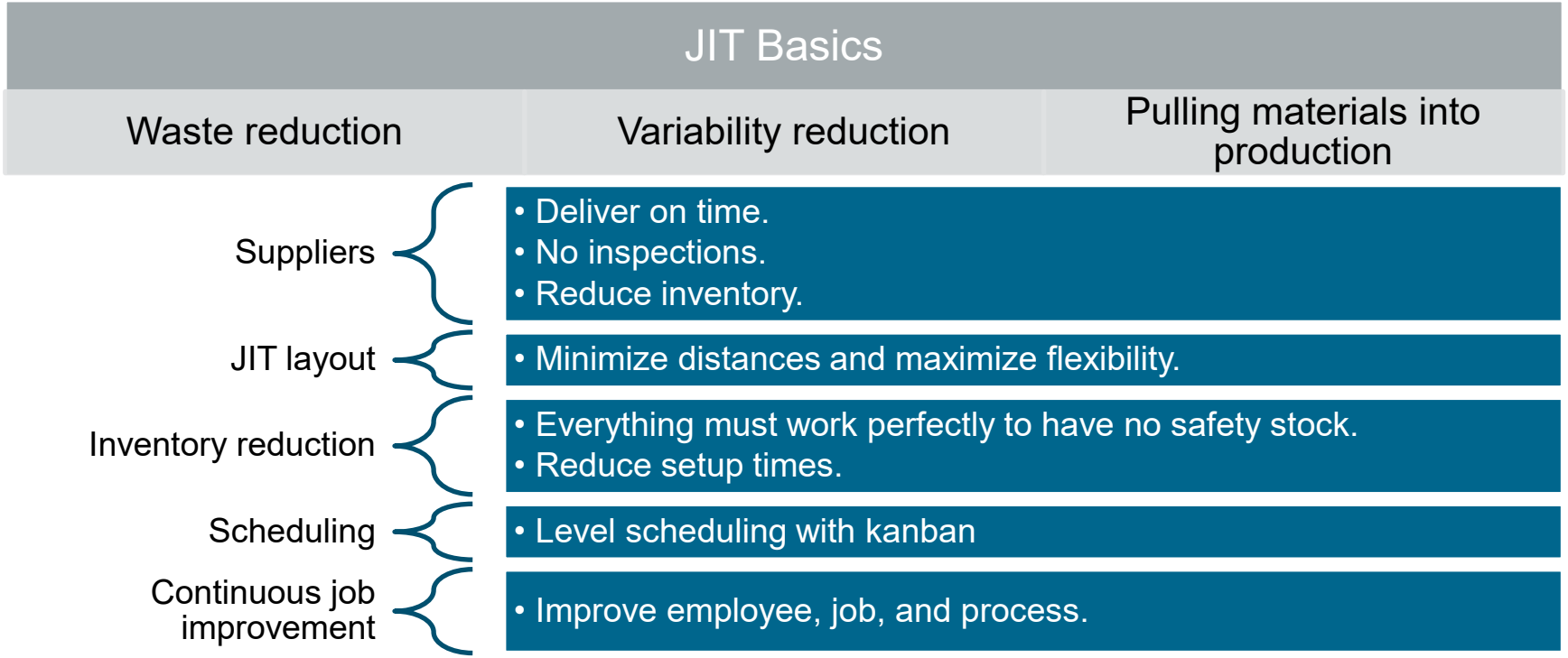
Applies to the following forms of manufacturing environments: job shops, process, repetitive.

## JIT Benefits

- Manufacturing cycle time reduction
- Inventory reduction
- Labor cost reduction
- Quality cost reduction
- Material cost reduction
- Improved vendor relationships

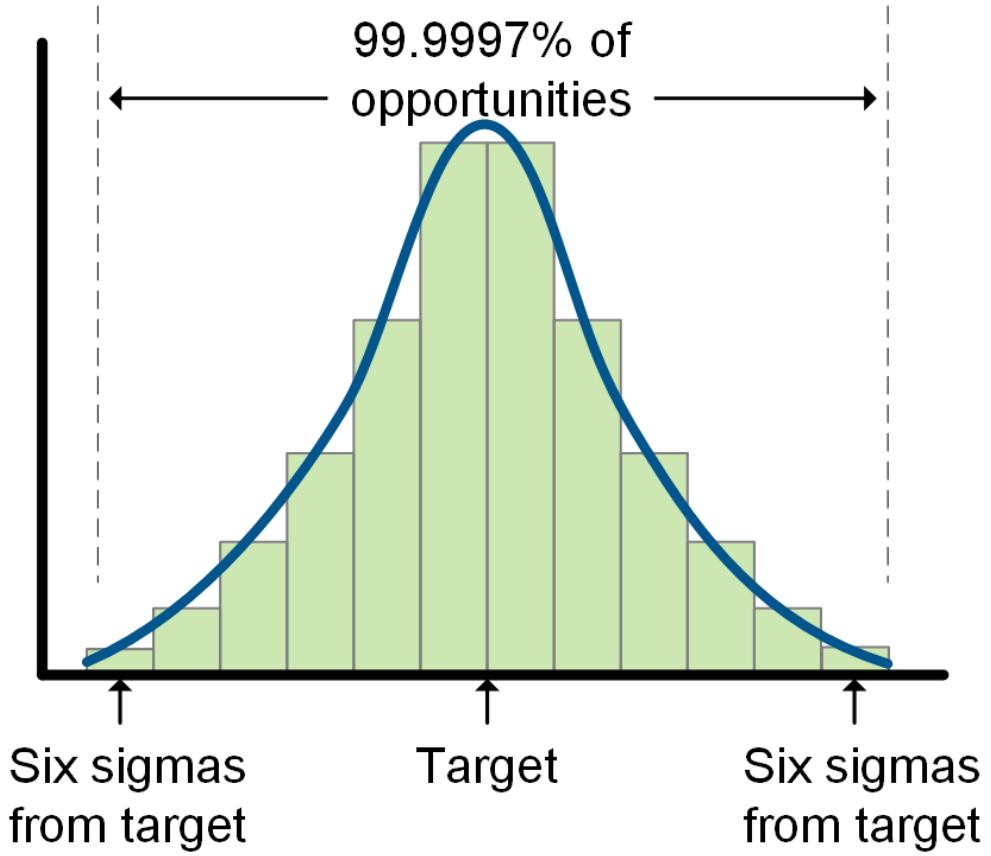
# Continuous Improvement Methods

## Just-in-Time (JIT)



## Six Sigma

- Aim for “zero defects.”
- Tolerate no more than 3.4 defects per million opportunities (99.9997% of opportunities with no defect).



# Elements of Six Sigma

## Customer

- Customer expectations define quality.
- Multiple opportunities for defects in each interaction/item.

## Process

- Take outside-in (customer) view of process.
- Minimize total errors and variability.

## Employee

- Full participation.
- Implement from below.
- Green belt, black belt, master black belt.

## Five-Phase Six Sigma Process: DMAIC


Define the nature of the problem.

Measure existing performance; record information about underlying causes.

Analyze information to find root causes.

Improve process by effecting solutions to problem.

Control process until solutions become ingrained.

# Theory of Constraints (TOC)

Any system, such as a supply chain or a production process, contains at least one element (constraint) that limits its maximum throughput.

**Five-step TOC process:**

1. Identify the constraint.
2. Exploit the constraint.
3. Subordinate other processes to the constraint.
4. Elevate the constraint.
5. Repeat the cycle.