Material Requirements Planning (MRP) and ERP

Source: Pearson Education Ltd. 2020. Chapter 14

8

Outline

- Global Company Profile: *Wheeled Coach*
- Dependent Demand
- Dependent Inventory Model Requirements
- MRP Structure
- MRP Management

Outline - Continued

- Lot-Sizing Techniques
- Extensions of MRP (reading)
- MRP In Services (reading)
- Enterprise Resource Planning (ERP) (reading)

MRP for Wheeled Coach

- Largest manufacturer of ambulances in the world
- International competitor
- 12 major ambulance designs
  - 18,000 different inventory items
  - 6,000 manufactured parts
  - 12,000 purchased parts

MRP for Wheeled Coach

- Four Key Tasks
  - Material plan must meet both the requirements of the master schedule and the capabilities of the production facility
  - Plan must be executed as designed
  - Minimize inventory investment
  - Maintain excellent record integrity

Learning Objectives

When you complete this chapter you should be able to:

8.1 ***Develop*** a product structure

8.2 ***Build*** a gross requirements plan

8.3 ***Build*** a net requirements plan

8.4 ***Determine*** lot sizes for lot-for-lot, EOQ, and POQ

Dependent Demand

For any well-defined product for which a schedule can be established, dependent demand techniques should be used

Dependent Demand

- 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 Inventory Model Requirements

- 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 – APP.
- Inputs from financial plans, customer demand, engineering, labor availability, inventory fluctuations, supplier performance
- As the process moves from planning to execution, each step must be tested for feasibility

Master Production Schedule (MPS)

- MPS is established in terms of specific products, it disaggregates the aggregate plan
- 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

The Planning Process

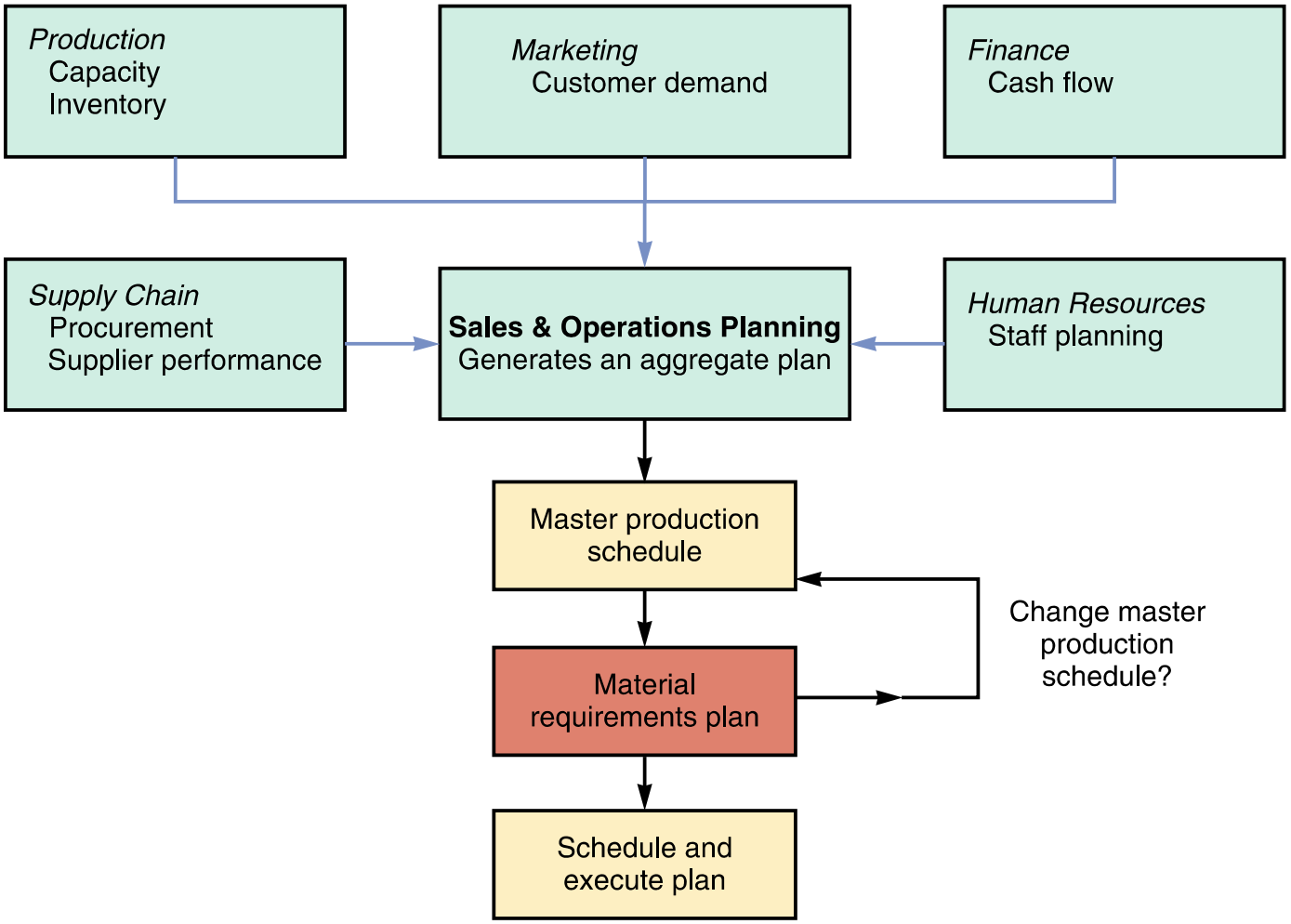


Figure 8.1

The Planning Process

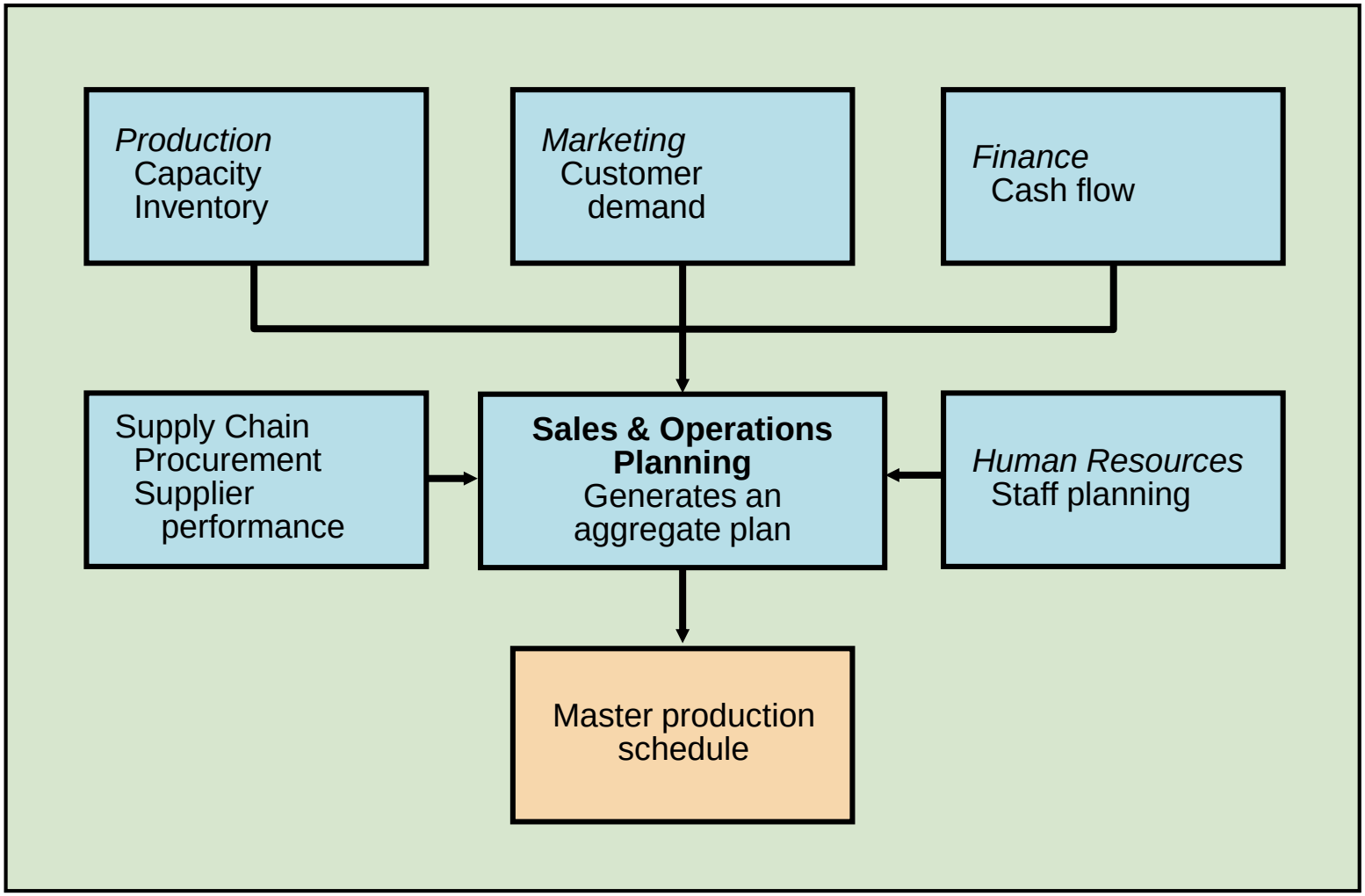


Figure 8.1

The Planning Process

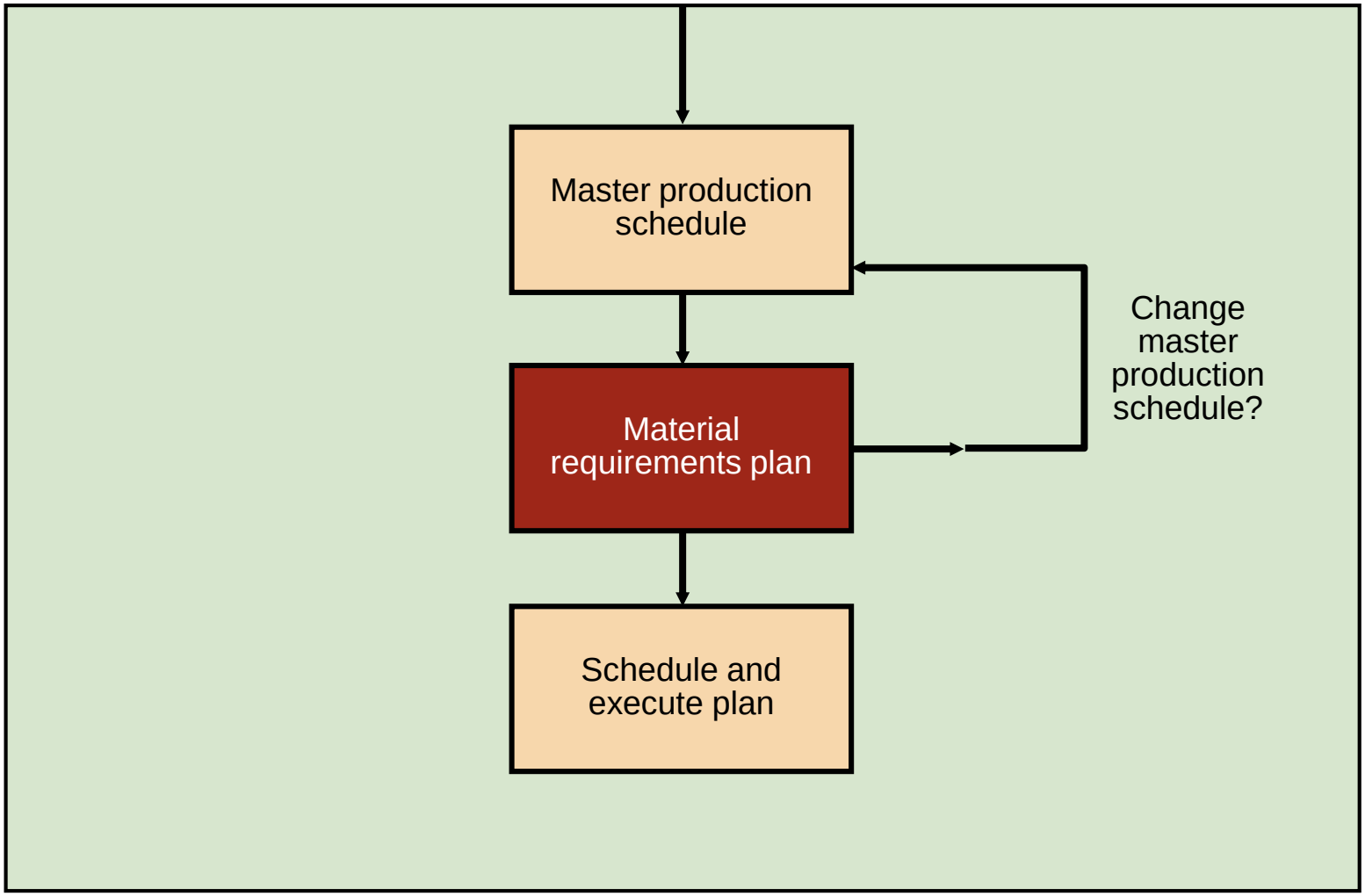


Figure 8.1

Aggregate Production Plan

Figure 8.2

Months	January				February			
Aggregate 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	

Master Production Schedule (MPS)

Can be expressed in any of the following terms:

1. A *customer order* in a job shop (make-to-order) company
2. *Modules* in a repetitive (assemble-to-order or forecast) company
3. An *end item* in a continuous (stock-to-forecast) company

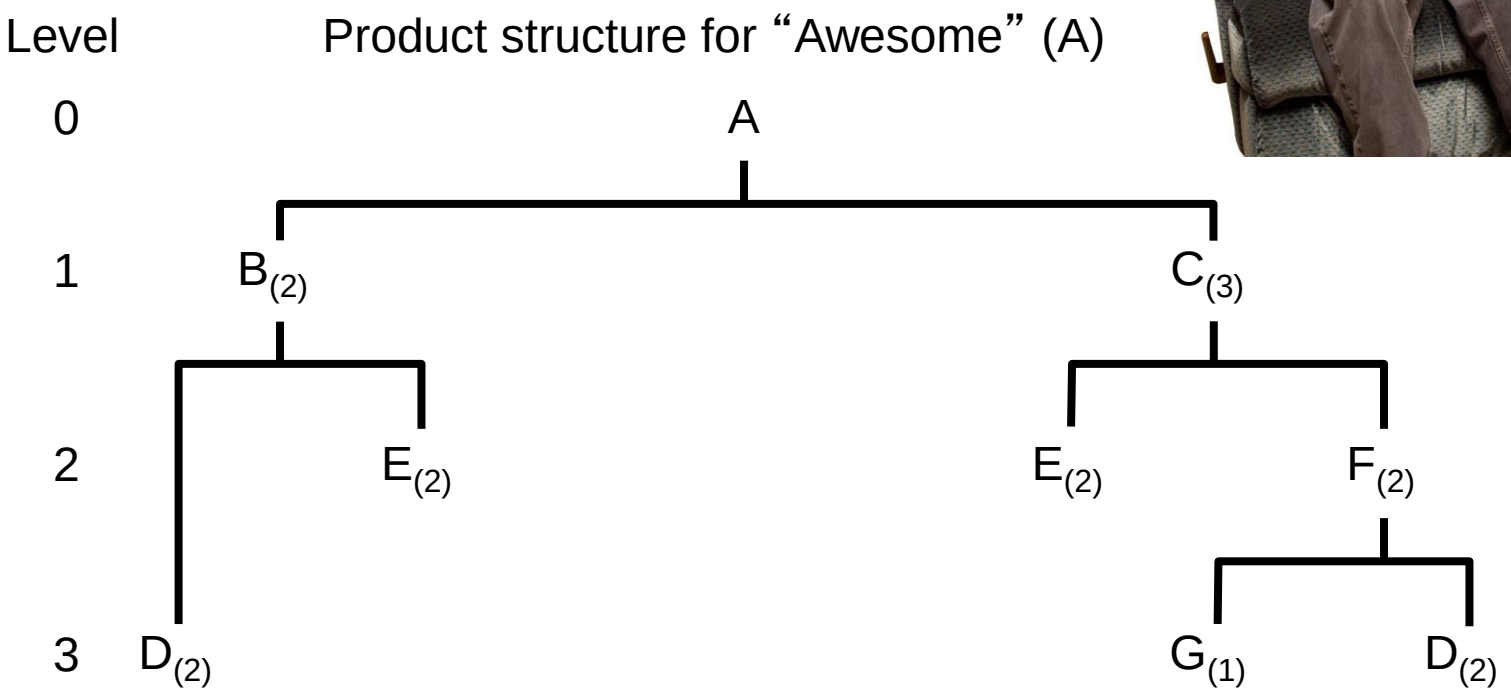
MPS Example

TABLE 8.1	Master Production Schedule for Chef John's Buffalo Chicken Mac & Cheese									
GROSS REQUIREMENTS FOR CHEF JOHN'S BUFFALO MAC & CHEESE										
Day	6	7	8	9	10	11	12	13	14	And so on
Quantity	450		200	350	525		235	375		

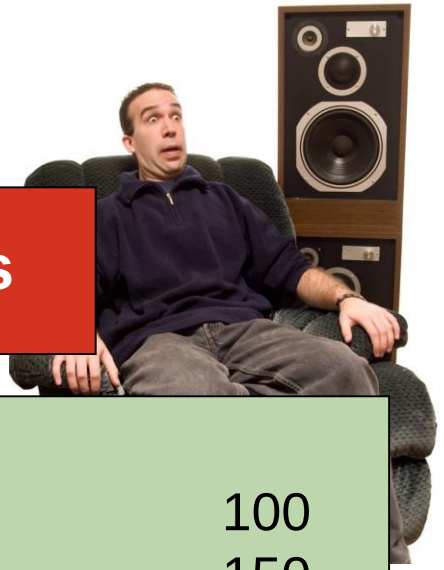
Bills of Material

- 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 *components* or *children*

BOM Example


Level
Product structure for “Awesome” (A)
0
A
1
B(2)
C(3)
2
E(2)
E(2)
F(2)
3
D(2)
G(1)
D(2)

BOM Example



For an order of 50 Awesome speaker kits

Part B:	2 × number of As =	(2)(50) =	100
Part C:	3 × number of As =	(3)(50) =	150
Part D:	2 × number of Bs		
	+ 2 × number of Fs =	(2)(100) + (2)(300) =	800
Part E:	2 x number of Bs		
	+ 2 × number of Cs =	(2)(100) + (2)(150) =	500
Part F:	2 × number of Cs =	(2)(150) =	300
Part G:	1 × number of Fs =	(1)(300) =	300

3 $D_{(2)}$ $G_{(1)}$ $D_{(2)}$

Bills of Material

- Modular Bills
  - *Modules* are not final products but components that can be assembled into multiple end items
  - Can significantly simplify planning and scheduling

Bills of Material

- Planning Bills
  - Also called “pseudo” or super bills
  - Created to assign an artificial parent to the BOM
    1. Used to group subassemblies to reduce the number of items planned and scheduled
    2. Used to create standard “kits” for production

Bills of Material

- Phantom Bills
  - Describe subassemblies that exist only temporarily
  - Are part of another assembly and never go into inventory
- Low-Level Coding
  - Item is coded at the lowest level at which it occurs
  - BOMs are processed one level at a time

Accurate Inventory Records

- Accurate inventory records are absolutely required for MRP (or any dependent demand system) to operate correctly
- MRP systems require more than 99% accuracy

Purchase Orders Outstanding

- A by-product of well-managed purchasing and inventory control department
- Outstanding purchase orders must accurately reflect quantities and scheduled receipts

Lead Times for Components

- The time required to purchase, produce, or assemble an item
  - For production – the sum of the *move*, *setup*, and *assembly* or *run times*
  - For purchased items – the time between the recognition of a need and when it's available for production

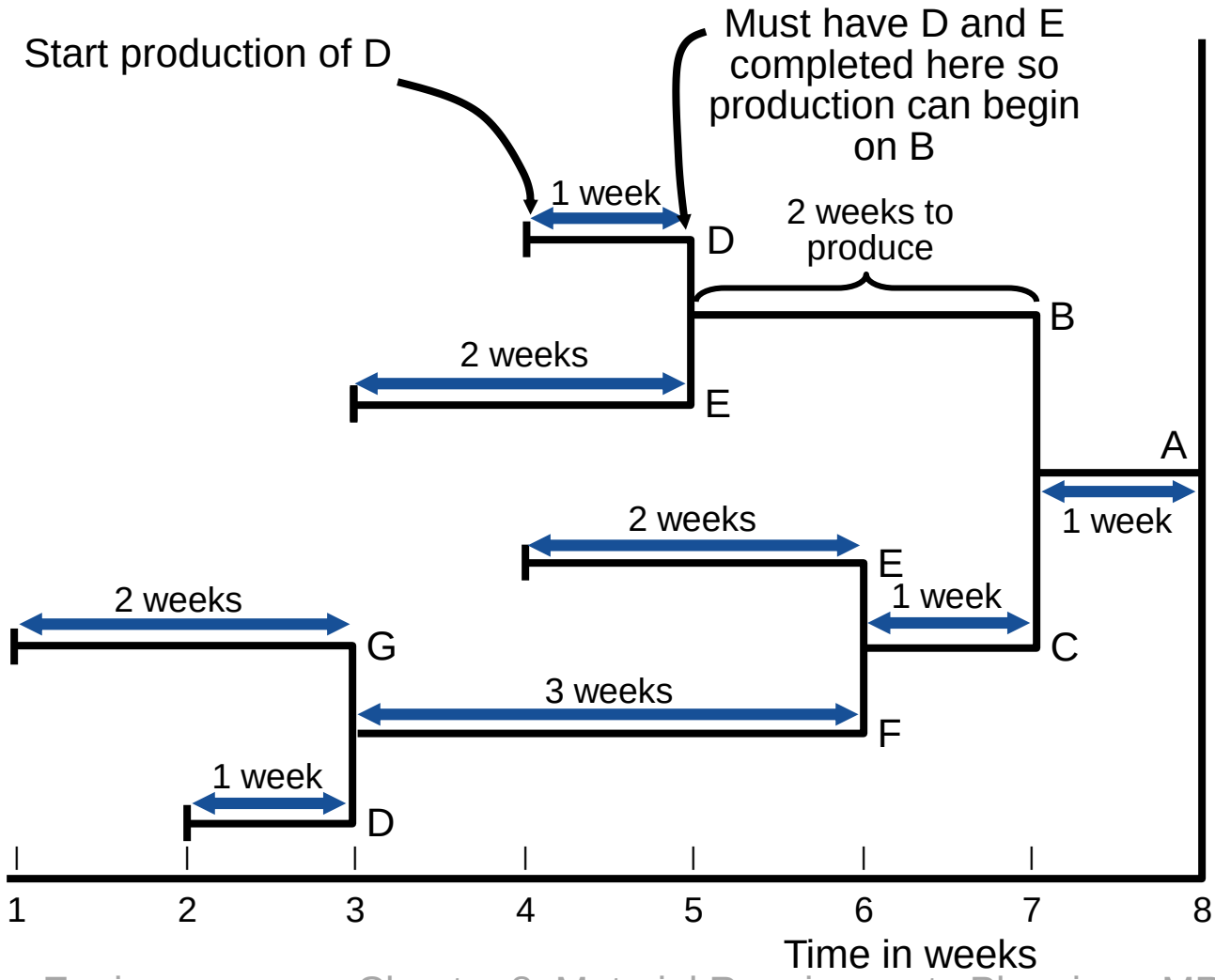
TABLE 14.2

Lead Times for Awesome Speaker Kits (As)

COMPONENT	LEAD TIME
A	1 week
B	2 weeks
C	1 week
D	1 week
E	2 weeks
F	3 weeks
G	2 weeks

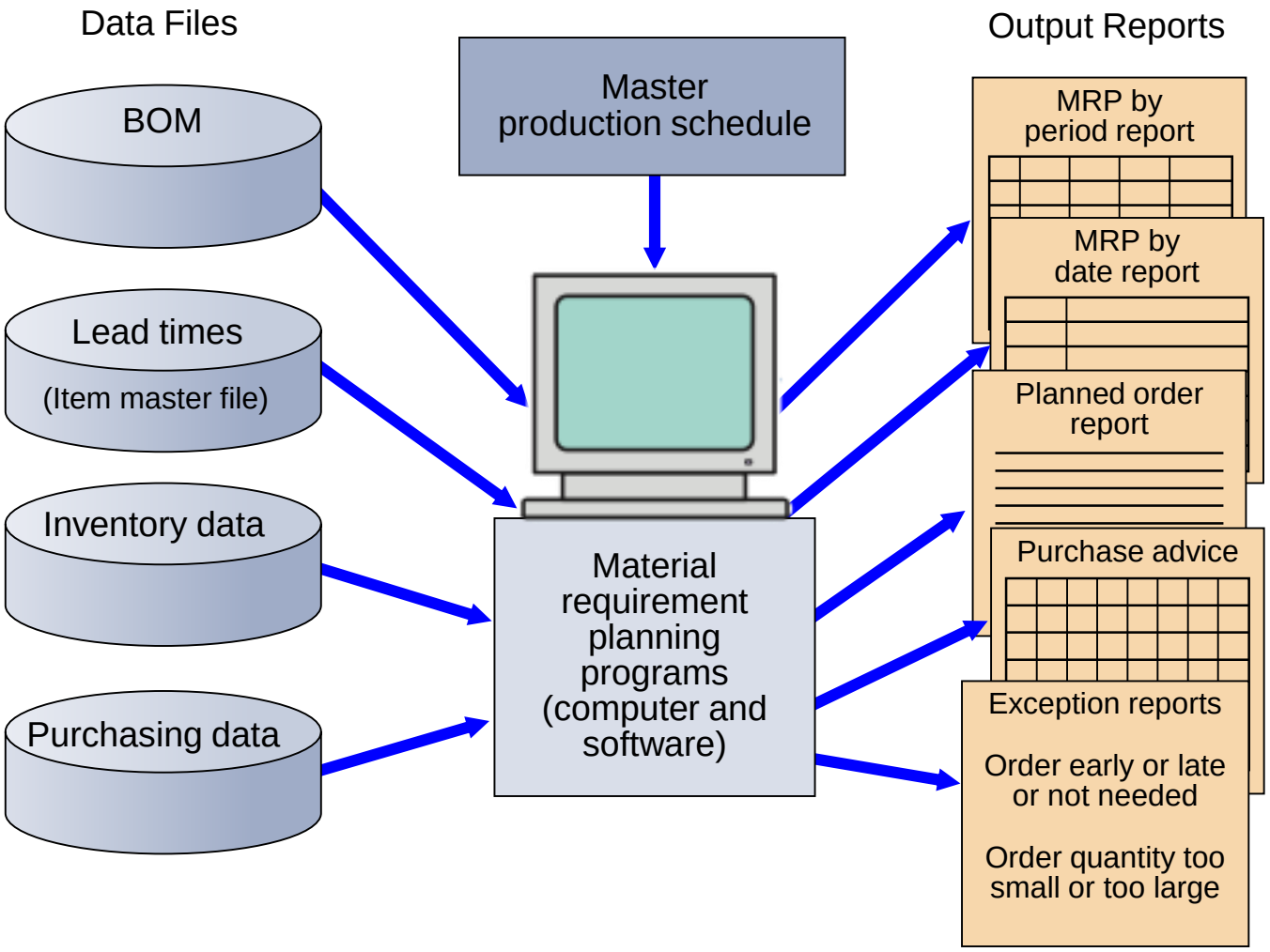
Time-Phased Product Structure

Figure 8.3



MRP Structure

Figure 8.4



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

Gross Requirements Plan

TABLE 8.3 Gross Material Requirements Plan for 50 Awesome Speaker Kits (As) with Order Release Dates Also Shown

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

Net Requir

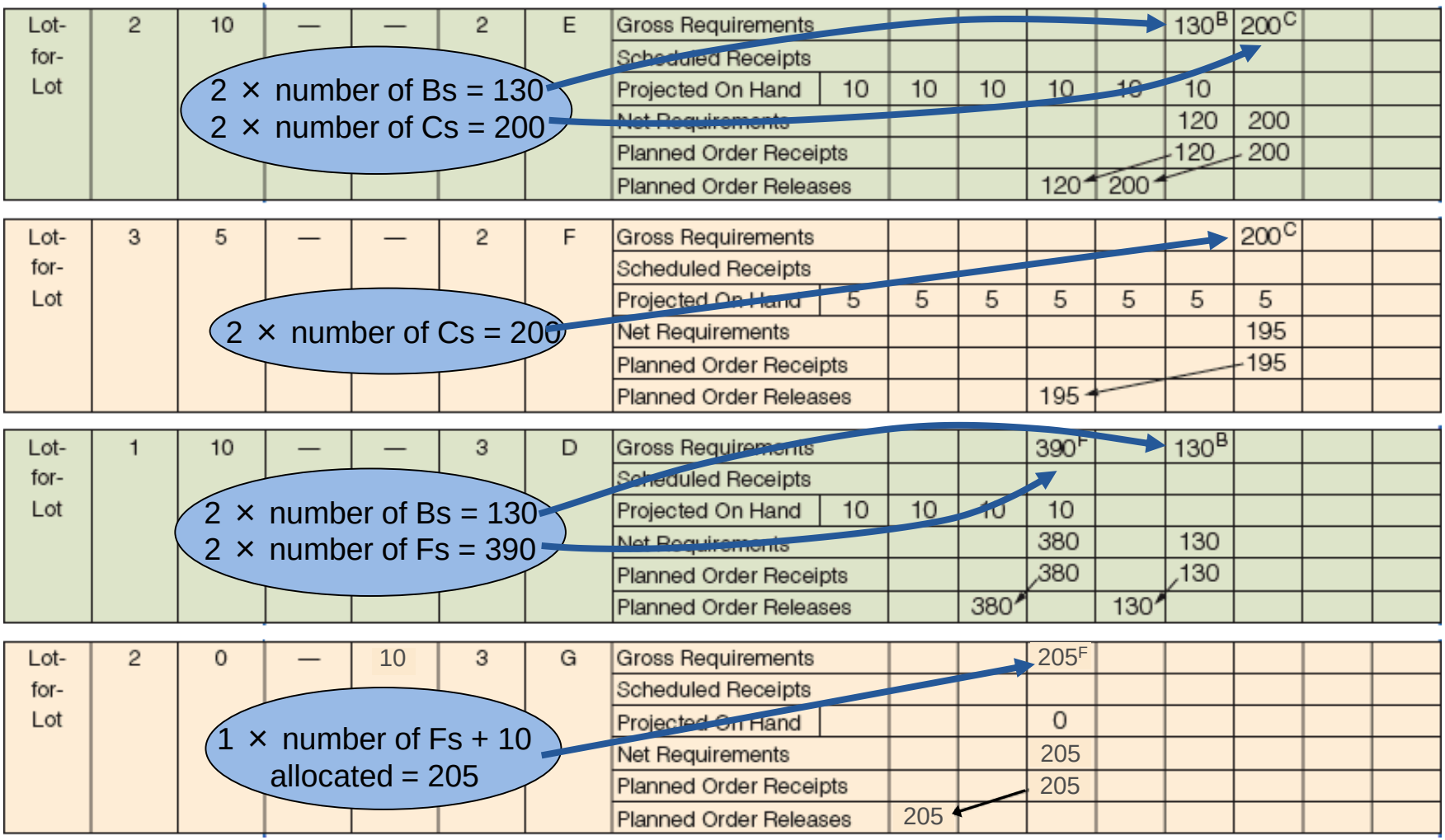
ITEM	ON HAND	ITEM	ON HAND
A	10	E	10
B	15	F	5
C	20	G	0
D	10		

Lot Size	Lead Time (weeks)	On Hand	Safety Stock	Allo-cated	Low-Level Code	Item Identi-fication		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								40
							Planned Order Releases							40	
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	
							Planned Order Releases					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	
							Planned Order Releases						100		

2 × number of As = 80

3 × number of As = 120

Net Requirements Plan



Determining Net Requirements

Trừ lượng đã có

- 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

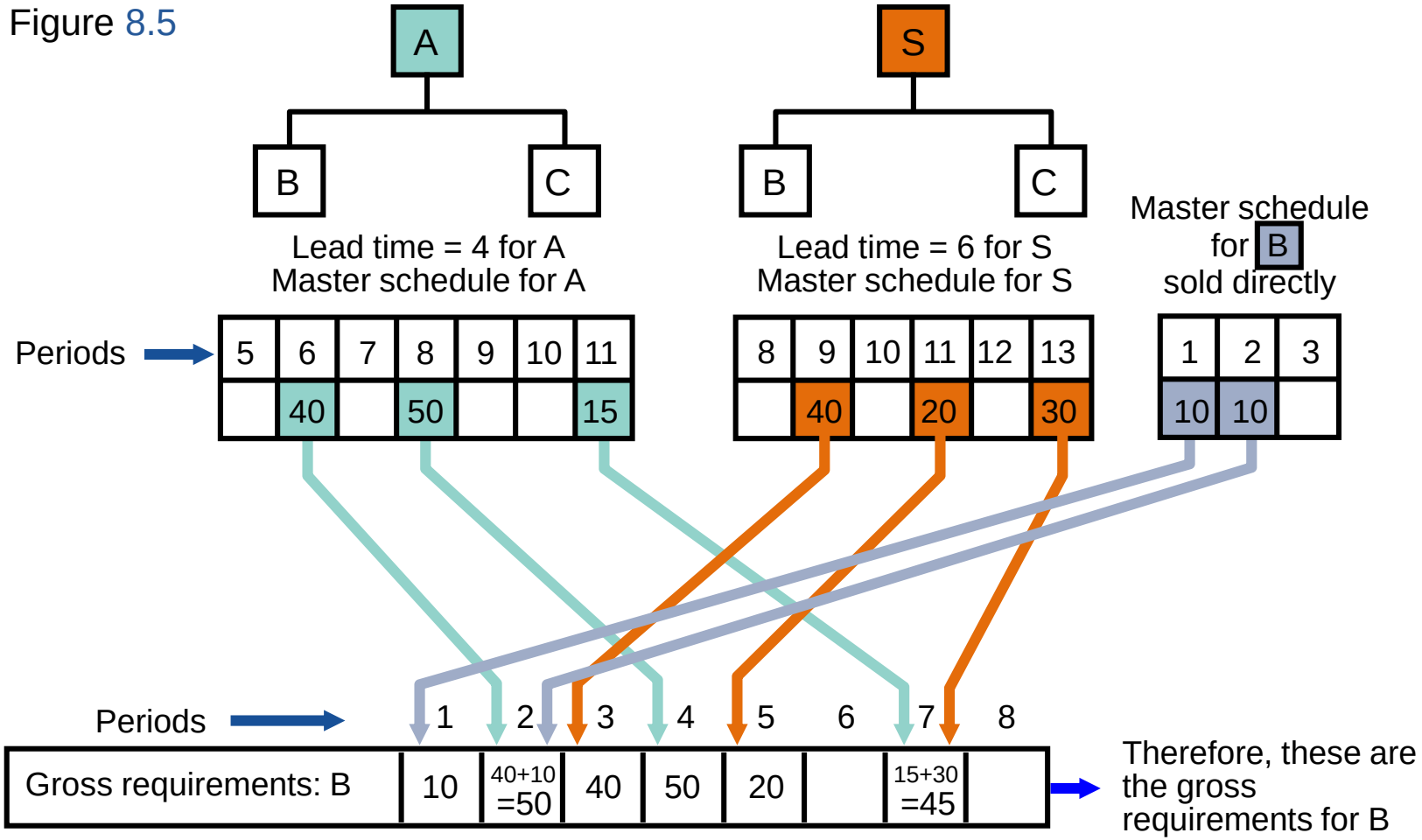
- Following the lead time offset procedure, the planned order release for Item A is now 40 units in week 7
- The gross requirement for Item B is now 80 units in week 7
- There are 15 units of Item B on hand, so the net requirement is 65 units in week 7
- A planned order receipt of 65 units in week 7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

Determining Net Requirements

- 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

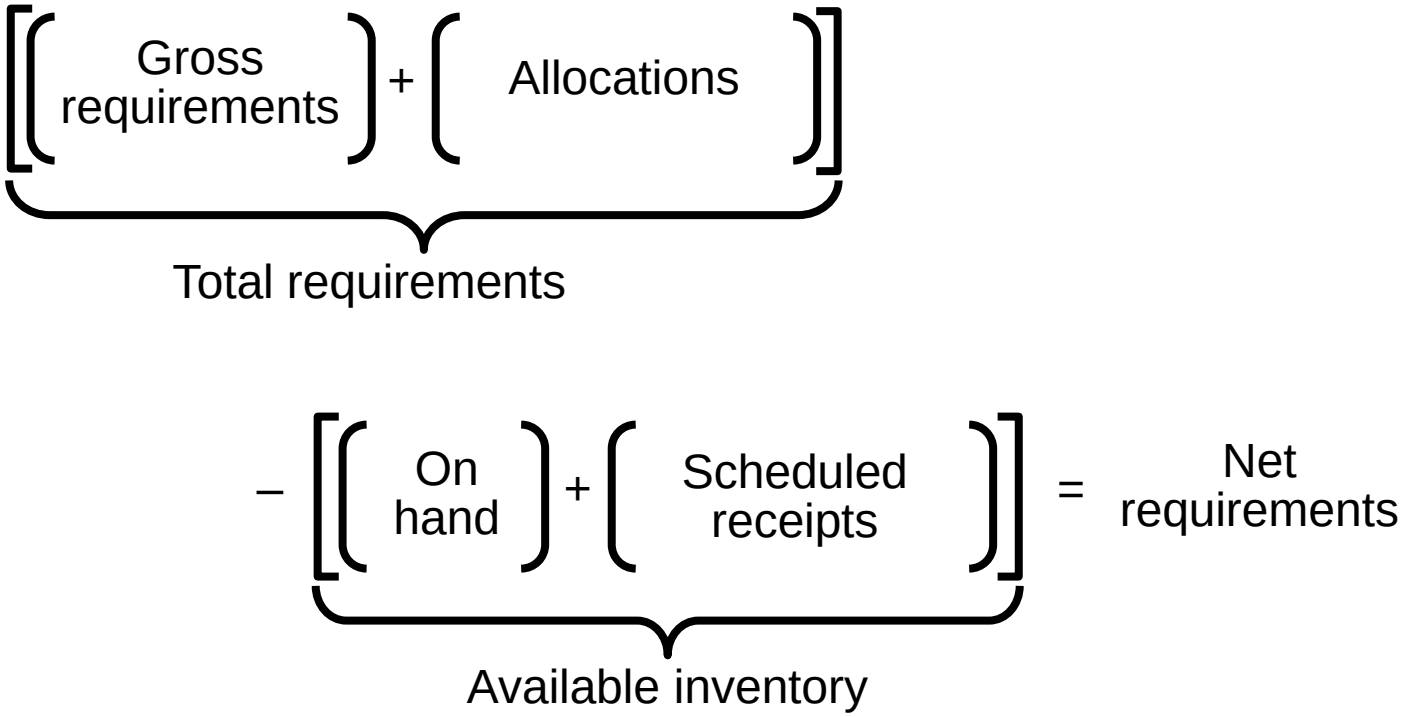
Gross Requirements Schedule

Figure 8.5



Net Requirements Plan

The logic of net requirements



MRP Management

- MRP dynamics
  - **Demand-driven MRP** strategically alters lead times and precisely places safety stock within the BOM structure to improve MRP performance
  - Can reduce stockouts and improve stability

Demand-Driven MRP

- Five primary components
  1. Determine where within the BOM structure to position the safety stock
  2. Determine initial safety-stock levels
  3. Monitor conditions and adjust levels
  4. Identify, track, and prioritize forecasted demand
  5. Use DDMRP information for increased communication and collaboration

Demand-Driven MRP

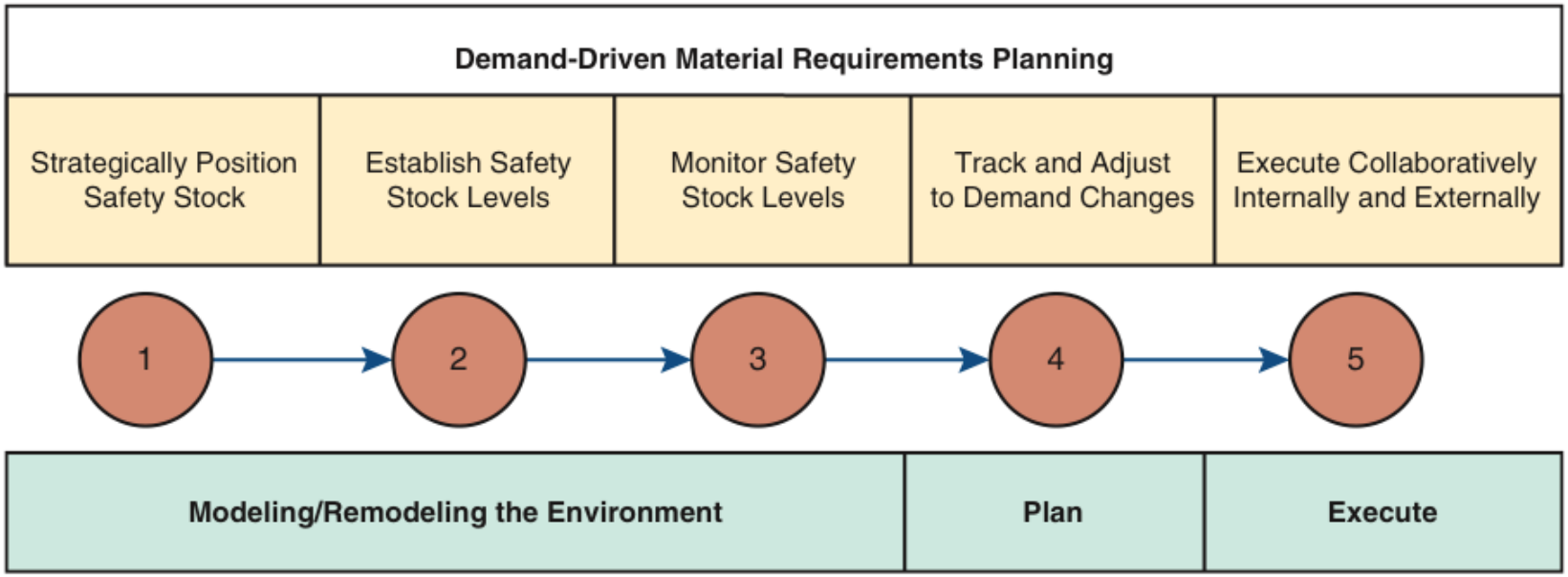


Figure 8.6

MRP Management

- MRP dynamics
  - 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 Management

- MRP limitations
  - MRP does not do detailed scheduling–it plans
  - Works best in product-focused, repetitive environments
  - Requires fixed lead times and time **buckets** with unlimited capacity

Lot-Sizing Techniques

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

Lot-Sizing Techniques

- **Periodic order quantity** (**POQ**) orders quantity needed for a predetermined time period
  - Interval = EOQ / average demand per period
  - Order quantity set to cover the interval
  - *Order quantity recalculated at the time of the order release*
  - No extra inventory

Lot-Sizing Techniques

- *Dynamic lot sizing* techniques
  - Balance lot size and setup costs
  - *Part period balancing* (*least total cost*)
  - *Least unit cost*
  - *Least period cost* (*Silver-Meal*)
- Dynamic programming approach
  - *Wagner-Whitin*

Lot-for-Lot Example

WEEK		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	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; Lead time = 1 week

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 ordering cost = 7 × $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; Lead time = 1 week

EOQ Lot Size Example

WEEK		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	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; Lead time = 1 week
Average weekly gross requirements = 27; EOQ = 73 units

EOQ Lot Size Example

Annual demand D = 1,404
Holding cost = 375 units × $1 (including 57 units on hand at end of week 10)
Ordering cost = 4 × $100 = $400
Total cost = $375 + $400 = $775

Projected on hand	35	35	0	43	3	3	66	26	69	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; Lead time = 1 week
Average weekly gross requirements = 27; EOQ = 73 units

POQ Lot Size Example

WEEK		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	40	0	0	70	30	0	0	55
Net requirements		0	30	0	0	10	0	0	0	55	0
Planned order receipts			70			80				85	
Planned order releases		70			80				85		

EOQ = 73 units; Average weekly gross requirements = 27;
POQ interval = 73/27 ≅ 3 weeks

POQ Lot Size Example

Setups = 3 × $100 = $300
Holding cost = (40 + 70 + 30 + 55) units × $1 = $195
Total cost = $300 + $195 = $495

Projected on hand	35	35	0	40	0	0	70	30	0	0	55
Net requirements		0	30	0	0	10	0		0	55	0
Planned order receipts			70			80				85	
Planned order releases		70			80				85		

EOQ = 73 units; Average weekly gross requirements = 27;
POQ interval = 73/27 ≅ 3 weeks

Lot-Sizing Summary

For these three examples

	COSTS		
	SETUP	HOLDING	TOTAL
Lot-for-lot	$700	$0	$700
EOQ	$400	$375	$775
POQ	$300	$195	$495

Wagner-Whitin would have yielded a plan with a total cost of $455

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 low-cost setups can be achieved

Lot-Sizing Summary

- Lot sizes can be modified to allow for scrap, process constraints, and purchase lots
- Use lot-sizing with care as it can cause considerable distortion of requirements at lower levels of the BOM
- When setup costs are significant and demand is reasonably smooth, POQ or EOQ should give reasonable results