CHAPTER 6- AGGREGATE PLANNING

Principles of Supply Chain Management:

A Balanced Approach

Learning Objectives

You should be able to:

- Describe the hierarchical operations planning process in terms of materials planning & capacity planning
- Describe MRP, closed-loop MRP, MRP-II & ERP
- Know how to compute available-to-promise quantities.
- Know how to perform an MRP explosion.
- Distinguish dependent from independent demand inventories.
- Describe the four basic types of inventories & their functions.
- Understand the EOQ model

Chapter Six Outline

- Operations Planning
- The Aggregate Production Plan: Chase, Level, & Mixed Strategies
- Mater Production Scheduling
  - Master Production Schedule Time Fence
  - Available-to-Promise Quantities
- Dependent Demand & Independent Demand
- The Bill of Materials
- Materials Requirement Planning
- Capacity Planning
- Independent Demand Inventory Systems
  - The ABC Inventory Control System
  - The Economic Order Quantity Model

Introduction

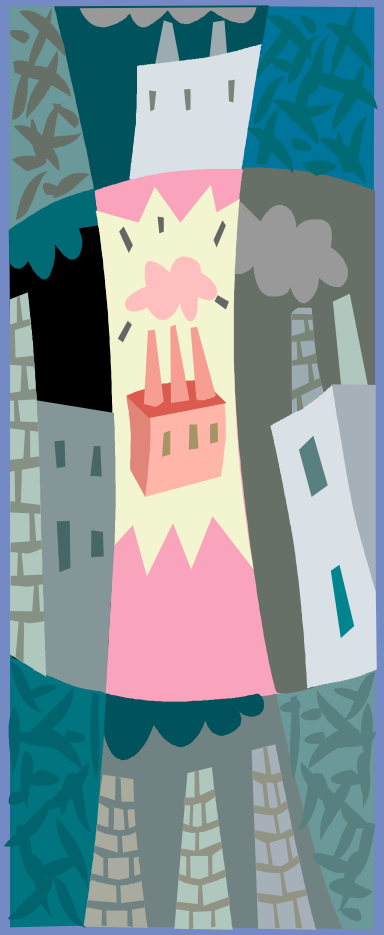
Scheduling & inventory management influence how assets are deployed.

Problem: A missed due date or stock-out may cascade downstream, affecting the supply chain.

Operations managers are continuously involved in balance capacity & output.

Here we will discuss:

- Hierarchical operations planning process
- Dependent & independent demand
- Basic types of inventories
- Various inventory management approaches



Matching Supply and Demand

- Suppliers must accurately forecast demand so they can produce & deliver the right quantities at the right time at the right cost.
- Suppliers must find ways to better match supply and demand to achieve optimal levels of cost, quality, and customer service to enable them to compete with other supply chains.
- Problems that affect product & delivery will have ramifications throughout the chain.

Operations Planning

- Operations planning is usually hierarchical & can be divided into three broad categories:

- **Long-range- Aggregate Production Plan** (APP) involves the construction of facilities & major equipment purchase

- **Intermediate-** Shows the quantity & timing of end items (i.e., **master production schedule-** MPS)

- S**hort-range-** detailed planning process for components & parts to support the master production schedule (i.e., **materials requirement planning- MRP**)

Operations Planning- Cont.

- **Closed-loop MRP-** incorporates the aggregate production plan, the master production schedule material requirements plan, capacity requirements plan.

- **Manufacturing resource planning (MRP-II)** incorporates the business & sales plans with the closed-loop MRP system.

- **Distribution requirement planning (DRP)** describes the time-phased net requirements from warehouses & distribution centers customer demand minus any on hand in-transit inventories.

Aggregate Production Plan

Hierarchical planning- process that translates annual business & marketing plans & demand forecasts into a production plan for ***all*** products in a plant or facility. Hence, ***Aggregate Production Plan***

Planning horizon of APP- at least one year & is usually ***rolled forward*** by three months every quarter

Costs relevant to the aggregate planning decision include inventory, setup, machine operation, hiring, firing, training, & overtime costs

Aggregate Production Plan- Cont.

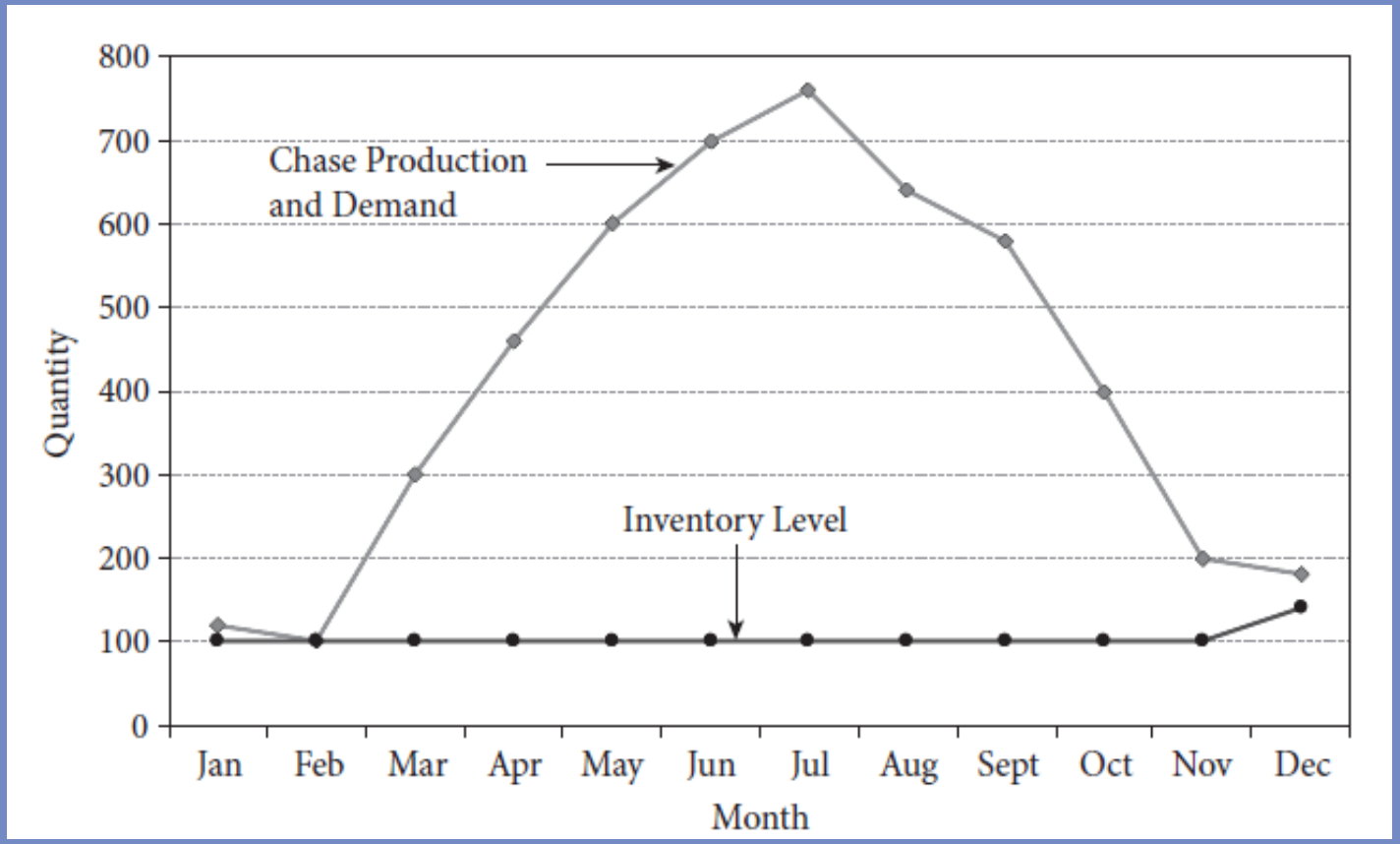
Three basic production strategies :

1. ***Chase Strategy-*** **A**djusts capacity to match the demand pattern. Firm hires & lays off workers to match production to demand. Workforce fluctuates but finished goods inventory remains constant. Works well for **make-to-order firms.**
2. ***Level Strategy-*** Relies on a constant output rate & capacity while varying inventory & backlog levels according to fluctuating demand pattern. Workforce levels stay constant & firm relies on fluctuating finished goods inventories & backlogs to meet demand. Works well for **make-to-stock manufacturing firms**.
3. ***Mixed Production Strategy-*** **T**o maintain stable workforce core while using other short-term means, such as overtime, & additional subcontracting or part time helpers to manage short-term demand.

Example-Chase Strategy

PERIOD	FORECAST DEMAND (UNITS)	PRODUCTION (UNITS)	CAPACITY NEEDED (LABOR)		ENDING INVENTORY (UNITS)
			HOURS	WORKERS	
January	120	120	960	6	100
February	100	100	800	5	100
March	300	300	2,400	15	100
April	460	460	3,680	23	100
May	600	600	4,800	30	100
June	700	700	5,600	35	100
July	760	760	6,080	38	100
August	640	640	5,120	32	100
September	580	580	4,640	29	100
October	400	400	3,200	20	100
November	200	200	1,600	10	100
December	140 + 40	180	1,120 + 320	9	140
	5,040	5,040	40,320	252	

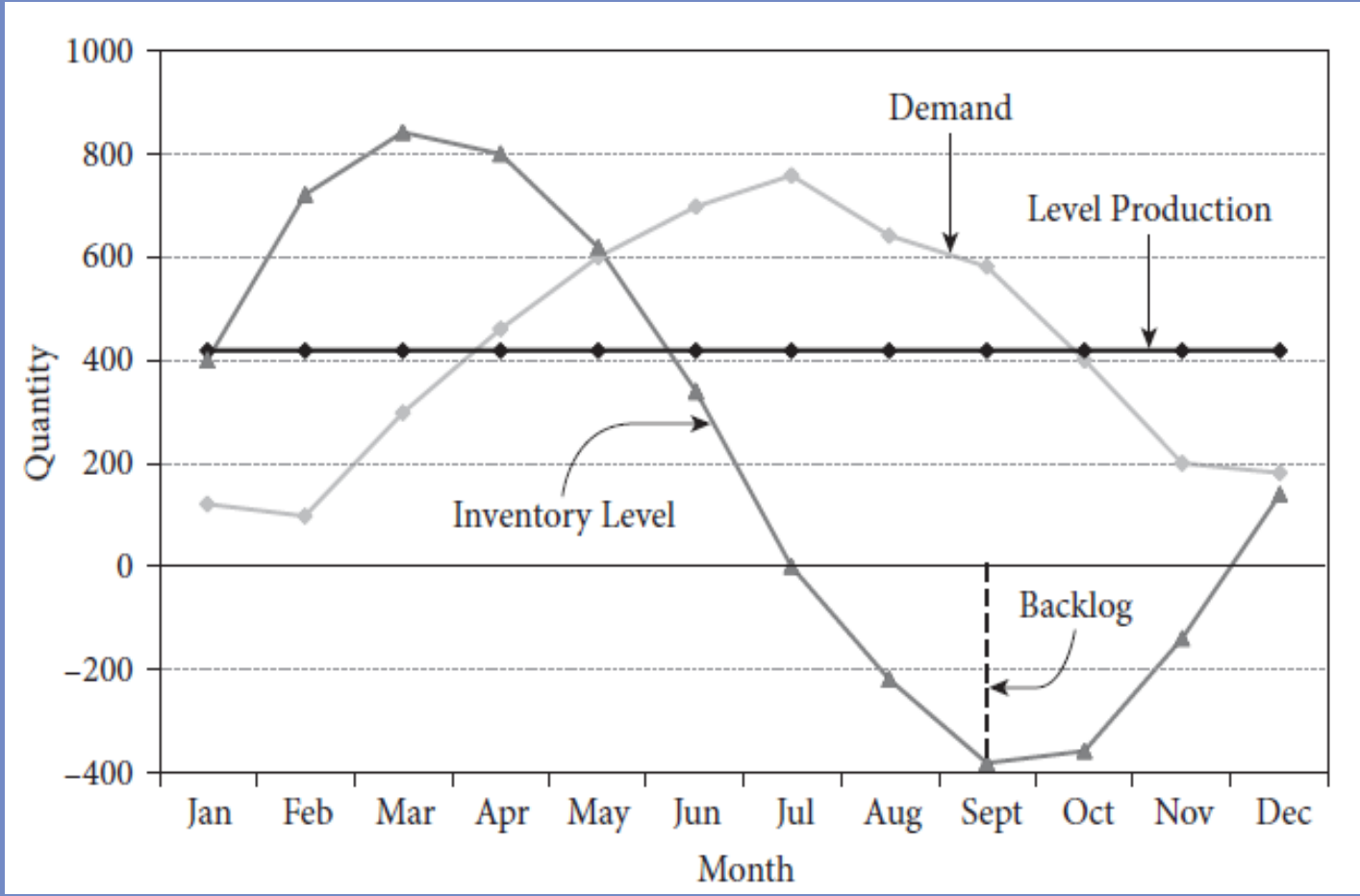
Example-Chase Strategy



Example-Level Strategy

PERIOD	FORECAST DEMAND (UNITS)	PRODUCTION (UNITS)	CAPACITY NEEDED (LABOR)		ENDING INV/ (BACKLOG) (UNITS)
			HOURS	WORKERS	
January	120	420	3,360	21	400
February	100	420	3,360	21	720
March	300	420	3,360	21	840
April	460	420	3,360	21	800
May	600	420	3,360	21	620
June	700	420	3,360	21	340
July	760	420	3,360	21	0
August	640	420	3,360	21	(220)
September	580	420	3,360	21	(380)
October	400	420	3,360	21	(360)
November	200	420	3,360	21	(140)
December	140 + 40	420	3,360	21	140
	5,040	5040	40,320	252	

Example-Level Strategy



Practice Questions

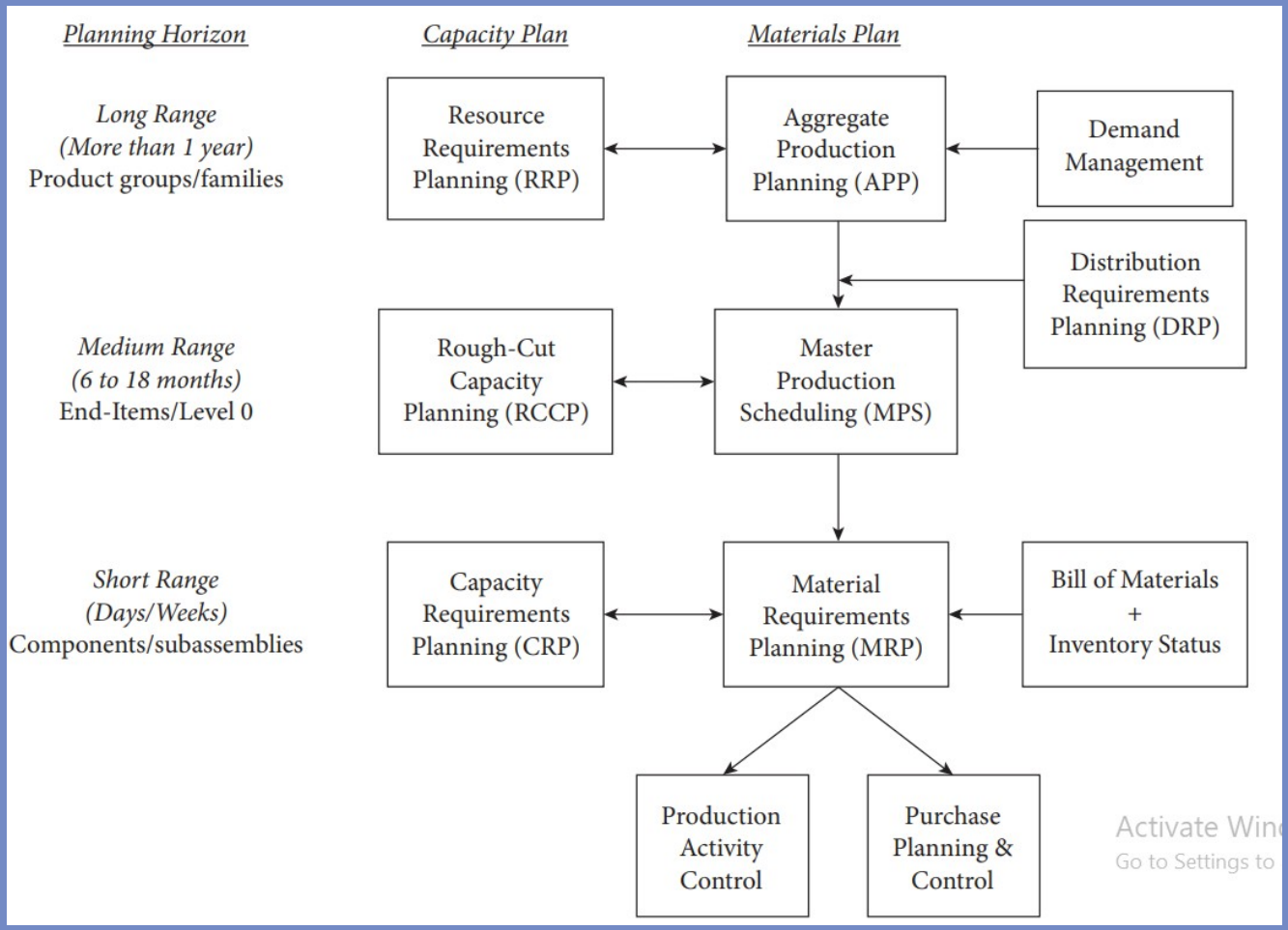
Given the following production plan, use a (a) chase production strategy and (b) level production strategy to compute the monthly production, ending inventory/(backlog) and workforce levels. A worker is capable of producing 100 units per month. Assume the beginning inventory as of January is zero, and the firm desires to have zero inventory at the end of June.

MONTH	JAN	FEB	MAR	APR	MAY	JUN
Demand	2000	3000	5000	6000	6000	2000
Production						
Ending Inventory						
Workforce						

Given the following production plan, use a (a) chase production strategy and (b) level production strategy to compute the monthly production, ending inventory/(backlog) and workforce levels. A worker can produce 50 units per month. Assume that the beginning inventory in January is 500 units, and the firm desires to have 200 of inventory at the end of June.

MONTH	JAN	FEB	MAR	APR	MAY	JUN
Demand	2000	3000	5000	6000	6000	2000
Production						
Ending Inventory						
Workforce						

Resource Planning



Master Production Scheduling

Master Production Schedule- A detailed disaggregation of the aggregate production plan, listing the exact end items to be produced by a specific period.

More detailed than APP & easier to plan under stable demand.

Planning horizon is shorter than APP, but longer than the lead time to produce the item.

Note: For the service industry, the master production schedule may just be the ***appointment log*** or book, which ensures that capacity (e.g., skilled labor or professional service) is balance with demand.

Example of MPS

PERIOD	APP QUANTITY	MPS QUANTITY		
		MODEL A	MODEL B	MODEL C
January—week 1	120 units	10	10	10
January—week 2		10	10	10
January—week 3		20	0	10
January—week 4		0	20	10
February—week 1	100 units	20	0	0
February—week 2		0	20	0
February—week 3		0	0	20
February—week 4		20	20	0
Total	220 units	80	80	60

Master Production Scheduling-Cont.

The MPS is the production quantity to meet demand from all sources & is used for computing the requirements of all time-phased end items.

Frequent changes to the MPS may create ***system nervousness***- Situation where a small change in the upper-level-production plan causes a major change in the lower-level production plan.

Many firms use a ***time fence*** system to deal with system nervousness. A ***time fence*** separates the planning horizon into two segments

- ***Firmed Segment*** (AKA as a demand time fence), from current period to several weeks into future. Can only be altered by senior management.
- ***Tentative segment*** (AKA **planning time fence)**, from end of the firmed segment to several weeks farther into the future.

Master Production Scheduling-Cont.

Available-to-Promise (ATP) Quantities-

The MPS decides whether additional orders can be accepted for difference between confirmed customer orders & the quantity the firm planned to produce.

Three basic methods of calculating the available-to-promise quantities:

1. Discrete available-to-promise
2. Cumulative available-to-promise without look ahead, &
3. Cumulative available-to-promise with look ahead.

Master Production Scheduling-Cont.

Discrete Available-to-Promise

1. Add the Beginning Inventory to the MPS for Period 1, subtracting the Committed Customer Orders.
2. For the next period, subtract the Committed Customer Orders. If quantity is positive, this becomes the Period 2 ATP. If negative, subtract enough from the previous period's ATP to make the current period's ATP zero.
3. For subsequent periods, follow Step 2.

Master Production Scheduling-Cont.

Table 6.5 Discrete ATP Calculation for January and February

		WEEK							
		1	2	3	4	5	6	7	8
Model A—0.4 liter Engine									
MPS	BI = 30	10	10	20	0	20	0	0	20
Committed Customer Orders		10	0	28	0	0	20	0	10
ATP:D		30	2	0	0	0	0	0	10
Model B—0.5 liter Engine									
MPS	BI = 30	10	10	0	20	0	20	0	20
Committed Customer Orders		20	10	7	0	0	20	18	0
ATP:D		13	0	0	2	0	0	0	20
Model C—0.6 Liter Engine									
MPS	BI = 40	10	10	10	10	0	0	20	0
Committed Customer Orders		20	10	0	0	0	10	0	15
ATP:D		30	0	10	0	0	0	5	0

ATP Calculations for Model A

Model A

1. $ATP_1 = BI + MPS_1 - CCO_1 = 30 + 10 - 10 = 30$
2. $ATP_2 = MPS_2 - CCO_2 = 10 - 0 = 10$
3. $ATP_3 = MPS_3 - CCO_3 - CCO_4 = 20 - 28 - 0 = -8$ (use 8 units from ATP_2)
   Revising: $ATP_2 = 10 - 8 = 2$ and $ATP_3 = -8 + 8 = 0$
4. $ATP_4 = 0$ (no scheduled MPS)
5. $ATP_5 = MPS_5 - CCO_5 - CCO_6 - CCO_7 = 20 - 0 - 20 - 0 = 0$
6. $ATP_6 = 0$ (no scheduled MPS)
7. $ATP_7 = 0$ (no scheduled MPS)
8. $ATP_8 = MPS_8 - CCO_8 = 20 - 10 = 10$

Try To Calculate ATP for Model B & C

ATP Calculations for Model B

Model B

1. $ATP_1 = BI + MPS_1 - CCO_1 = 30 + 10 - 20 = 20$
2. $ATP_2 = MPS_2 - CCO_2 - CCO_3 = 10 - 10 - 7 = -7$ (use 7 units from ATP_1)
   Revising: $ATP_1 = 20 - 7 = 13$ and $ATP_2 = -7 + 7 = 0$
3. $ATP_3 = 0$ (no scheduled MPS)
4. $ATP_4 = MPS_4 - CCO_4 - CCO_5 = 20 - 0 - 0 = 20$
5. $ATP_5 = 0$ (no scheduled MPS)
6. $ATP_6 = MPS_6 - CCO_6 - CCO_7 = 20 - 20 - 18 = -18$ (use 18 units from ATP_4 since $ATP_5 = 0$)
   Revising: $ATP_4 = 20 - 18 = 2$ and $ATP_6 = -18 + 18 = 0$
7. $ATP_7 = 0$ (no scheduled MPS)
8. $ATP_8 = MPS_8 - CCO_8 = 20 - 0 = 20$

ATP Calculations for Model C

Model C

1. $ATP_1 = BI + MPS_1 - CCO_1 = 40 + 10 - 20 = 30$
2. $ATP_2 = MPS_2 - CCO_2 = 10 - 10 = 0$
3. $ATP_3 = MPS_3 - CCO_3 = 10 - 0 = 10$
4. $ATP_4 = MPS_4 - CCO_4 - CCO_5 - CCO_6 = 10 - 0 - 0 - 10 = 0$
5. $ATP_5 = 0$ (no scheduled MPS)
6. $ATP_6 = 0$ (no scheduled MPS)
7. $ATP_7 = MPS_7 - CCO_7 - CCO_8 = 20 - 0 - 15 = 5$
8. $ATP_8 = 0$ (no scheduled MPS)

Dependent & Independent Demand

Dependent Demand

Describes the internal demand for parts based on the demand of the final product in which the parts are used. Subassemblies, components, & raw materials are examples of dependent demand items.

Independent Demand

The demand for final products & has a demand pattern affected by trends, seasonal patterns, & general market conditions.

The Bill of Materials

Bill of Materials (BOM)

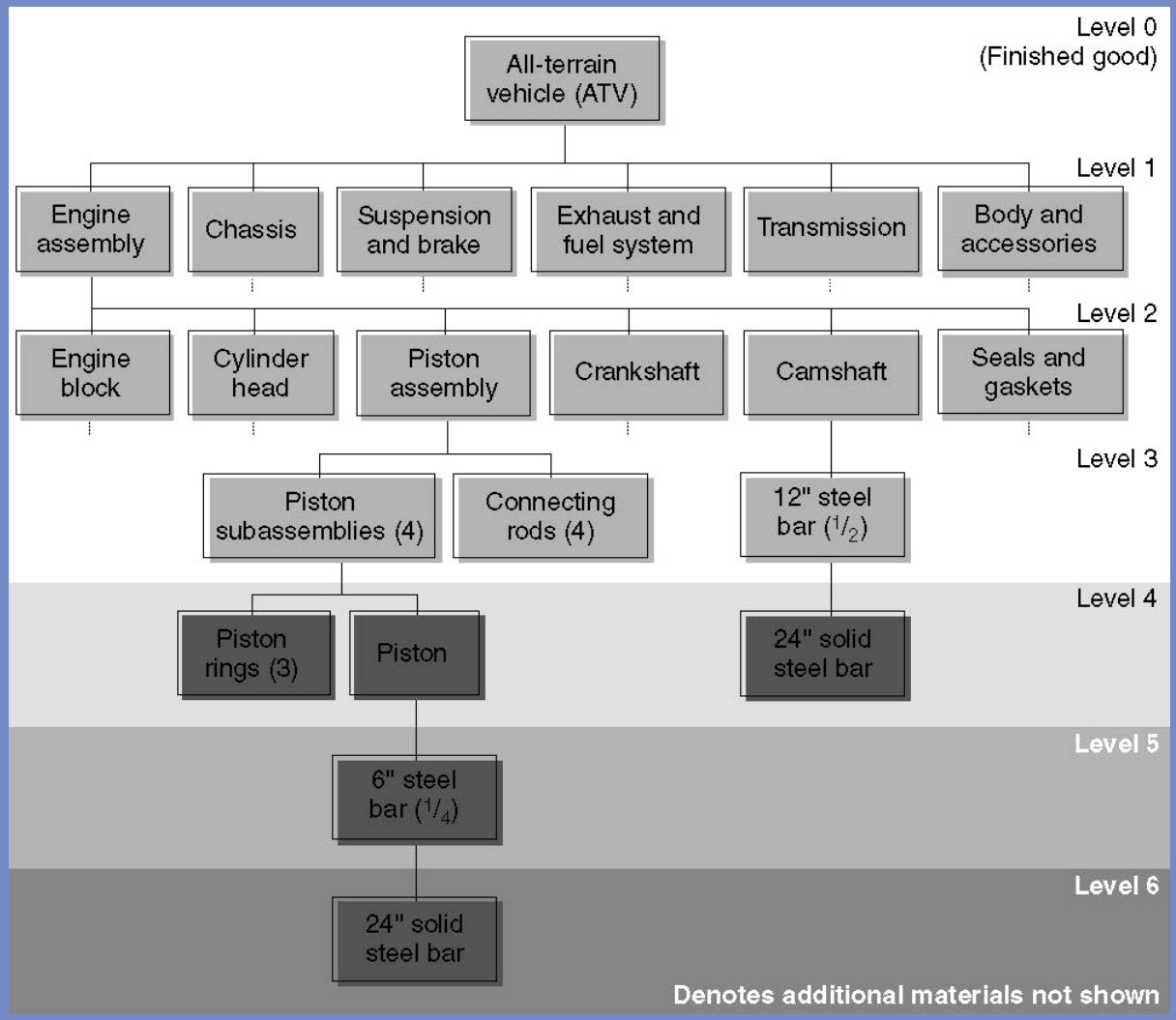
An engineering document that shows an inclusive listing of all component parts & assemblies making up the final product.

M***ultilevel Bill of Materials***

shows the parent-component relationships & the specific units of components known as the planning factor. The multilevel bill of materials can be presented as an indented bill of materials. At each level of indentation, the level number increases by one.

Super Bill of Materials (AKA planning BOM, pseudo BOM, phantom BOM, or family BOM) ***e***nables the firm to forecast the total demand end products.

The Bill of Materials- Cont.

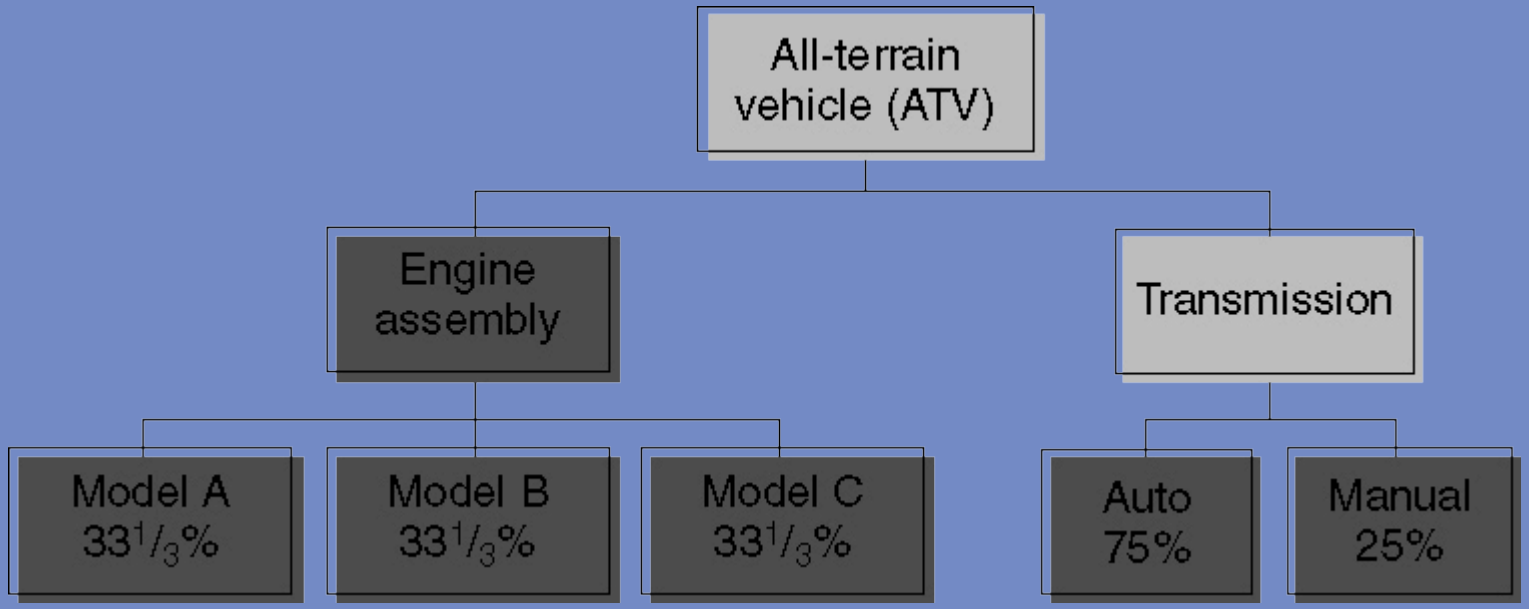


The Bill of Materials- Cont.

Table 6.6 Indented Bill of Materials—All-Terrain Vehicles

Part Description	Level	Planning Factor
Engine assembly 1		1
Engine block (components not shown)	2	1
Cylinder head (components not shown)	2	1
Piston assembly	2	1
Piston subassembly	3	4
Piston rings	4	3
Pistons	4	1
6″ steel bar	5	¼
24″ solid steel bar	6	1
Connecting rods	3	4
Crankshaft (components not shown)	2	1
Camshaft	2	1
12″ steel bar	3	½
24″ solid steel bar	4	1
Seals & gaskets (components not shown)	2	1
Chassis (components not shown)	1	1
Suspension & brake (components not shown)	1	1
Exhaust & fuel system (components not shown)	1	1
Transmission (components not shown)	1	1
Body & Accessories (components not shown)	1	1

The Bill of Materials- Cont.



Materials Requirement Planning

MRP- A computer-based materials management system. The materials requirement plan calculates the exact quantities, need dates, & planned order releases for subassemblies & materials required to manufacture the final products listed on .

MRP requires:

- The independent demand information.
- Parent-component relationships from the bill of materials.
- Inventory status of the final product & all of the components.
- Planned order releases (output of the MRP system)

Advantage of MRP- provides planning information

Disadvantage of MRP- ***loss of visibility***, especially acute for products with a deep bill of materials, & ignore capacity & shop floor conditions.

Materials Requirement Planning- Cont.

Terms used in Materials Requirement Planning

1. Parent: Item generating the demand for lower-level components.
2. Components: parts demanded by a parent.
3. Gross requirement: A time-phased requirement prior to netting out on-hand inventory & the lead-time consideration.
4. Net requirement: The unsatisfied item requirement for a specific time period. Gross requirement for that period minus the current on-hand inventory.
5. Scheduled receipt: A committed order awaiting delivery for a specific period.
6. Projected on-hand inventory: Projected closing inventory at the end of the period. Beginning inventory minus the gross requirement, plus the scheduled receipt & planned receipt & planned receipt from planned order releases.
7. Planned order release: Specific order to be released to the shop or to the supplier.

Materials Requirement Planning- Cont.

Terms used in Materials Requirement Planning- Cont.

8. Time bucket: Time period used on the MRP. Days or weeks.
9. Explosion: The process of converting a parent item's planned order releases into component gross requirements.
10. Planning factor: Number of components needed to produce a unit of the parent item.
11. Firmed planned order: Planned order that the MRP computer logic system does not automatically change when conditions change to prevent system nervousness.
12. Pegging: Relates gross requirements for a part to the planned order releases the reverse of the explosion process.
13. Low-level coding: assigns the lowest level on the bill of materials to all common components to avoid duplicate MRP computations.
14. Lot size: The order size for MRP logic
15. Safety Stock: Protects against uncertainties in demand supply, quality, & lead time.

Example

Model A's production schedule for the ATV Corporation is used to illustrate the MRP logic. Its gross requirements are first obtained from the master production schedule in Table 6.4, and the inventory status shows that 30 units of Model A are available at the start of the year. The parent-component relationships and planning factors are available from the BOM in Figure 6.4. Assuming the following lot sizes (Q), lead times (LT) and safety stocks (SS) are used, the MRP computations of the Model A ATV and some of its components are as follows:

MODEL A ATV—LEVEL 0		1	2	3	4	5	6	7	8
Gross Requirements		10	10	20	0	20	0	0	20
Scheduled Receipts			10						
Projected On-hand Inventory	30	20	20	20	20	20	20	20	20
Planned Order Releases		20		20			20		

Q = 10; LT = 2; SS = 15

Practice Questions

PART E		1	2	3	4	5	6
Gross Requirements		10	12	15	11	6	8
Scheduled Receipts			11				
Projected On-hand Inventory	15						
Planned Order Releases							

Q = LFL; LT = 2; SS = 3

PART D		1	2	3	4	5	6
Gross Requirements		7	11	9	5	8	6
Scheduled Receipts							
Projected On-hand Inventory	10						
Planned Order Releases							

Q = 30; LT = 1; SS = 0

PART F		1	2	3	4	5	6
Gross Requirements							
Scheduled Receipts		60					
Projected On-hand Inventory	20						
Planned Order Releases							

Q = 60; LT = 1; SS = 0

Capacity Planning

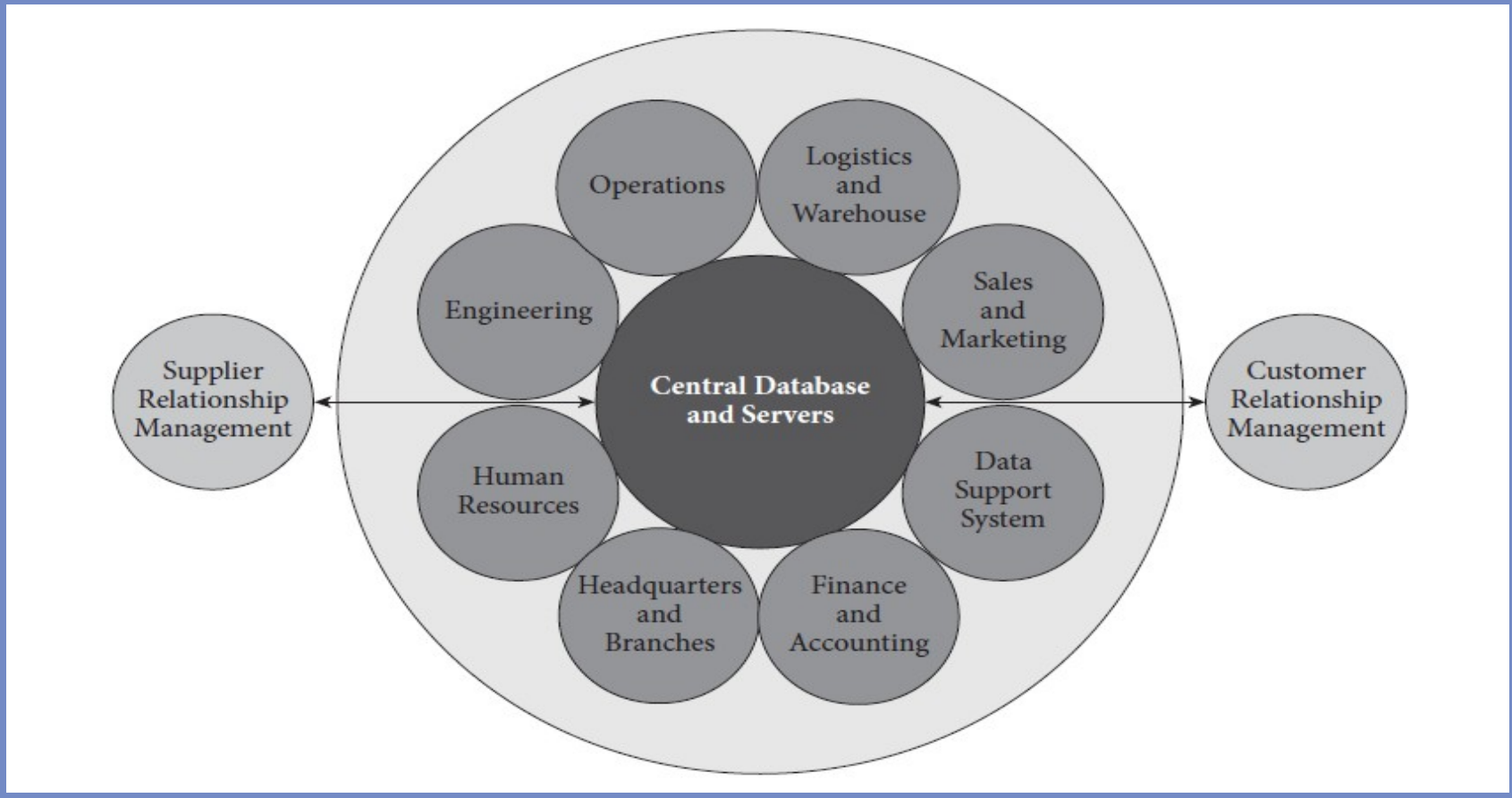
Excess (or insufficient) capacity prevents firm from taking advantage of the efficiency of manufacturing planning & control system.

Resource Requirement Planning (RRP), a long-range capacity planning module, checks whether aggregate resources are capable of satisfying the aggregate production. Resources considered include gross labor hours & machine hours.

Medium-range capacity plan, or rough-cut capacity plan (RCCP), used to check feasibility of MPS. Converts MPS from production needed to capacity required, then compares it to capacity available.

Capacity requirement planning (CRP) is a short-range capacity planning technique that is used to check the feasibility of the material requirements plan.

Generic ERP


Operations
Logistics and Warehouse
Engineering
Sales and Marketing
Supplier Relationship Management
Central Database and Servers
Customer Relationship Management
Human Resources
Data Support System
Headquarters and Branches
Finance and Accounting

Independent Demand Inventory Systems

Independent demand inventory system-

Ensures smooth operations & allows storing-up *WIP & finished goods*.

Service firms are unable to inventory their output, but may use appointment backlogs, labor scheduling & cross-training to balance supply & demand.

Four broad categories of inventories

- ***Raw materials-*** unprocessed purchase inputs.
- ***Work-in-process*** (WIP)- partially processed materials not yet ready for sales.
- ***Finished goods-*** products ready for shipment.
- ***Maintenance, repair & operating*** *(MRO)*- materials used when producing (e.g., cleaners & brooms).

Independent Demand Inventory Systems- Cont.

ABC Inventory Control System- Determines which inventories should be counted and managed more closely than others.

Groups inventory as ***A***, ***B***, and ***C*** Items.

A items are given the highest priority with larger safety stocks. ***A*** items, which account for approximately 20 % of the total items, account for about 80 % of the total inventory cost

B and ***C*** account for the other 80% of total items and only 20% of costs. The ***B*** items require closer management since they are relatively more expensive (per unit), require more effort to purchase/make, and may be more prone to obsolescence than the "trivial many" ***C*** items.

C items have the lowest priority.

Independent Demand Inventory Systems-Cont.

The Economic Order Quantity (EOQ) Model-

A quantitative decision model based on the trade-off between annual inventory holding costs and annual order costs.

The EOQ model seeks to determine an optimal order quantity, where the sum of the annual order cost and the annual inventory holding cost is minimized.

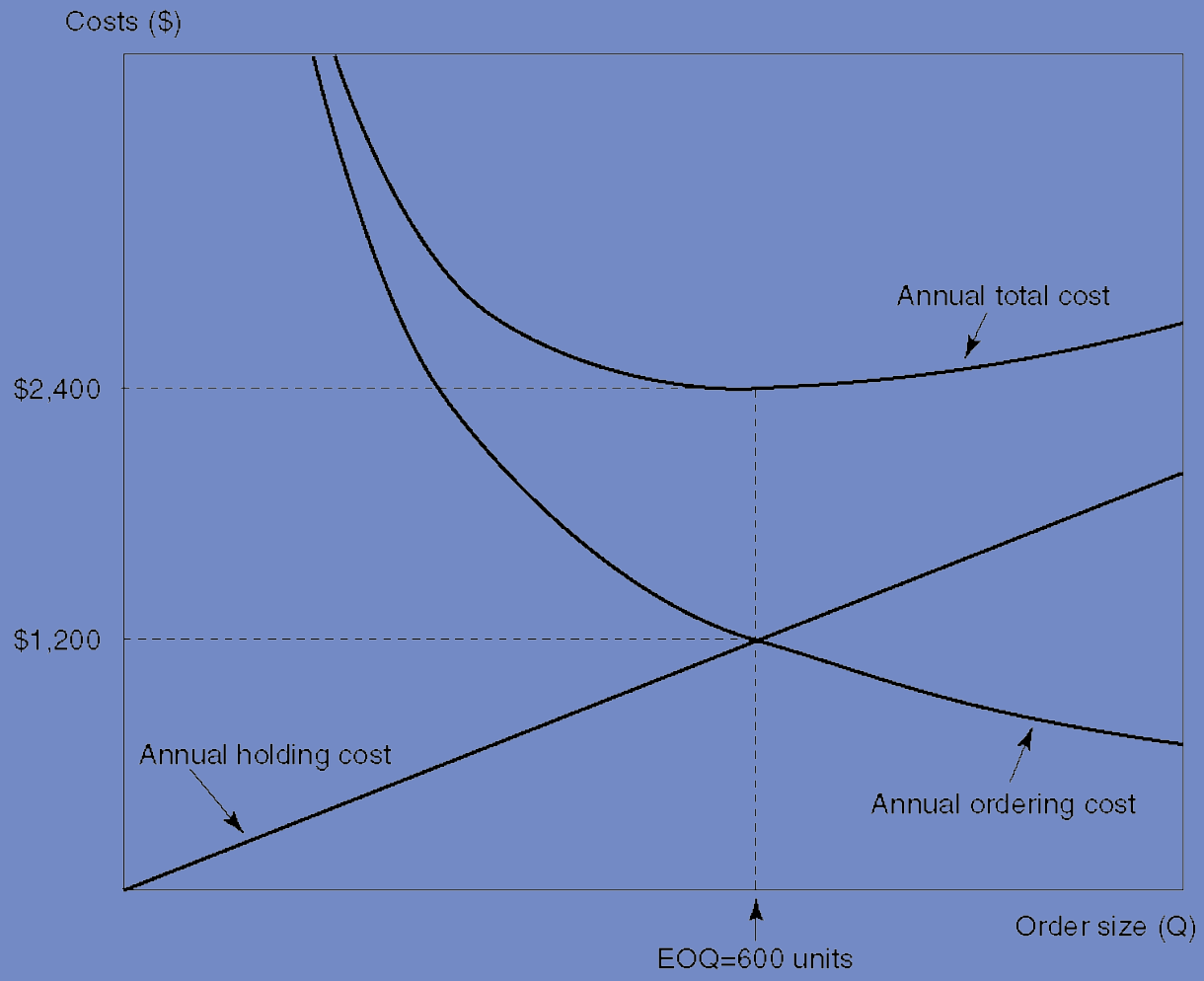
- ***Order Cost*** is the direct variable cost associated with placing an order.
- ***Holding Cost*** **or carrying cost** is the cost incurred for holding inventory in storage.

Independent Demand Inventory Systems-Cont.

Assumptions of the Economic Order Quantity Model

- Demand must be known & constant.
- Delivery time is known & constant.
- Replenishment is instantaneous.
- Price is constant.
- Holding cost is known & constant.
- Ordering cost is known & constant.
- Stock-outs are not allowed.

Independent Demand Inventory Systems-Cont.



Independent Demand Inventory Systems-Cont.