

Operations Management

Chapter 4 – Material Requirements Planning (MRP)

PowerPoint presentation for accompany
Book: MRP Under
Principles of Operations Management,
Operations Management, 1e

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Outline

- ☑ **Dependent Inventory Model Requirements**
 - ☑ **Master Production Schedule**
 - ☑ **Bills of Material**
 - ☑ **Accurate Inventory Records**
 - ☑ **Purchase Orders Outstanding**
 - ☑ **Lead Times for Each Component**

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Outline – Continued

- ☑ **MRP Structure**
- ☑ **MRP Management**
 - ☑ **MRP Dynamics**
 - ☑ **MRP and JIT**
- ☑ **Lot-Sizing Techniques**

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Outline – Continued

- ☑ **Extensions Of MRP**
 - ☑ **Closed-Loop MRP**
 - ☑ **Capacity Planning**
 - ☑ **Material Requirements Planning II (MRP II)**
- ☑ **MRP In Services**
- ☑ **Distribution Resource Planning (DRP)**

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Outline – Continued

- ☑ ***Enterprise Resource Planning (ERP)***
 - ☑ ***Advantages and Disadvantages of ERP Systems***
 - ☑ ***ERP in the Service Sector***

Benefits of MRP

- 1. Better response to customer orders***
- 2. Faster response to market changes***
- 3. Improved utilization of facilities and labor***
- 4. Reduced inventory levels***

Dependent Demand

- ☑ ***The demand for one item is related to the demand for another item***
- ☑ ***Given a quantity for the end item, the demand for all parts and components can be calculated***
- ☑ ***In general, used whenever a schedule can be established for an item***
- ☑ ***MRP is the common technique***

Dependent Demand

Effective use of dependent demand inventory models requires the following

- 1. Master production schedule***
- 2. Specifications or bill of material***
- 3. Inventory availability***
- 4. Purchase orders outstanding***
- 5. Lead times***

Master Production Schedule (MPS)

- ✓ *Specifies what is to be made and when*
- ✓ *Must be in accordance with the aggregate production plan*
- ✓ *Aggregate production plan sets the overall level of output in broad terms*
- ✓ *As the process moves from planning to execution, each step must be tested for feasibility*
- ✓ *The MPS is the result of the production planning process*

Master Production Schedule (MPS)

- ✓ *MPS is established in terms of specific products*
- ✓ *Schedule must be followed for a reasonable length of time*
- ✓ *The MPS is quite often fixed or frozen in the near term part of the plan*
- ✓ *The MPS is a rolling schedule*
- ✓ *The MPS is a statement of what is to be produced, not a forecast of demand*

Master Production Schedule (MPS)

Can be expressed in any of the following terms:

- ✓ *A customer order in a job shop (make-to-order) company*
- ✓ *Modules in a repetitive (assemble-to-stock) company*
- ✓ *An end item in a continuous (make-to-stock) company*

Aggregate Production Plan

Months	January				February			
Aggregate Production Plan (shows the total quantity of amplifiers)	1,500				1,200			
Weeks	1	2	3	4	5	6	7	8
Master Production Schedule (shows the specific type and quantity of amplifier to be produced)								
240 watt amplifier	100		100		100		100	
150 watt amplifier		500		500		450		450
75 watt amplifier			300				100	

Figure 14.2

The Planning Process

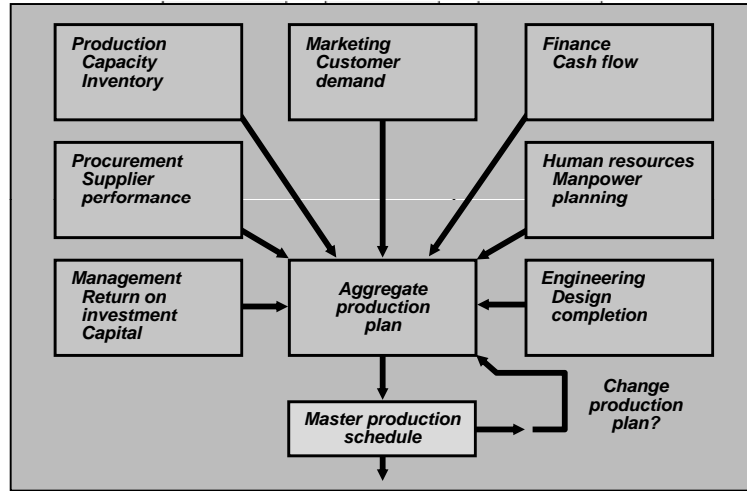


Figure 14.1

The Planning Process

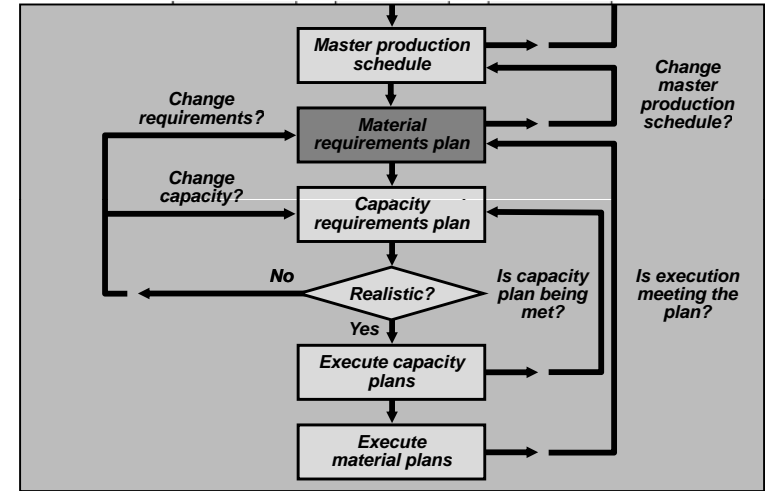


Figure 14.1

Focus for Different Process Strategies

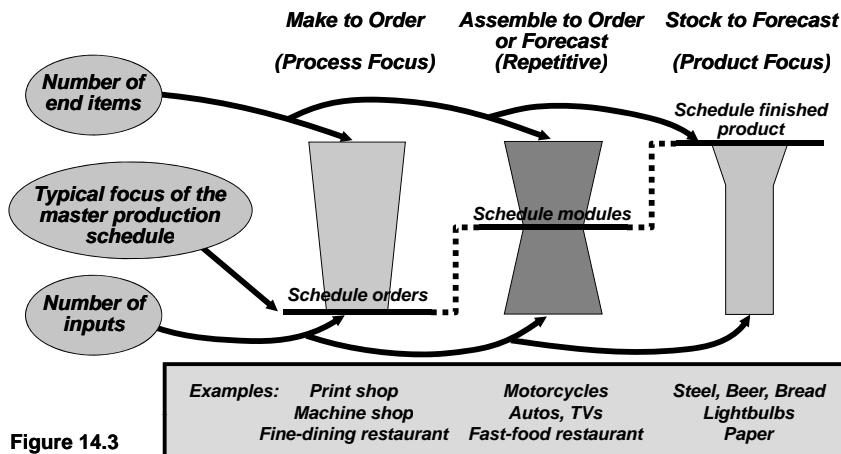


Figure 14.3

MPS Examples

For Nancy's Specialty Foods

Gross Requirements for Crabmeat Quiche										
Day	6	7	8	9	10	11	12	13	14	and so on
Amount	50		100	47	60		110	75		

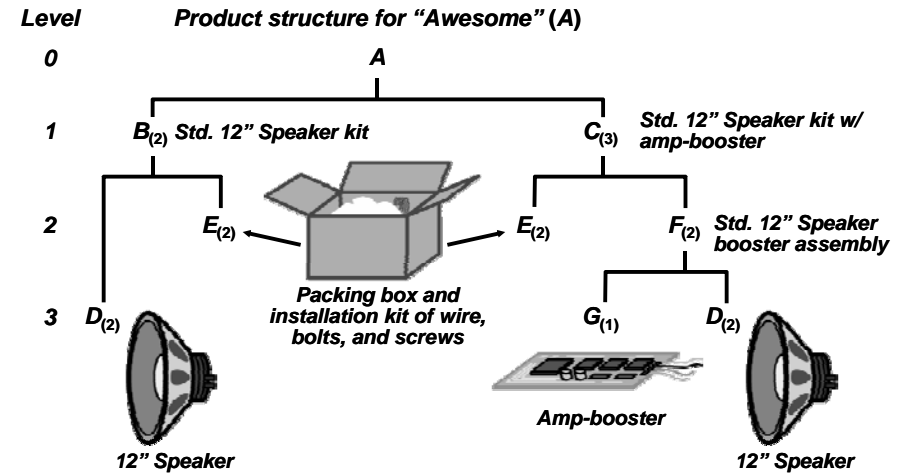
Gross Requirements for Spinach Quiche										
Day	7	8	9	10	11	12	13	14	15	16 and so on
Amount	100	200	150			60	75		100	

Table 14.1

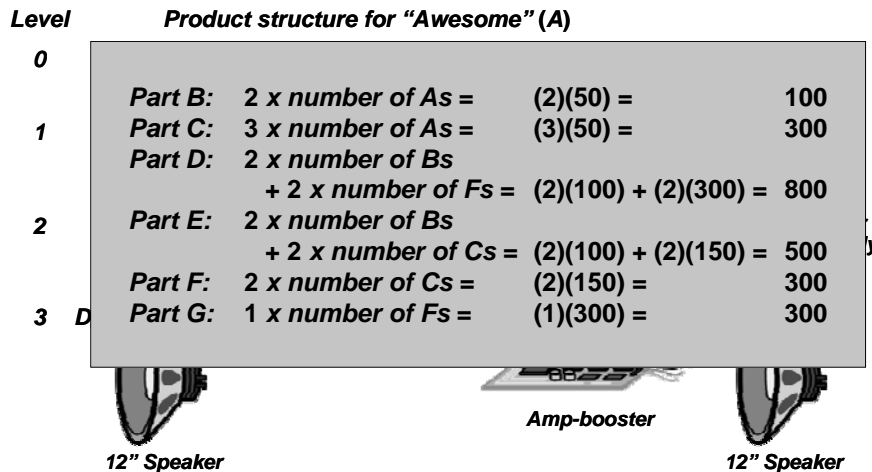
Bills of Material

- ✓ **List of components, ingredients, and materials needed to make product**
- ✓ **Provides product structure**
 - ✓ **Items above given level are called parents**
 - ✓ **Items below given level are called children**

BOM Example



BOM Example



Accurate Records

- ✓ **Accurate inventory records are absolutely required for MRP (or any dependent demand system) to operate correctly**
- ✓ **Generally MRP systems require 99% accuracy**
- ✓ **Outstanding purchase orders must accurately reflect quantities and schedule receipts**

Lead Times

- ☑ **The time required to purchase, produce, or assemble an item**
 - ☑ **For purchased items – the time between the recognition of a need and the availability of the item for production**
 - ☑ **For production – the sum of the order, wait, move, setup, store, and run times**

Time-Phased Product Structure

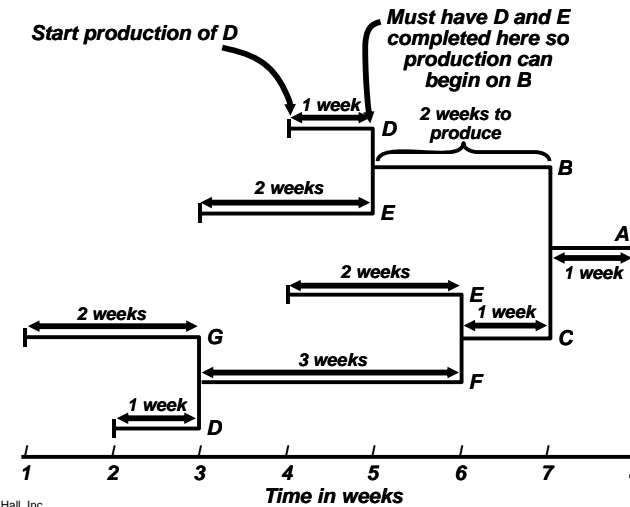


Figure 14.4

MRP Structure

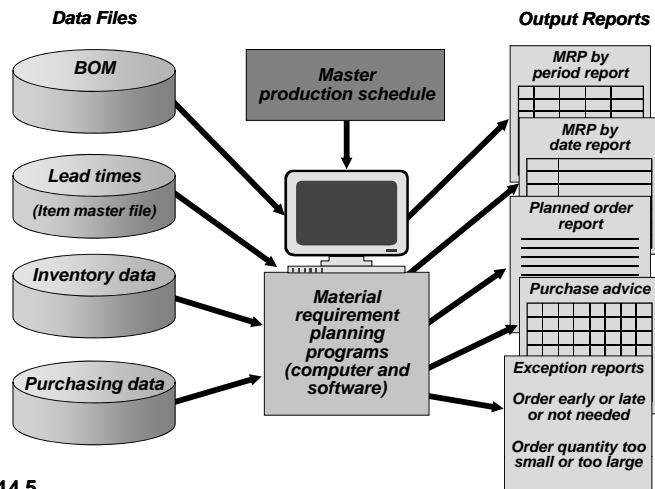


Figure 14.5

Gross Requirements Plan

	Week								Lead Time
	1	2	3	4	5	6	7	8	
A. Required date								50	1 week
Order release date							50		
B. Required date							100		2 weeks
Order release date					100				
C. Required date							150		1 week
Order release date						150			
E. Required date					200	300			1 week
Order release date			200	300					
F. Required date						300			3 weeks
Order release date			300						
D. Required date			600	200					1 week
Order release date		600							
G. Required date			300						1 week
Order release date	300								

Table 14.3

Determining Gross Requirements

- ☑ Starts with a production schedule for the end item – 50 units of Item A in week 8
- ☑ Using the lead time for the item, determine the week in which the order should be released – a 1 week lead time means the order for 50 units should be released in week 7
- ☑ This step is often called “lead time offset” or “time phasing”

Determining Gross Requirements

- ☑ From the BOM, every Item A requires 2 Item Bs – 100 Item Bs are required in week 7 to satisfy the order release for Item A
- ☑ The lead time for the Item B is 2 weeks – release an order for 100 units of Item B in week 5
- ☑ The timing and quantity for component requirements are determined by the order release of the parent(s)

Determining Gross Requirements

- ☑ The process continues through the entire BOM one level at a time – often called “explosion”
- ☑ By processing the BOM by level, items with multiple parents are only processed once, saving time and resources and reducing confusion
- ☑ Low-level coding ensures that each item appears at only one level in the BOM

Net Requirements Plan

Lot Size	Lead Time (weeks)	On Hand	Safety Stock	Allocated	Low-Level Code	Item Identification	Week												
							1	2	3	4	5	6	7	8					
Lot for Lot	1	10	—	—	0	A	Gross Requirements									50			
							Scheduled Receipts												
							Projected On Hand	10	10	10	10	10	10	10	10	10			
							Net Requirements									40			
							Planned Order Receipts									10			
Lot for Lot	2	15			1	B	Gross Requirements									80 ^A			
							Scheduled Receipts												
							Projected On Hand	15	15	15	15	15	15	15	15				
							Net Requirements									65			
							Planned Order Receipts									65			
Lot for Lot	1	20	—	—	1	C	Gross Requirements									120 ^A			
							Scheduled Receipts												
							Projected On Hand	20	20	20	20	20	20	20	20				
							Net Requirements									100			
							Planned Order Receipts									100			

Net Requirements Plan

Lot-for-Lot	2	10	—	—	2	E	Gross Requirements					130 ^U	200 ^C		
							Scheduled Receipts								
							Projected On Hand	10	10	10	10	10	10		
							Net Requirements						120	200	
							Planned Order Receipts							120	200
							Planned Order Releases					120	200		
Lot-for-Lot	3	5			2	F	Gross Requirements							200 ^C	
							Scheduled Receipts								
							Projected On Hand	h	h	h	h	h	h	h	
							Net Requirements							195	
							Planned Order Receipts							195	
							Planned Order Releases					195			
Lot-for-Lot	1	10	—	—	3	D	Gross Requirements					390 ^F	130 ^H		
							Scheduled Receipts								
							Projected On Hand	10	10	10	10				
							Net Requirements							130	
							Planned Order Receipts							130	
							Planned Order Releases			380		130			
Lot-for-Lot	2	0	—	—	3	G	Gross Requirements					195 ^F			
							Scheduled Receipts								
							Projected On Hand					0			
							Net Requirements					195			
							Planned Order Receipts						195		
							Planned Order Releases	195							

Determining Net Requirements

- ✓ **Starts with a production schedule for the end item – 50 units of Item A in week 8**
- ✓ **Because there are 10 Item As on hand, only 40 are actually required – (net requirement) = (gross requirement - on-hand inventory)**
- ✓ **The planned order receipt for Item A in week 8 is 40 units – $40 = 50 - 10$**

Determining Net Requirements

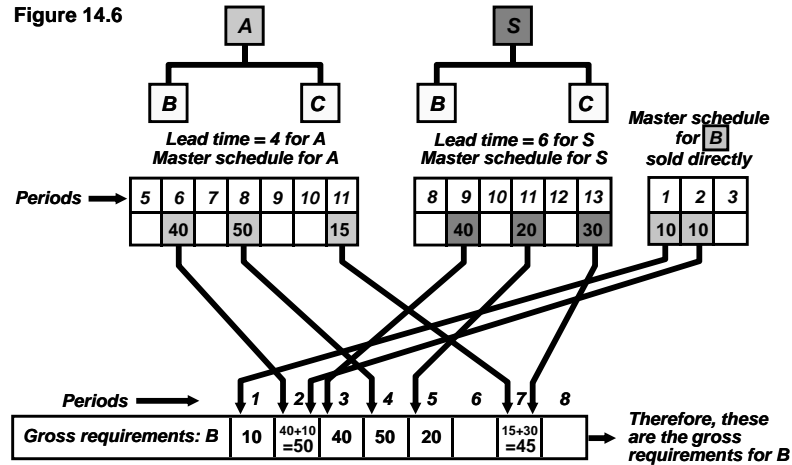
- ✓ **Following the lead time offset procedure, the planned order release for Item A is now 40 units in week 7**
- ✓ **The gross requirement for Item B is now 80 units in week 7**
- ✓ **There are 15 units of Item B on hand, so the net requirement is 65 units in week 7**
- ✓ **A planned order receipt of 65 units in week 7 generates a planned order release of 65 units in week 5**

Determining Net Requirements

- ✓ **A planned order receipt of 65 units in week 7 generates a planned order release of 65 units in week 5**
- ✓ **The on-hand inventory record for Item B is updated to reflect the use of the 15 items in inventory and shows no on-hand inventory in week 8**
- ✓ **This is referred to as the Gross-to-Net calculation and is the third basic function of the MRP process**

Gross Requirements Schedule

Figure 14.6



MRP Planning Sheet

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low-Level Code	Item ID	Period											
							1	2	3	4	5	6	7	8				
Lot	1	0	0	10	0	Z	Gross Requirements										207	90
For							Scheduled Receipts										0	0
Lot							Projected On Hand	0	0	0	0	0	0	0	0	0	0	0
							Net Requirements										90	90
							Planned Order Receipts											
							Planned Order Releases											90

Figure 14.7

Net Requirements Plan

The logic of net requirements

$$\left[\left(\text{gross requirements} \right) + \left(\text{allocations} \right) \right]$$

total requirements

$$- \left[\left(\text{on hand} \right) + \left(\text{scheduled receipts} \right) \right] = \text{net requirements}$$

available inventory

MRP Management

- ✓ MRP is a dynamic system
- ✓ Facilitates replanning when changes occur
- ✓ System nervousness can result from too many changes
- ✓ Time fences put limits on replanning
- ✓ Pegging links each item to its parent allowing effective analysis of changes

MRP and JIT

- ✓ **MRP is a planning system that does not do detailed scheduling**
- ✓ **MRP requires fixed lead times which might actually vary with batch size**
- ✓ **JIT excels at rapidly moving small batches of material through the system**

Finite Capacity Scheduling

- ✓ **MRP systems do not consider capacity during normal planning cycles**
- ✓ **Finite capacity scheduling (FCS) recognizes actual capacity limits**
- ✓ **By merging MRP and FCS, a finite schedule is created with feasible capacities which facilitates rapid material movement**

Lot-Sizing Techniques

- ✓ **Lot-for-lot techniques order just what is required for production based on net requirements**
 - ✓ **May not always be feasible**
 - ✓ **If setup costs are high, costs may be high as well**
- ✓ **Economic order quantity (EOQ)**
 - ✓ **EOQ expects a known constant demand and MRP systems often deal with unknown and variable demand**

Lot-for-Lot Example

	1	2	3	4	5	6	7	8	9	10
Gross requirements	35	30	40	0	10	40	30	0	30	55
Scheduled receipts										
Projected on hand	35	35	0	0	0	0	0	0	0	0
Net requirements	0	30	40	0	10	40	30	0	30	55
Planned order receipts		30	40		10	40	30		30	55
Planned order releases	30	40		10	40	30		30	55	

Holding cost = \$1/week; Setup cost = \$100

Lot-for-lot Example

No on-hand inventory is carried through the system
 Total holding cost = \$0

There are seven setups for this item in this plan
 Total setup cost = 7 x \$100 = \$700

Projected on hand	35	35	0	0	0	0	0	0	0	0	0
Net requirements	0	30	40	0	10	40	30	0	30	55	
Planned order receipts			30	40		10	40	30		30	55
Planned order releases	30	40			10	40	30		30	55	

Holding cost = \$1/week; Setup cost = \$100

EOQ Lot Size Example

	1	2	3	4	5	6	7	8	9	10
Gross requirements	35	30	40	0	10	40	30	0	30	55
Scheduled receipts										
Projected on hand	35	35	0	43	3	3	66	26	69	39
Net requirements	0	30	0	0	7	0	4	0	0	16
Planned order receipts			73			73		73		73
Planned order releases	73				73		73			73

Holding cost = \$1/week; Setup cost = \$100;
 Average weekly gross requirements = 27; EOQ = 73 units

EOQ Lot Size Example

Annual demand = 1,404
 Total cost = setup cost + holding cost
 Total cost = $(1,404/73) \times \$100 + (73/2) \times (\$1 \times 52 \text{ weeks})$
 Total cost = \$3,798
 Cost for 10 weeks = $\$3,798 \times (10 \text{ weeks}/52 \text{ weeks}) = \730

Projected on hand	35	35	0	43	3	3	66	26	69	39
Net requirements	0	30	0	0	7	0	4	0	0	16
Planned order receipts			73			73		73		73
Planned order releases	73				73		73			73

Holding cost = \$1/week; Setup cost = \$100;
 Average weekly gross requirements = 27; EOQ = 73 units

Lot-Sizing Summary

For these examples

Lot-for-lot	\$700
EOQ	\$730
EOQ(Actual)	\$718

Lot-Sizing Summary

- ☑ **In theory, lot sizes should be recomputed whenever there is a lot size or order quantity change**
- ☑ **In practice, this results in system nervousness and instability**
- ☑ **Lot-for-lot should be used when economical**
- ☑ **Lot sizes can be modified to allow for scrap, process constraints, and purchase lots**

Extensions of MRP

- ☑ **Closed-Loop MRP**
 - ☑ **MRP system provides input to the capacity plan, MPS, and production planning process**
- ☑ **Capacity Planning**
 - ☑ **MRP system generates a load report which details capacity requirements**
 - ☑ **This is used to drive the capacity planning process**
 - ☑ **Changes pass back through the MRP system for rescheduling**

Closed-Loop MRP System

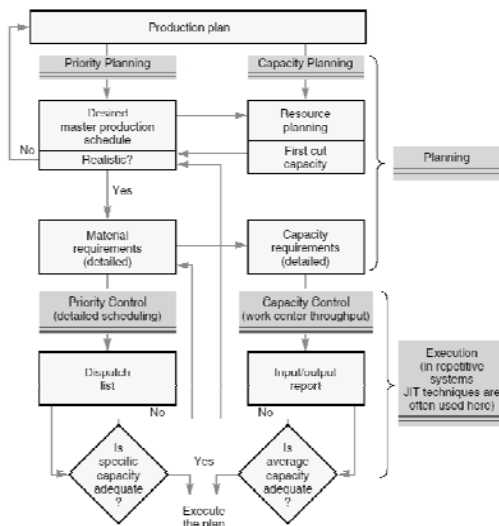


Figure 14.8

Resource Requirements Profile

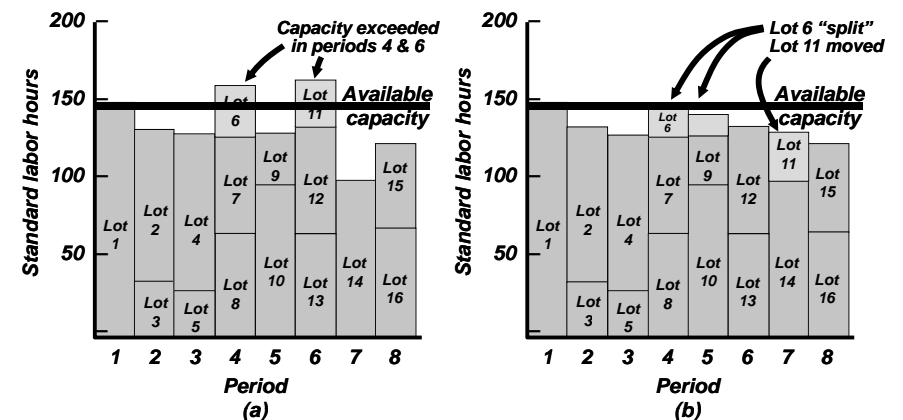


Figure 14.9

Smoothing Tactics

1. Overlapping

- Sends part of the work to following operations before the entire lot is complete
- Reduces lead time

2. Operations splitting

- Sends the lot to two different machines for the same operation
- Shorter throughput time but increased setup costs

3. Lot splitting

- Breaking up the order into smaller lots and running part ahead of schedule

Material Requirements Planning II

- Once an MRP system is in place, inventory data can be augmented by other useful information
 - Labor hours
 - Material costs
 - Capital costs
 - Virtually any resource
- System is generally called MRP II or Material Resource Planning

Material Resource Planning

	Week			
	5	6	7	8
A. Units (lead time 1 week)				100
Labor: 10 hours each				1,000
Machine: 2 hours each				200
Payable: \$0 each				0
B. Units (lead time 2 weeks, 2 each required)			200	
Labor: 10 hours each			2,000	
Machine: 2 hours each			400	
Payable: Raw material at \$5 each			1,000	
C. Units (lead time 4 weeks, 3 each required)	300			
Labor: 2 hours each	600			
Machine: 1 hour each	300			
Payable: Raw material at \$10 each	3,000			

Table 14.4

MRP in Services

- Some services or service items are directly linked to demand for other services
- These can be treated as dependent demand services or items
 - Restaurants
 - Hospitals
 - Hotels

MRP in Services

(a) PRODUCT STRUCTURE TREE

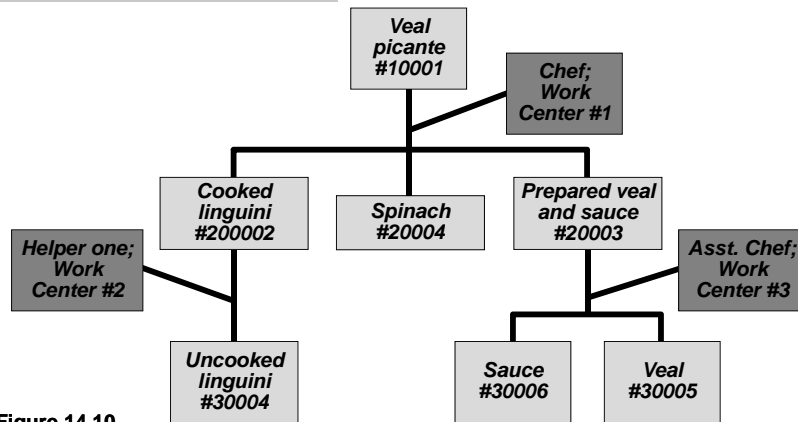


Figure 14.10

MRP in Services

(b) BILL OF MATERIALS

Part Number	Description	Quantity	Unit of Measure	Unit cost
10001	Veal picante	1	Serving	—
20002	Cooked linguini	1	Serving	—
20003	Prepared veal and sauce	1	Serving	—
20004	Spinach	0.1	Bag	0.94
30004	Uncooked linguini	0.5	Pound	—
30005	Veal	1	Serving	2.15
30006	Sauce	1	Serving	0.80

MRP in Services

(c) BILL OF LABOR FOR VEAL PICANTE

Work Center	Operation	Labor Type	Labor Hours	
			Setup Time	Run Time
1	Assemble dish	Chef	.0069	.0041
2	Cook linguini	Helper one	.0005	.0022
3	Cook veal and sauce	Assistant Chef	.0125	.0500

Distribution Resource Planning (DRP)

Using dependent demand techniques through the supply chain

- Gross requirements, which are the same as expected demand or sales forecasts
- Minimum levels of inventory to meet customer service levels
- Accurate lead times
- Definition of the distribution structure

Enterprise Resource Planning (ERP)

- ✓ **An extension of the MRP system to tie in customers and suppliers**
 1. **Allows automation and integration of many business processes**
 2. **Shares common data bases and business practices**
 3. **Produces information in real time**
- ✓ **Coordinates business from supplier evaluation to customer invoicing**

Enterprise Resource Planning (ERP)

- ✓ **ERP modules include**
 - ✓ **Basic MRP**
 - ✓ **Finance**
 - ✓ **Human resources**
 - ✓ **Supply chain management (SCM)**
 - ✓ **Customer relationship management (CRM)**

Enterprise Resource Planning (ERP)

- ✓ **ERP can be highly customized to meet specific business requirements**
- ✓ **ERP systems can be integrated with**
 - ✓ **Warehouse management**
 - ✓ **Logistics**
 - ✓ **Electronic catalogs**
 - ✓ **Quality management**

Enterprise Resource Planning (ERP)

- ✓ **ERP systems have the potential to**
 - ✓ **Reduce transaction costs**
 - ✓ **Increase the speed and accuracy of information**
- ✓ **Facilitates a strategic emphasis on JIT systems and integration**

ERP and MRP

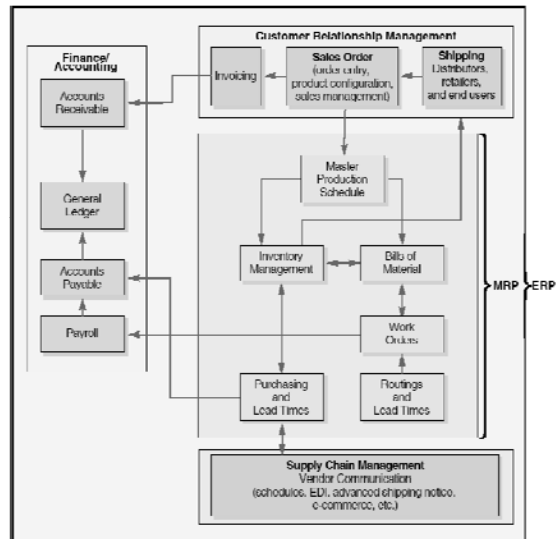


Figure 14.11

Advantages of ERP Systems

1. Provides integration of the supply-chain, production, and administration
2. Creates commonality of databases
3. Can incorporate improved best processes
4. Increases communication and collaboration between business units and sites
5. Has an off-the-shelf software database
6. May provide a strategic advantage

Disadvantages of ERP Systems

1. Is very expensive to purchase and even more so to customize
2. Implementation may require major changes in the company and its processes
3. Is so complex that many companies cannot adjust to it
4. Involves an ongoing, possibly never ending, process for implementation
5. Expertise is limited with ongoing staffing problems