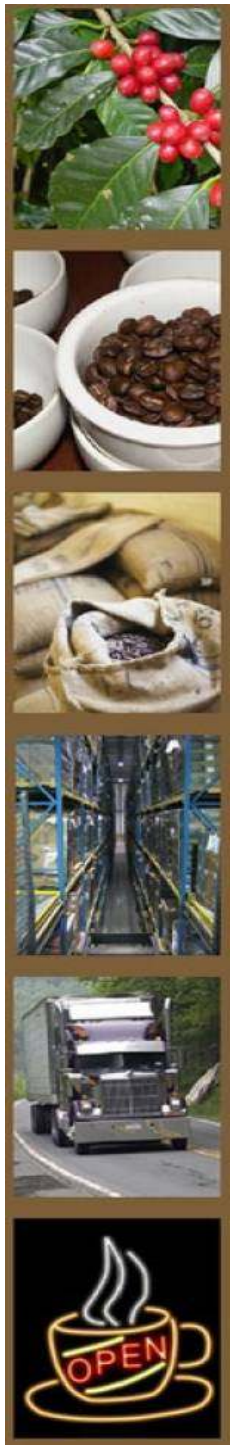
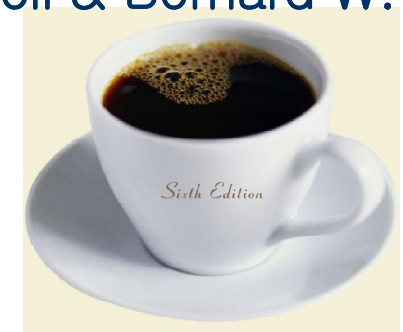


Chapter 15

Resource Planning

Operations Management - 6th Edition

Roberta Russell & Bernard W. Taylor, III

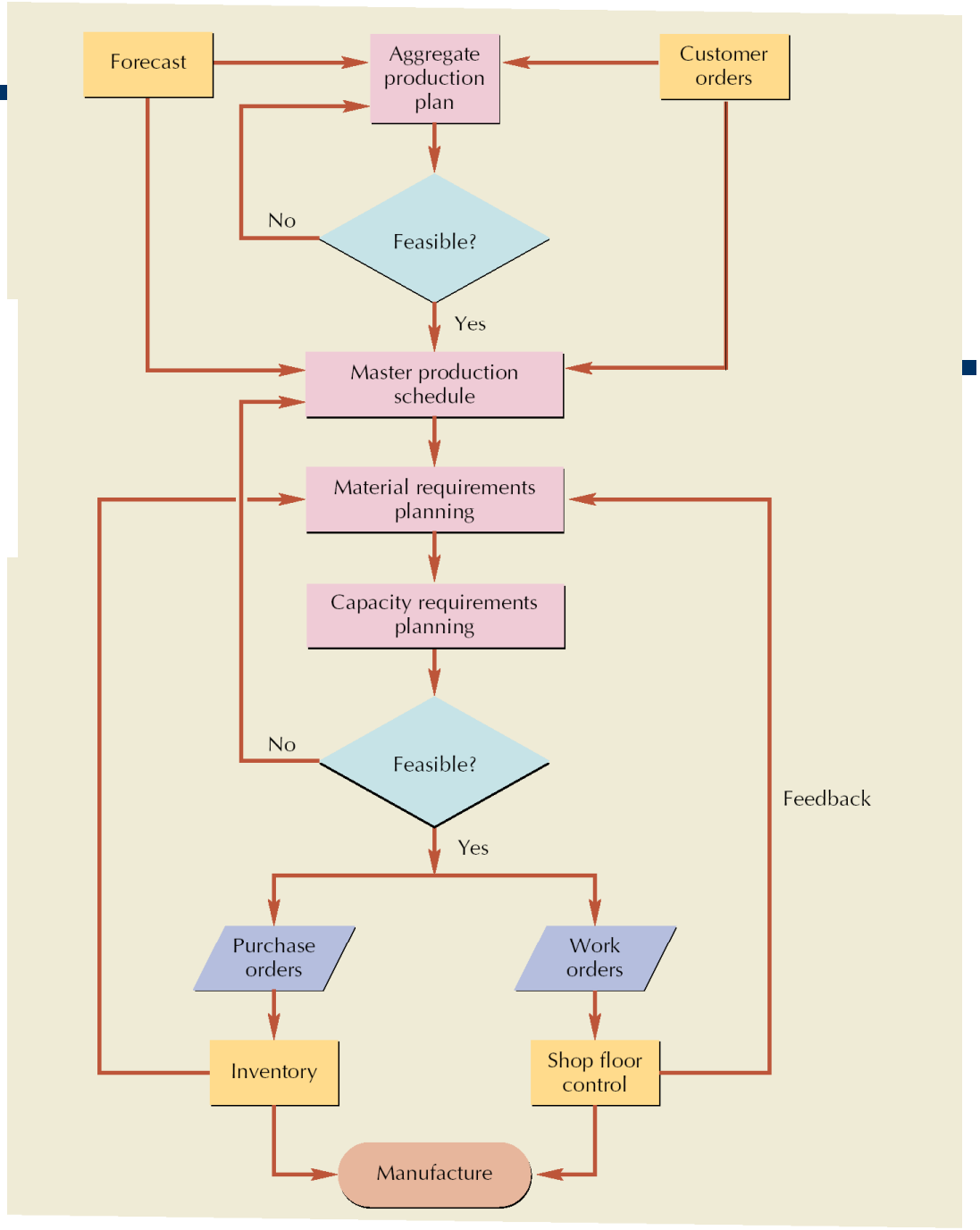


Beni Asllani
University of Tennessee at Chattanooga

Lecture Outline

- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)
- Enterprise Resource Planning (ERP)
- Customer Relationship Management (CRM)
- Supply Chain Management (SCM)
- Product Lifecycle Management (PLM)

Resource Planning for Manufacturing



Material Requirements Planning (MRP)

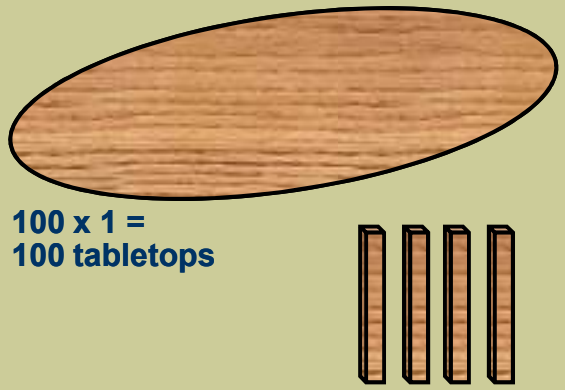
- Computerized inventory control and production planning system
- When to use MRP?
  - Dependent demand items
  - Discrete demand items
  - Complex products
  - Job shop production
  - Assemble-to-order environments

Demand Characteristics

Independent demand

100 tables

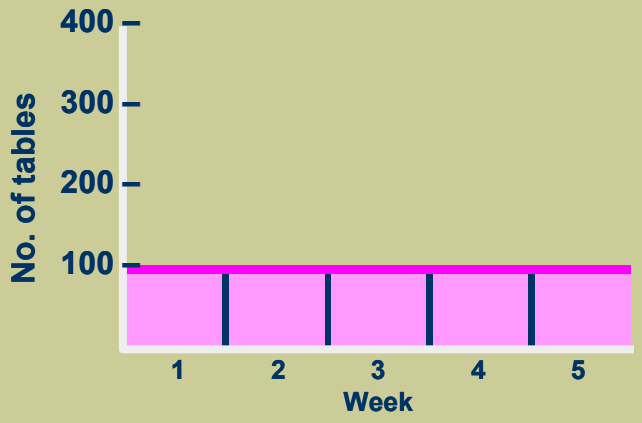
Dependent demand



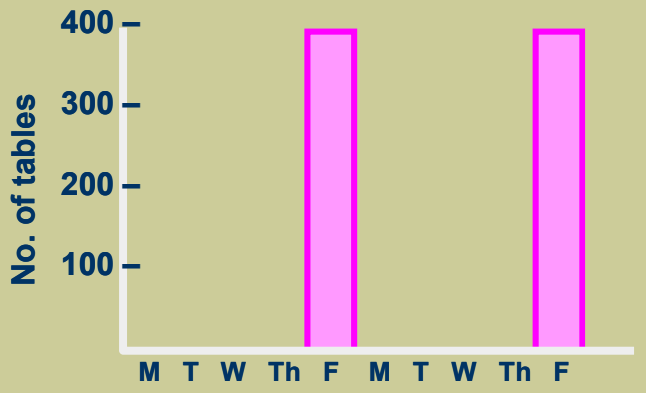
100 x 1 =
100 tabletops

100 x 4 = 400 table legs

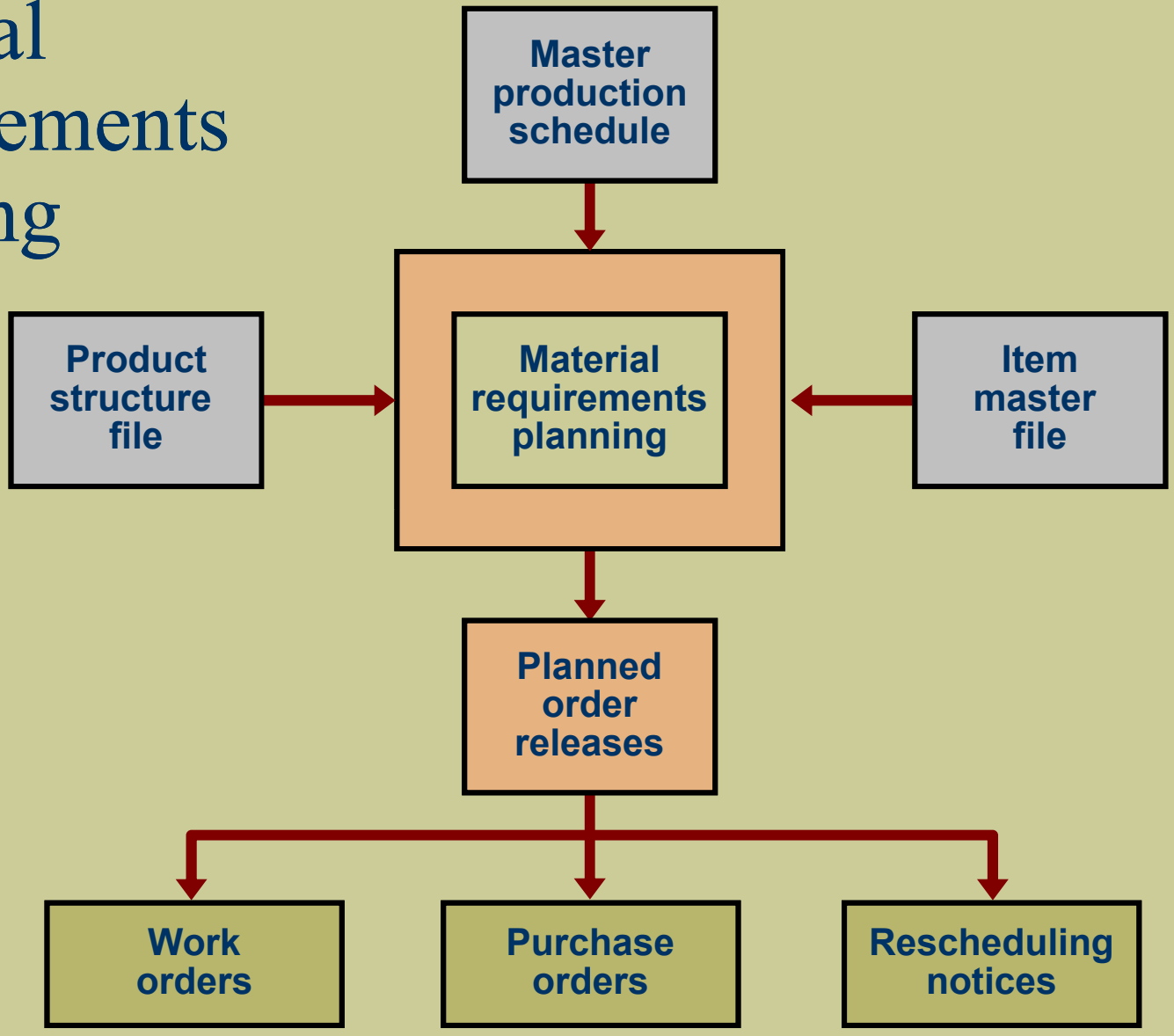
Continuous demand



Discrete demand



Material Requirements Planning



MRP Inputs and Outputs

- Inputs
  - Master production schedule
  - Product structure file
  - Item master file
- Outputs
  - Planned order releases
    - Work orders
    - Purchase orders
    - Rescheduling notices

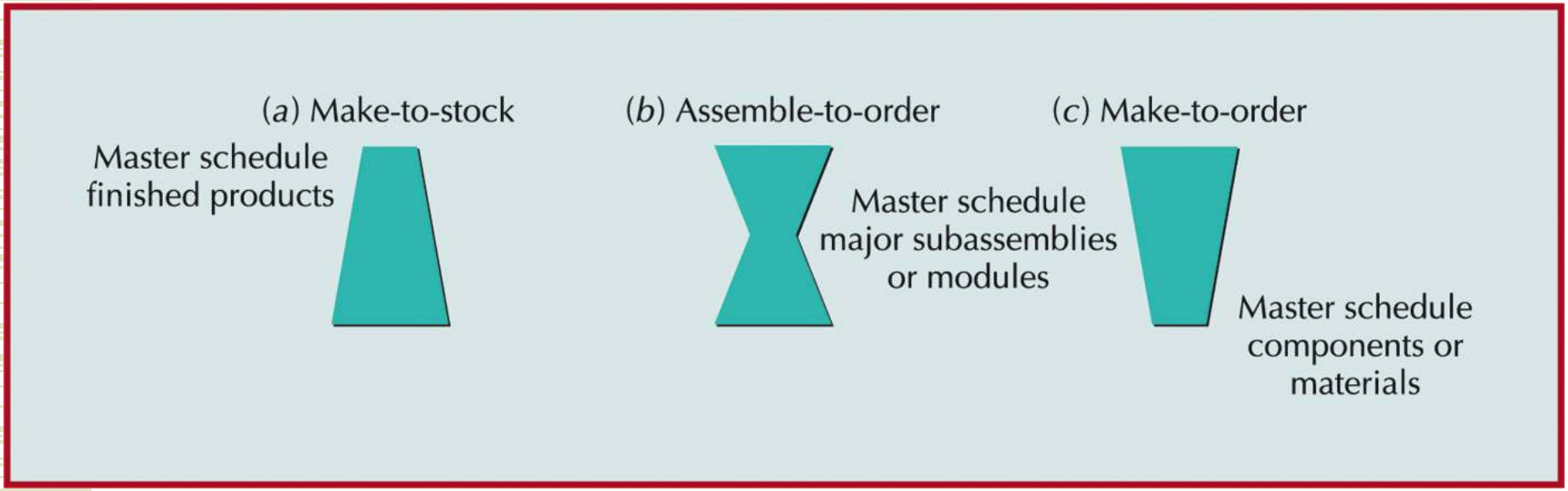
Master Production Schedule

- Drives MRP process with a schedule of finished products
- Quantities represent production not demand
- Quantities may consist of a combination of customer orders and demand forecasts
- Quantities represent what needs to be produced, not what can be produced
- Quantities represent end items that may or may not be finished products

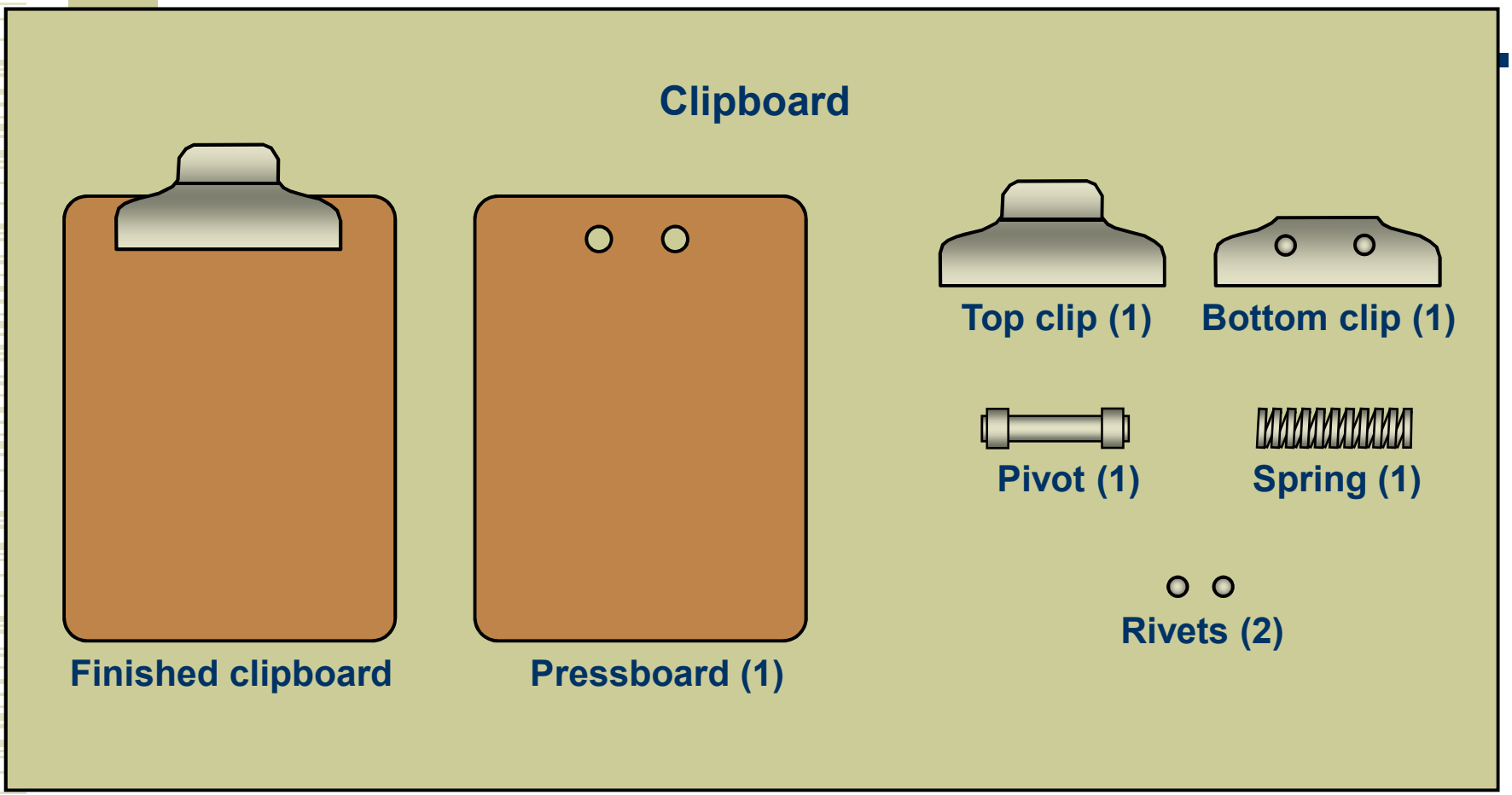
Master Production Schedule (cont.)

	PERIOD				
MPS ITEM	*1*	*2*	*3*	*4*	*5*
Pencil Case	125	125	125	125	125
Clipboard	85	95	120	100	100
Lapboard	75	120	47	20	17
Lapdesk	0	50	0	50	0

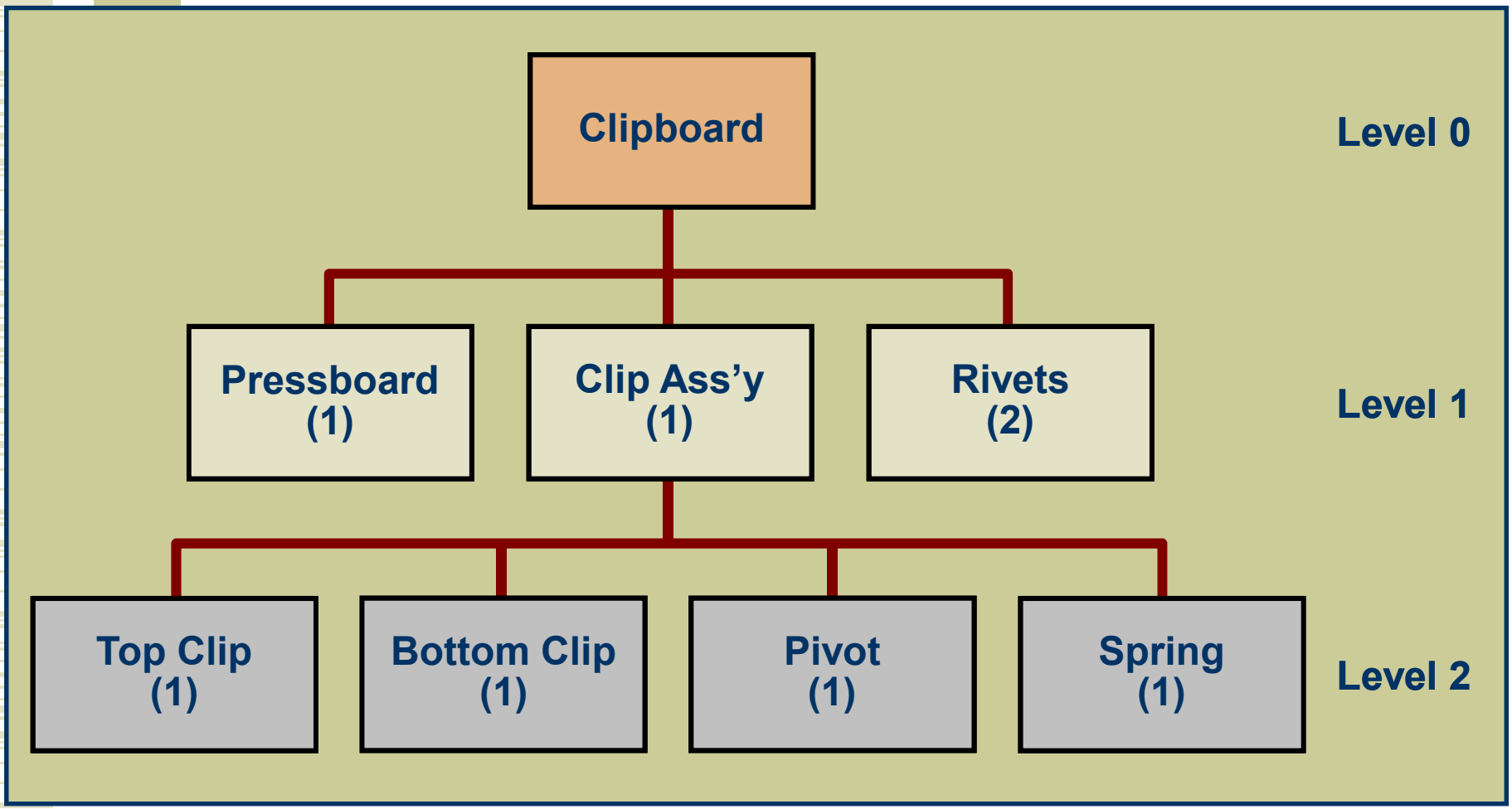
Product Structure File



Product Structure



Product Structure Tree



Multilevel Indented BOM

LEVEL	ITEM	UNIT OF MEASURE	QUANTITY
0 - - - -	Clipboard	ea	1
- 1 - - -	Clip Assembly	ea	1
- - 2 - -	Top Clip	ea	1
- - 2 - -	Bottom Clip	ea	1
- - 2 - -	Pivot	ea	1
- - 2 - -	Spring	ea	1
- 1 - - -	Rivet	ea	2
- 1 - - -	Press Board	ea	1

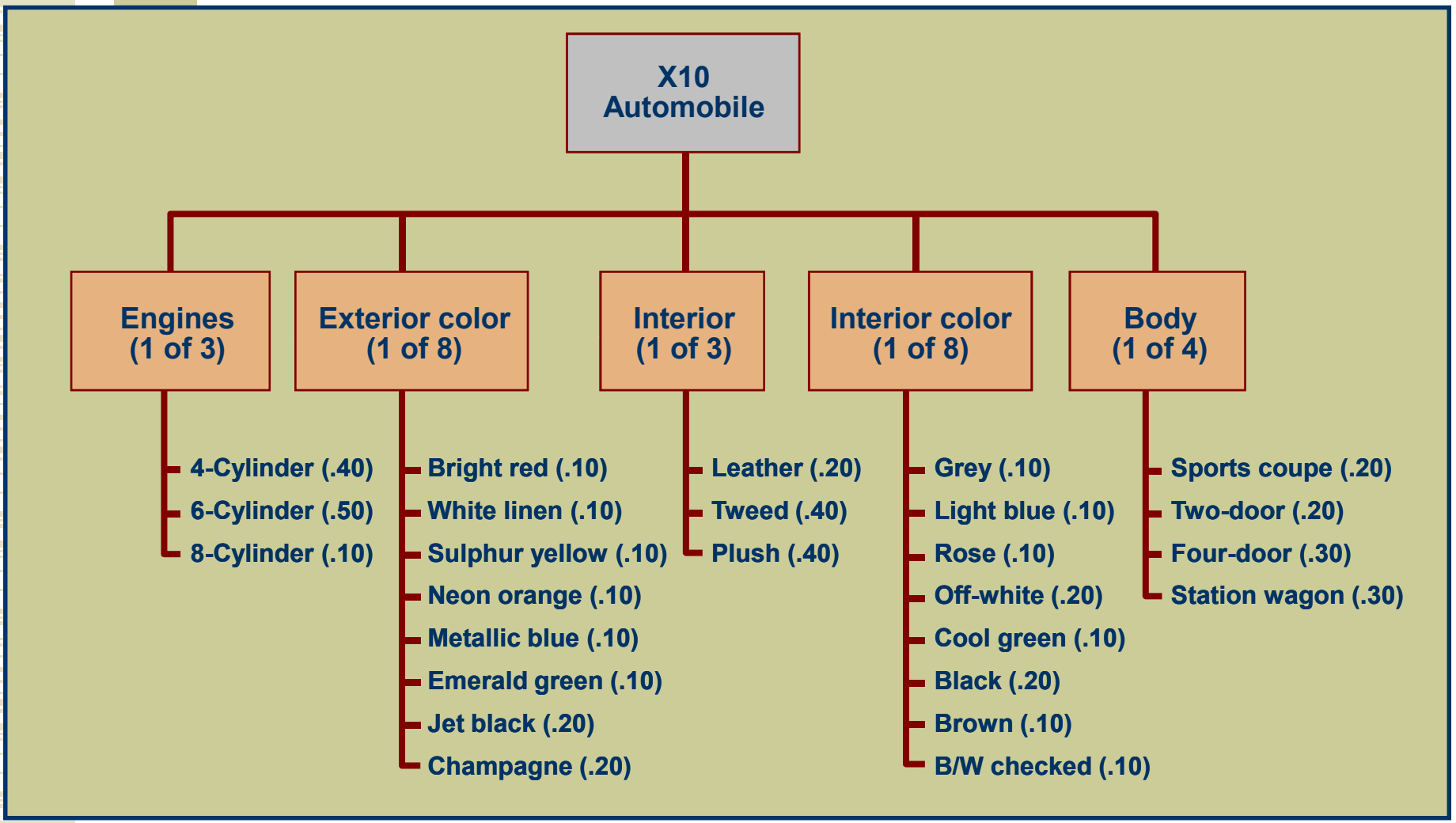
Specialized BOMs

- Phantom bills
  - Transient subassemblies
  - Never stocked
  - Immediately consumed in next stage
- K-bills
  - Group small, loose parts under pseudo-item number
  - Reduces paperwork, processing time, and file space

Specialized BOMs (cont.)

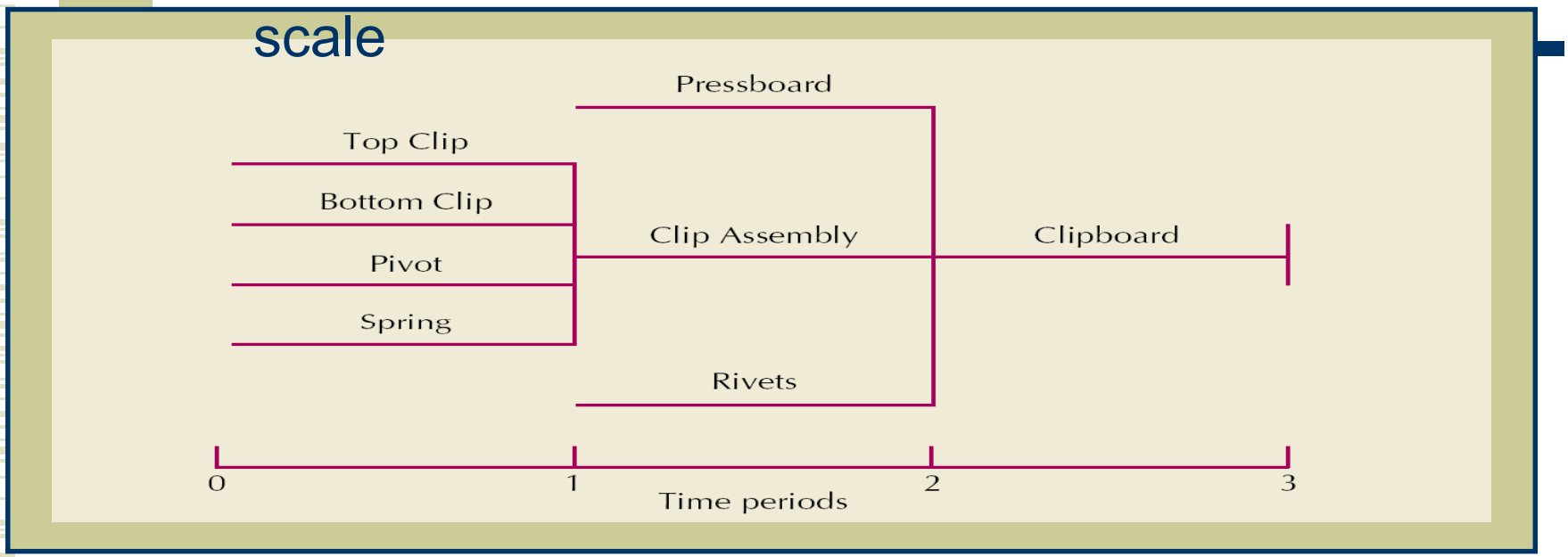
- Modular bills
  - Product assembled from major subassemblies and customer options
  - Modular bill kept for each major subassembly
  - Simplifies forecasting and planning
  - X10 automobile example
    - 3 x 8 x 3 x 8 x 4 = 2,304 configurations
    - 3 + 8 + 3 + 8 + 4 = 26 modular bills

Modular BOMs



Time-phased Bills

- an assembly chart shown against a time scale



Forward scheduling: start at today's date and schedule forward to determine the earliest date the job can be finished. If each item takes one period to complete, the clipboards can be finished in three periods

Backward scheduling: start at the due date and schedule backwards to determine when to begin work. If an order for clipboards is due by period three, we should start production now

Item Master File

DESCRIPTION		INVENTORY POLICY	
Item	Pressboard	Lead time	1
Item no.	7341	Annual demand	5000
Item type	Purch	Holding cost	1
Product/sales class	Comp	Ordering/setup cost	50
Value class	B	Safety stock	0
Buyer/planner	RSR	Reorder point	39
Vendor/drawing	07142	EOQ	316
Phantom code	N	Minimum order qty	100
Unit price/cost	1.25	Maximum order qty	500
Pegging	Y	Multiple order qty	1
LLC	1	Policy code	3

Item Master File (cont.)

PHYSICAL INVENTORY	
On hand	150
Location	W142
On order	100
Allocated	75
Cycle	3
Last count	9/5
Difference	-2

USAGE/SALES	
YTD usage/sales	1100
MTD usage/sales	75
YTD receipts	1200
MTD receipts	0
Last receipt	8/25
Last issue	10/5

CODES	
Cost acct.	00754
Routing	00326
Engr	07142

MRP Processes

- Exploding the bill of material
- Netting out inventory
- Lot sizing
- Time-phasing requirements

- Netting
  - process of subtracting on-hand quantities and scheduled receipts from gross requirements to produce net requirements
- Lot sizing
  - determining the quantities in which items are usually made or purchased

MRP Matrix

Item Lot size	LLC LT	Period 1	2	3	4	5
Gross Requirements		*Derived from MPS or planned order releases of the parent*				
Scheduled Receipts		*On order and scheduled to be received*				
Projected on Hand	Beg Inv	*Anticipated quantity on hand at the end of the period*				
Net Requirements		*Gross requirements net of inventory and scheduled receipts*				
Planned Order Receipts		*When orders need to be received*				
Planned Order Releases		*When orders need to be placed to be received on time*				

MRP: Example

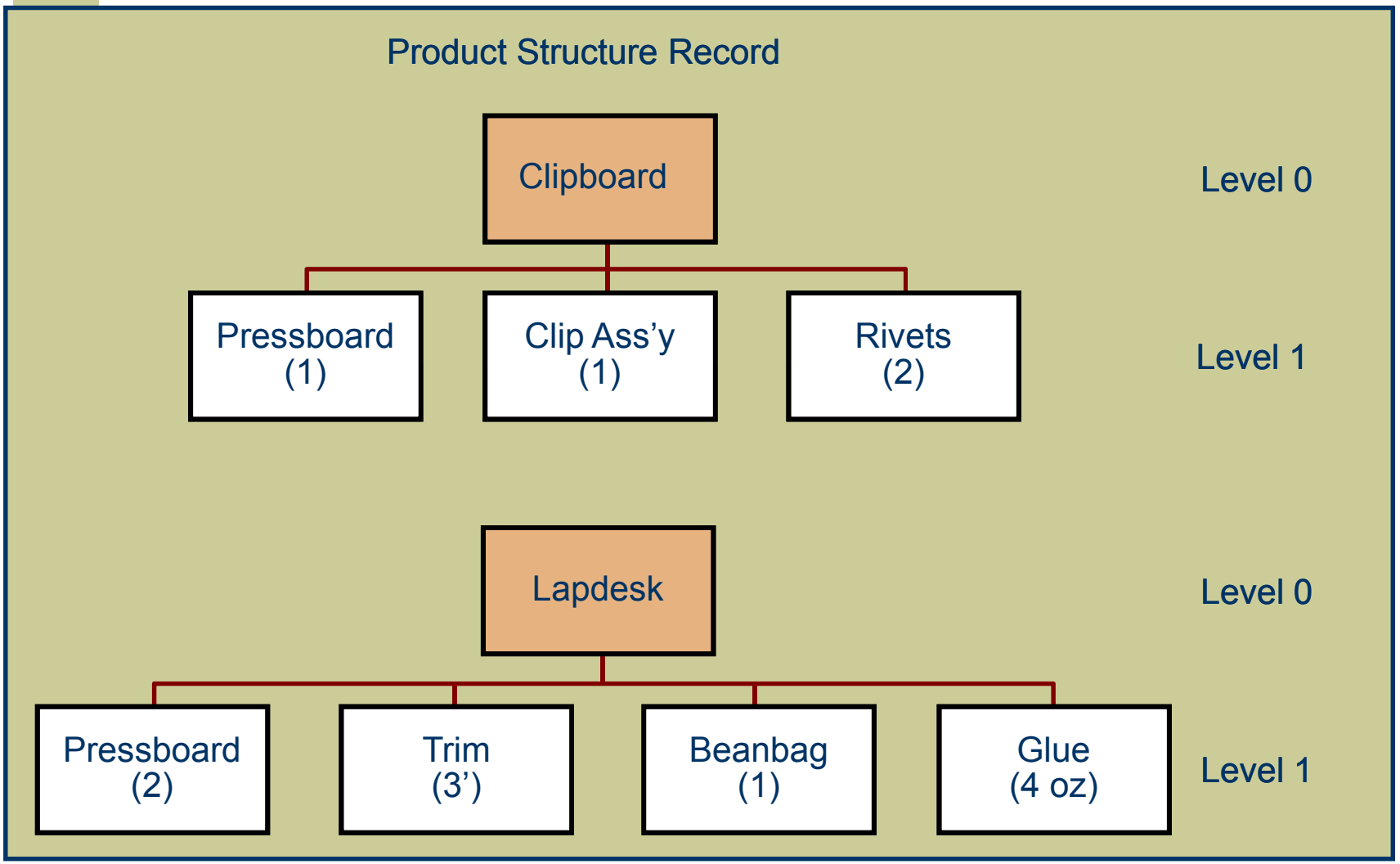
Master Production Schedule

	1	2	3	4	5
Clipboard	85	95	120	100	100
Lapdesk	0	60	0	60	0

Item Master File

	CLIPBOARD	LAPDESK	PRESSBOARD
On hand	25	20	150
On order (sch receipt)	175 (Period 1)	0	0
LLC	0	0	1
Lot size	L4L	Mult 50	Min 100
Lead time	1	1	1

MRP: Example (cont.)



MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115				
Net Requirements		0				
Planned Order Receipts						
Planned Order Releases						

(25 + 175) = 200 units available
(200 - 85) = 115 on hand at the end of Period 1

MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0		PERIOD				
LOT SIZE: L4L	LT: 1		*1*	*2*	*3*	*4*	*5*
Gross Requirements			85	95	120	100	100
Scheduled Receipts			175				
Projected on Hand		25	115	20			
Net Requirements			0	0			
Planned Order Receipts							
Planned Order Releases							

115 units available
(115 - 85) = 20 on hand at the end of Period 2

MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0		PERIOD			
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115	20	0		
Net Requirements		0	0	100		
Planned Order Receipts				100		
Planned Order Releases			100			

20 units available
(20 - 120) = -100 — 100 additional Clipboards are required
Order must be placed in Period 2 to be received in Period 3

MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115	20	0	0	0
Net Requirements		0	0	100	100	100
Planned Order Receipts				100	100	100
Planned Order Releases			100	100	100	

Following the same logic Gross Requirements in Periods 4 and 5 develop Net Requirements, Planned Order Receipts, and Planned Order Releases

MRP: Example (cont.)

ITEM: LAPDESK	LLC: 0	PERIOD				
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		0	60	0	60	0
Scheduled Receipts						
Projected on Hand	20					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP: Example (cont.)

ITEM: LAPDESK	LLC: 0		PERIOD				
LOT SIZE: MULT 50	LT: 1		*1*	*2*	*3*	*4*	*5*
Gross Requirements			0	60	0	60	0
Scheduled Receipts							
Projected on Hand		20	20	10	10	0	0
Net Requirements			0	40		50	
Planned Order Receipts				50		50	
Planned Order Releases			50		50		

Following the same logic, the Lapdesk MRP matrix is completed as shown

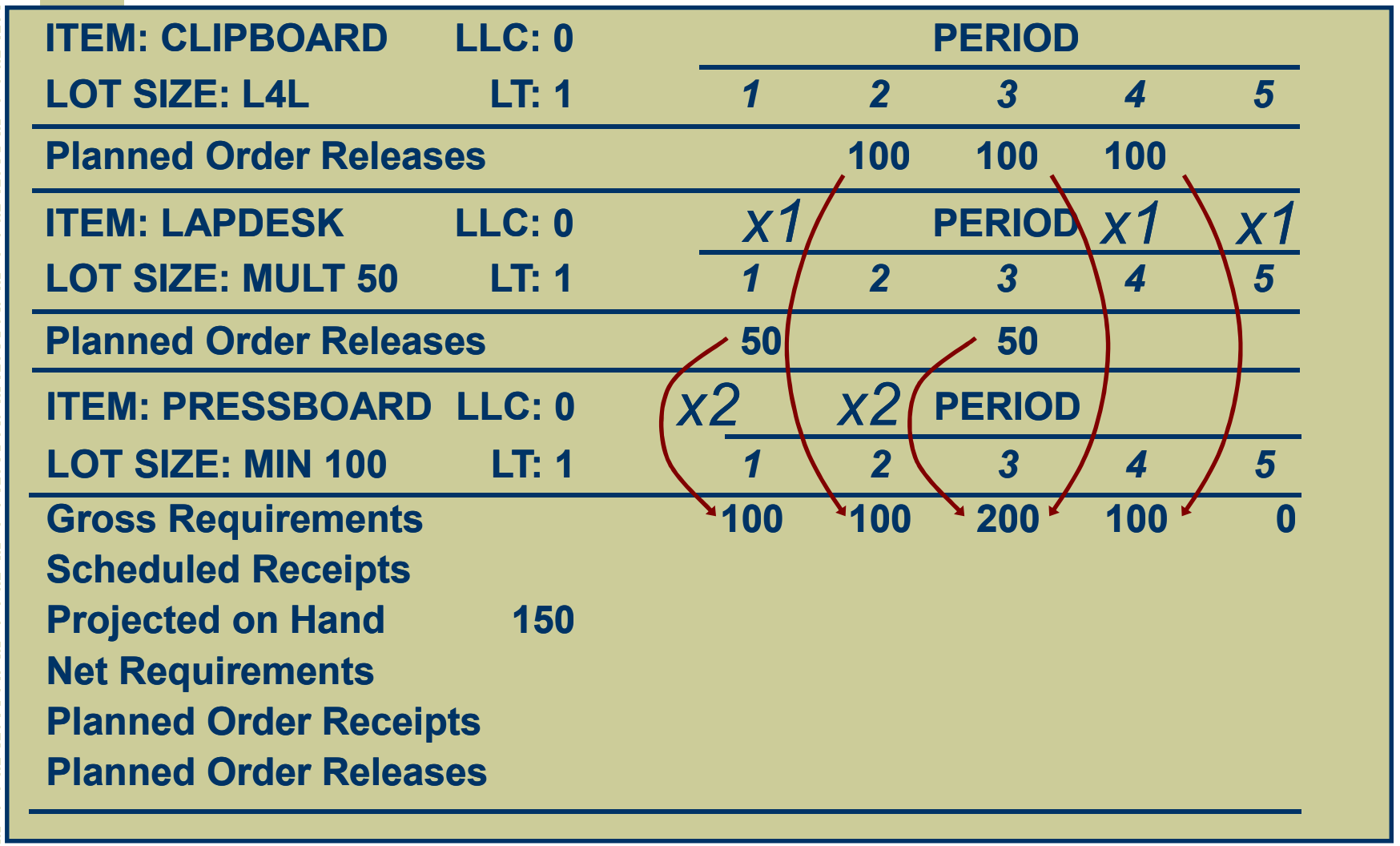
MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases			100	100	100	

ITEM: LAPDESK	LLC: 0	PERIOD				
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases		50		50		

ITEM: PRESSBOARD	LLC: 0	PERIOD				
LOT SIZE: MIN 100	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements						
Scheduled Receipts						
Projected on Hand	150					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP: Example (cont.)



MRP: Example (cont.)

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases			100	100	100	

ITEM: LAPDESK	LLC: 0	PERIOD				
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases		50		50		

ITEM: PRESSBOARD	LLC: 0	PERIOD				
LOT SIZE: MIN 100	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		100	100	200	100	0
Scheduled Receipts						
Projected on Hand	150	50	50	0	0	0
Net Requirements			50	150	100	
Planned Order Receipts			100	150	100	
Planned Order Releases		100	150	100		

MRP: Example (cont.)

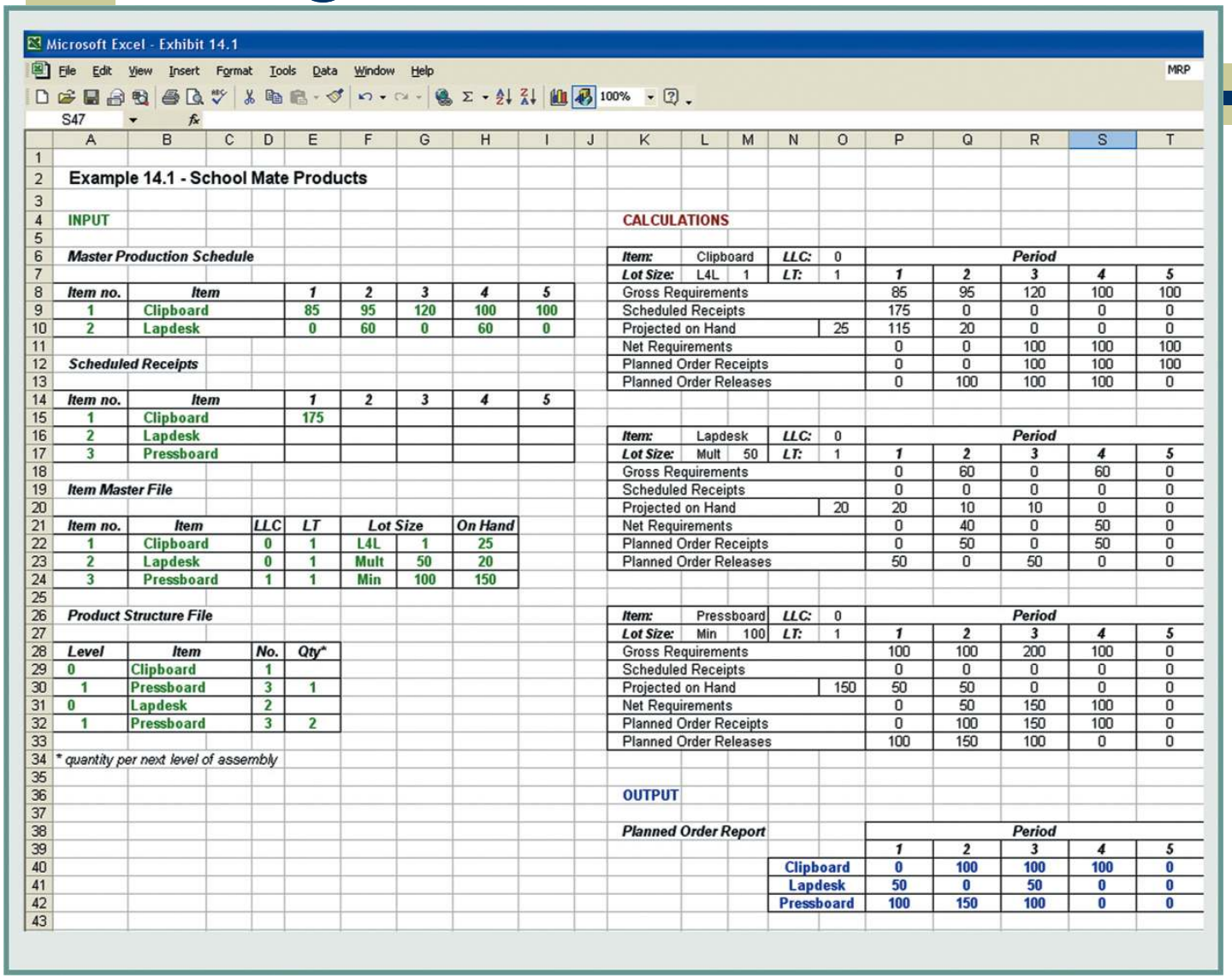
Planned Order Report

ITEM	PERIOD 1	2	3	4	5
Clipboard		100	100	100	
Lapdesk	50		50		
Pressboard	100	150	100		

Lot Sizing in MRP Systems

- Lot-for-lot ordering policy
- Fixed-size lot ordering policy
  - Minimum order quantities
  - Maximum order quantities
  - Multiple order quantities
  - Economic order quantity
  - Periodic order quantity

Using Excel for MRP Calculations



Microsoft Excel - Exhibit 14.1

File Edit View Insert Format Tools Data Window Help MRP

S47

Example 14.1 - School Mate Products

INPUT

Master Production Schedule

Item no.	Item	1	2	3	4	5
1	Clipboard	85	95	120	100	100
2	Lapdesk	0	60	0	60	0

Scheduled Receipts

Item no.	Item	1	2	3	4	5
1	Clipboard	175				
2	Lapdesk					
3	Pressboard					

Item Master File

Item no.	Item	LLC	LT	Lot Size		On Hand
1	Clipboard	0	1	L4L	1	25
2	Lapdesk	0	1	Mult	50	20
3	Pressboard	1	1	Min	100	150

Product Structure File

Level	Item	No.	Qty*
0	Clipboard	1	
1	Pressboard	3	1
0	Lapdesk	2	
1	Pressboard	3	2

* quantity per next level of assembly

CALCULATIONS

Item: Clipboard	LLC: 0				
Lot Size: L4L 1	LT: 1	Period 1	2	3	4	5
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175	0	0	0	0
Projected on Hand	25	115	20	0	0	0
Net Requirements		0	0	100	100	100
Planned Order Receipts		0	0	100	100	100
Planned Order Releases		0	100	100	100	0

Item: Lapdesk	LLC: 0				
Lot Size: Mult 50	LT: 1	Period 1	2	3	4	5
Gross Requirements		0	60	0	60	0
Scheduled Receipts		0	0	0	0	0
Projected on Hand	20	20	10	10	0	0
Net Requirements		0	40	0	50	0
Planned Order Receipts		0	50	0	50	0
Planned Order Releases		50	0	50	0	0

Item: Pressboard	LLC: 0				
Lot Size: Min 100	LT: 1	Period 1	2	3	4	5
Gross Requirements		100	100	200	100	0
Scheduled Receipts		0	0	0	0	0
Projected on Hand	150	50	50	0	0	0
Net Requirements		0	50	150	100	0
Planned Order Receipts		0	100	150	100	0
Planned Order Releases		100	150	100	0	0

OUTPUT

Planned Order Report	Period 1	2	3	4	5
Clipboard	0	100	100	100	0
Lapdesk	50	0	50	0	0
Pressboard	100	150	100	0	0

Advanced Lot Sizing Rules: L4L

Period	1	2	3	4	5
Gross Requirements	30	50	20	10	40

$C_o = \$60$

$C_c = \$1$

$\bar{d} = (30 + 50 + 20 + 10 + 40)/5 = 30$

Item: Rod	**LLC: 0**	**Period**				
Lot size: L4L	**LT: 1**	*1*	*2*	*3*	*4*	*5*
Gross Requirements		30	50	20	10	40
Scheduled Receipts						
Projected on hand	30	0	0	0	0	0
Net Requirements			50	20	10	40
Planned Order Receipts			50	20	10	40
Planned Order Releases		50	20	10	40	

Total cost of L4L = (4 X $60) + (0 X $1) = $240

Advanced Lot Sizing Rules: EOQ

$$EOQ = \sqrt{\frac{2(30)(60}{1}} = 60$$ minimum order quantity

Item: Rod	LLC: 0	Period				
Lot size: EOQ 60	**LT: 1**	*1*	*2*	*3*	*4*	*5*
Gross Requirements		30	50	20	10	40
Scheduled Receipts						
Projected on hand	30	0	10	50	40	0
Net Requirements			50	10		
Planned Order Receipts			60	60		
Planned Order Releases		60	60			

Total cost of EOQ = (2 X $60) + [(10 + 50 + 40) X $1)] = $220

Advanced Lot Sizing Rules: POQ

$POQ = Q / \bar{d} = 60 / 30 = 2$ periods worth of requirements

Item: Rod	LLC: 0	Period				
Lot size: POQ 2	**LT: 1**	*1*	*2*	*3*	*4*	*5*
Gross Requirements		30	50	20	10	40
Scheduled Receipts						
Projected on hand	30	0	20	0	40	0
Net Requirements			50		10	
Planned Order Receipts			70		50	
Planned Order Releases		70		50		

Total cost of POQ = (2 X $60) + [(20 + 40) X $1] = $180

Planned Order Report

Item	#2740	Date	9 - 25 - 05
On hand	100	Lead time	2 weeks
On order	200	Lot size	200
Allocated	50	Safety stock	50

DATE	ORDER NO.	GROSS REQS.	SCHEDULED RECEIPTS	PROJECTED ON HAND	ACTION
				50	
9-26	AL 4416	25		25	
9-30	AL 4174	25		0	
10-01	GR 6470	50		- 50	
10-08	SR 7542		200	150	Expedite SR 10-01
10-10	CO 4471	75		75	
10-15	GR 6471	50		25	
10-23	GR 6471	25		0	
10-27	GR 6473	50		- 50	Release PO 10-13

Key: AL = allocated
CO = customer order
PO = purchase order
WO = work order
SR = scheduled receipt
GR = gross requirement

MRP Action Report

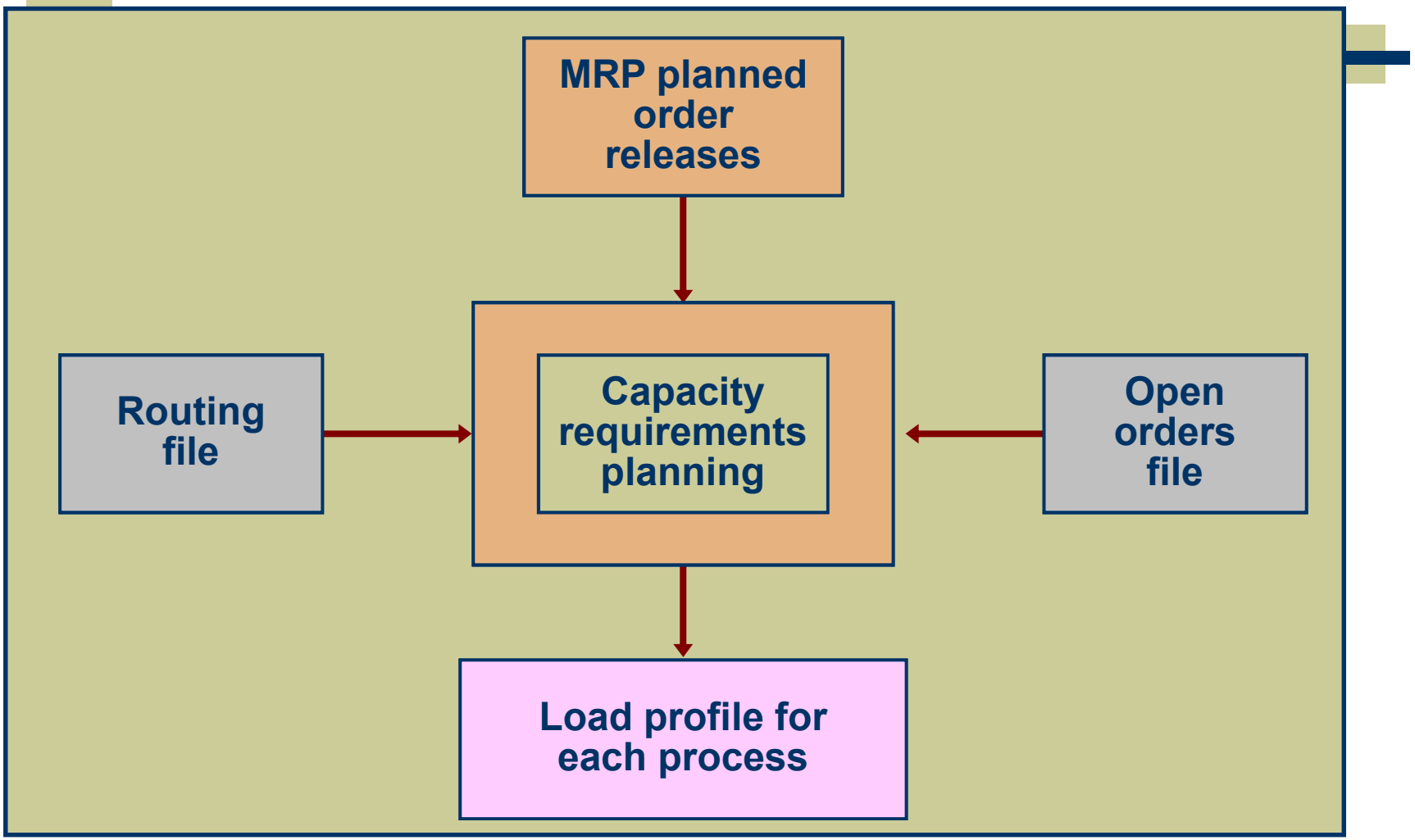
Current date 9-25-08

ITEM	DATE	ORDER NO.	QTY.	ACTION		
#2740	10-08	7542	200	Expedite	SR	10-01
#3616	10-09			Move forward	PO	10-07
#2412	10-10			Move forward	PO	10-05
#3427	10-15			Move backward	PO	10-25
#2516	10-20	7648	100	De-expedite	SR	10-30
#2740	10-27		200	Release	PO	10-13
#3666	10-31		50	Release	WO	10-24

Capacity Requirements Planning (CRP)

- Creates a load profile
- Identifies under-loads and over-loads
- Inputs
  - Planned order releases
  - Routing file
  - Open orders file

CRP



Calculating Capacity

- Maximum capability to produce
- Rated Capacity
  - Theoretical output that could be attained if a process were operating at full speed without interruption, exceptions, or downtime
- Effective Capacity
  - Takes into account the efficiency with which a particular product or customer can be processed and the utilization of the scheduled hours or work

Effective Daily Capacity = (no. of machines or workers) x (hours per shift) x (no. of shifts) x (utilization) x (efficiency)

Calculating Capacity (cont.)

- Utilization
  - Percent of available time spent working
- Efficiency
  - How well a machine or worker performs compared to a standard output level
- Load
  - Standard hours of work assigned to a facility
- Load Percent
  - Ratio of load to capacity

$$\text{Load Percent} = \frac{\text{load}}{\text{capacity}} \times 100\%$$

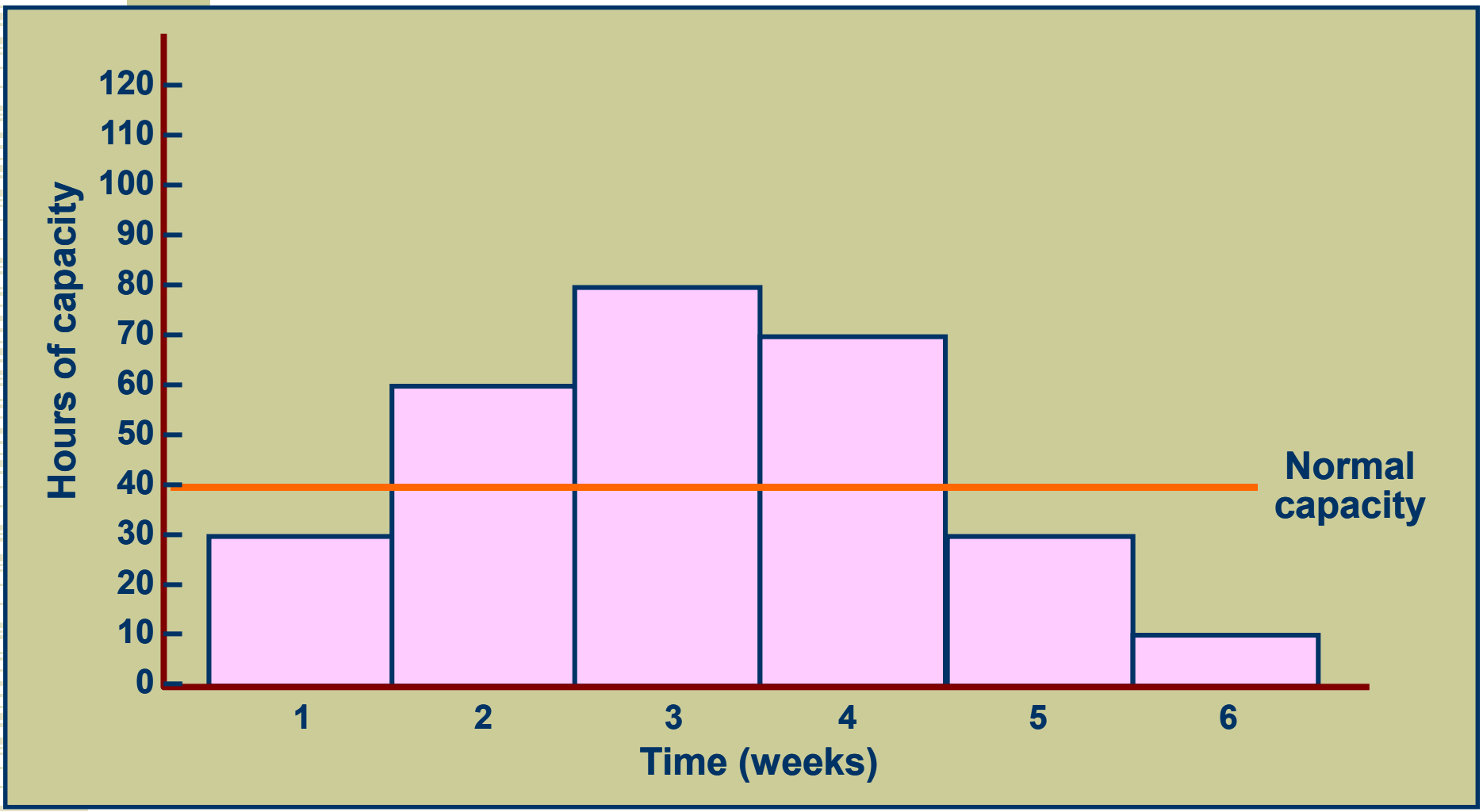
Load Profiles

- graphical comparison of load versus capacity
- Leveling underloaded conditions:
  - Acquire more work
  - Pull work ahead that is scheduled for later time periods
  - Reduce normal capacity

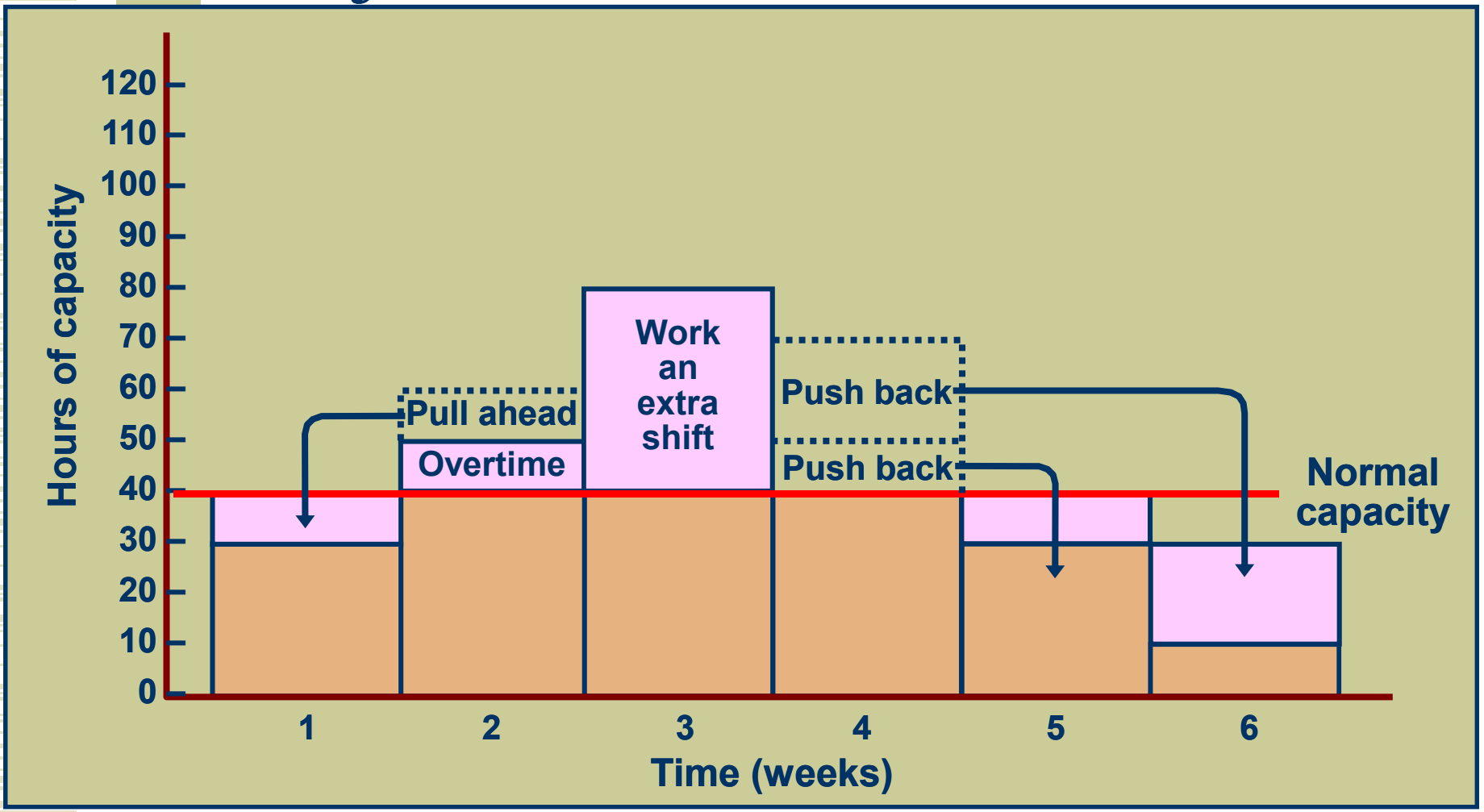
Reducing Over-load Conditions

1. Eliminating unnecessary requirements
2. Rerouting jobs to alternative machines, workers, or work centers
3. Splitting lots between two or more machines
4. Increasing normal capacity
5. Subcontracting
6. Increasing efficiency of the operation
7. Pushing work back to later time periods
8. Revising master schedule

Initial Load Profile



Adjusted Load Profile



- Load leveling
  - process of balancing underloads and overloads

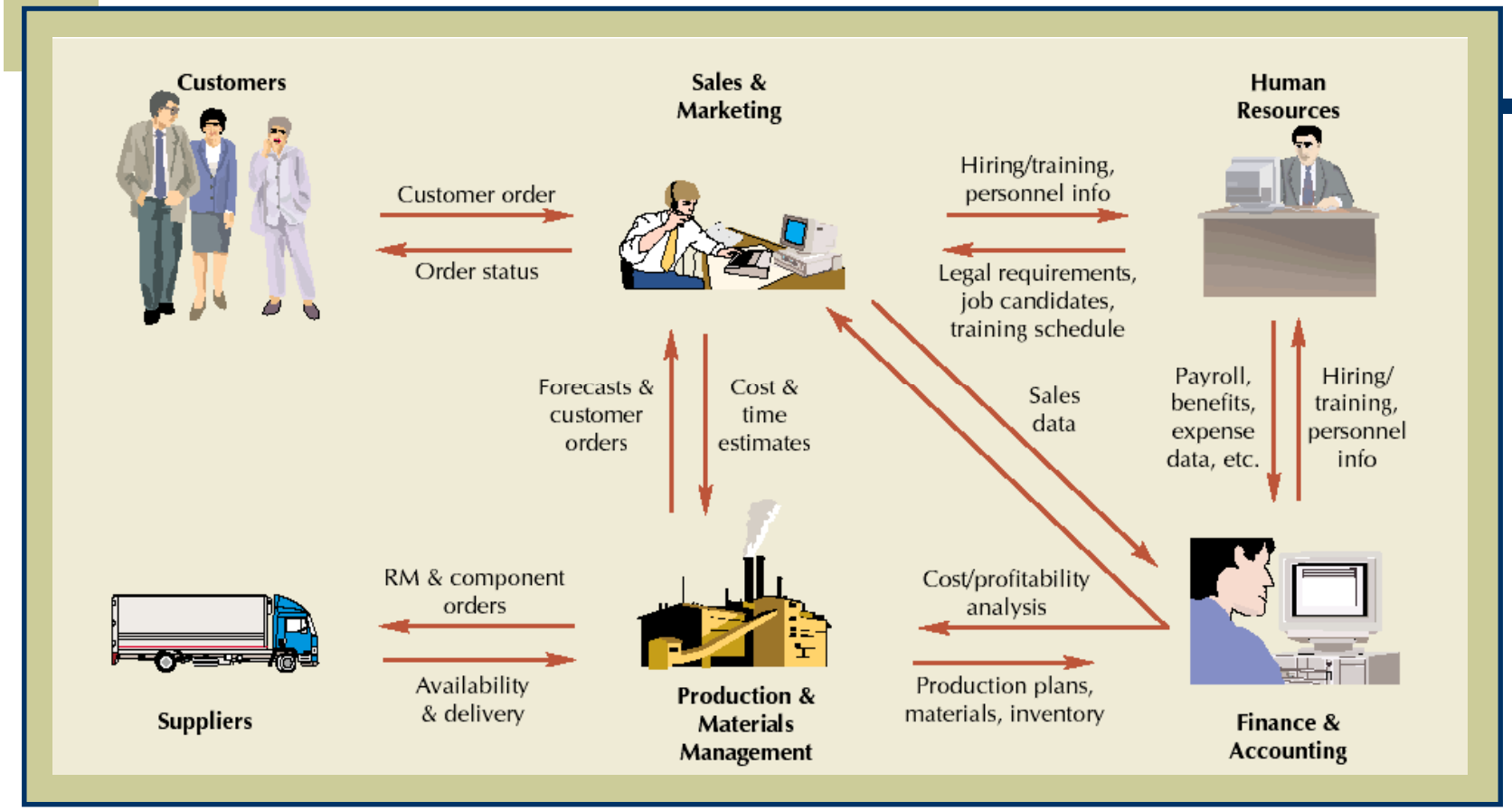
Relaxing MRP Assumptions

- Material is not always the most constraining resource
- Lead times can vary
- Not every transaction needs to be recorded
- Shop floor may require a more sophisticated scheduling system
- Scheduling in advance may not be appropriate for on-demand production.

Enterprise Resource Planning (ERP)

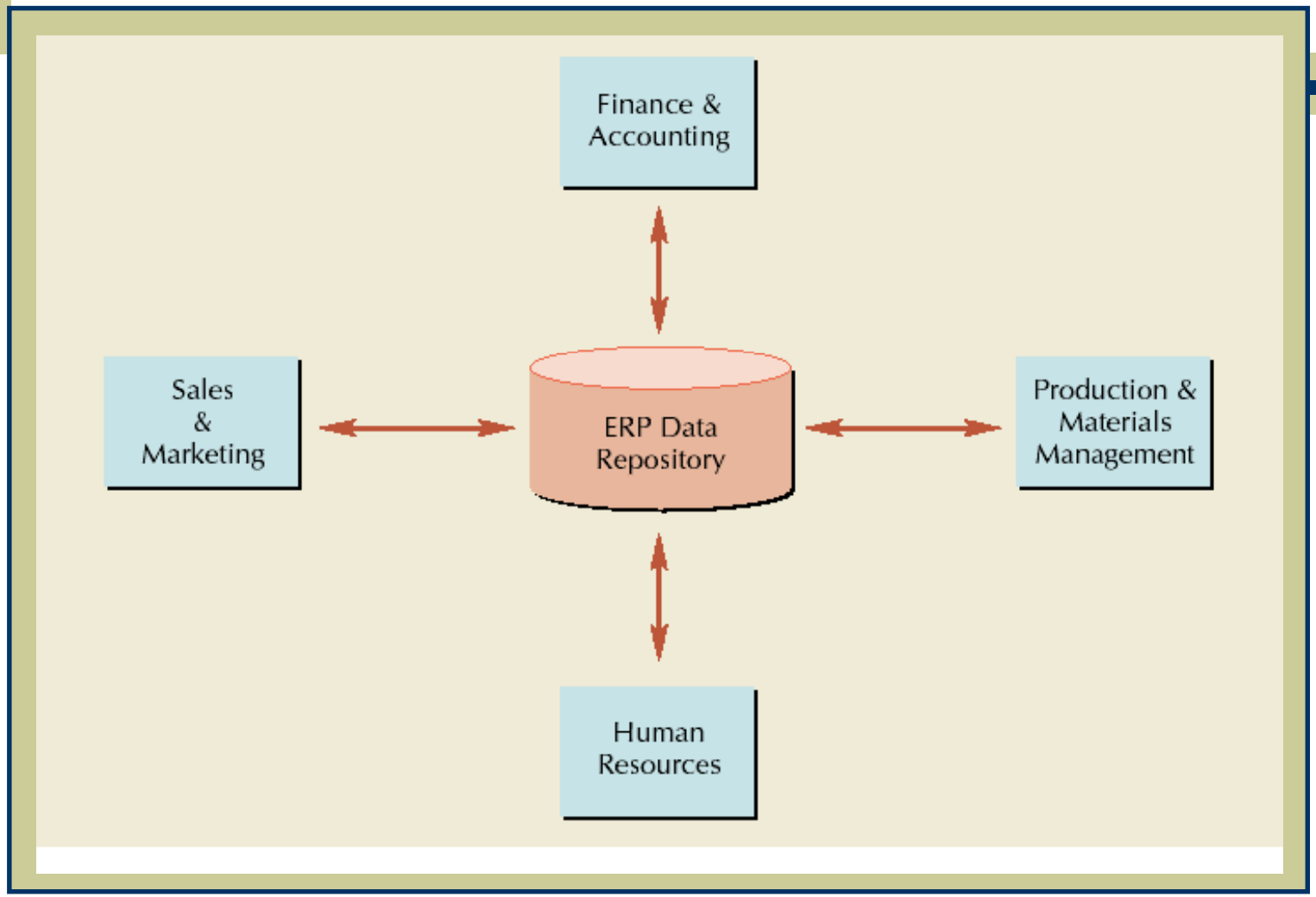
- Software that organizes and manages a company's business processes by
  - sharing information across functional areas
  - integrating business processes
  - facilitating customer interaction
  - providing benefit to global companies

Organizational Data Flows



Source: Adapted from Joseph Brady, Ellen Monk, and Bret Wagner, *Concepts in Enterprise Resource Planning* (Boston: Course Technology, 2001), pp. 7–12

ERP's Central Database



Selected Enterprise Software Vendors

Vendor	Specialty
1. SAP	Large enterprise discrete manufacturing ERP, SCM
2. Oracle Corp.	Large enterprise discrete manufacturing and services
3.Oracle's PeopleSoft	Human resources and employee relationship management
4. Oracle's Siebel Systems	Customer relationship management (CRM)
5. i2 Technologies	Supply chain management (SCM)
6. PTC, EDS, Dassault Systems	Product life cycle management (PLM)
7. Siemens Energy & Automation	Manufacturing execution systems (MES)
8. SCT	Process industry; education; energy
9. QAD	Multinational midmarket manufacturing
10. Microsoft Dynamics	Small to midmarket CRP, CRM

ERP Implementation

- Analyze business processes
- Choose modules to implement
  - Which processes have the biggest impact on customer relations?
  - Which process would benefit the most from integration?
  - Which processes should be standardized?
- Align level of sophistication
- Finalize delivery and access
- Link with external partners

Customer Relationship Management (CRM)

- Software that
  - Plans and executes business processes
  - Involves customer interaction
  - Changes focus from managing products to managing customers
  - Analyzes point-of-sale data for patterns used to predict future behavior

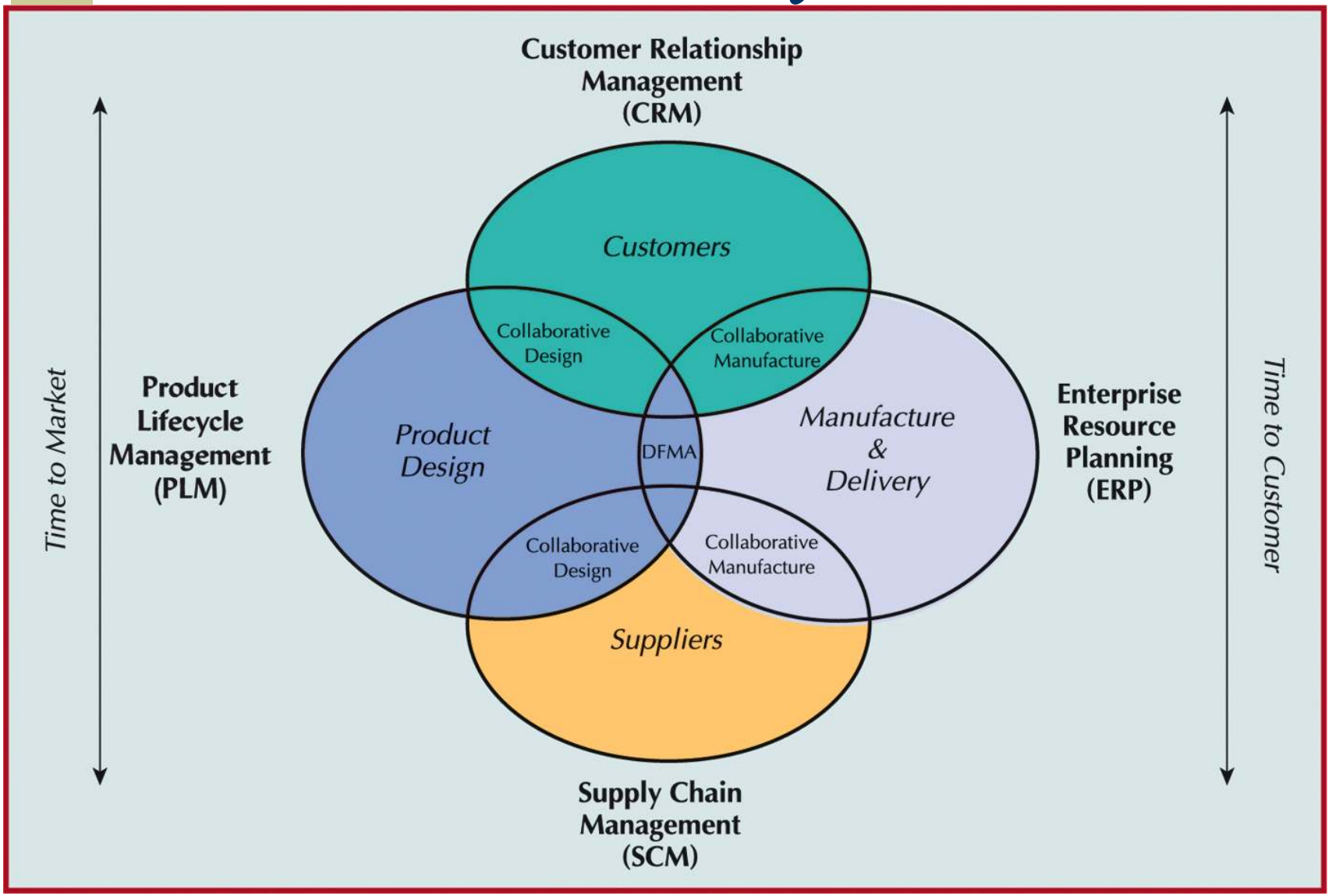
Supply Chain Management

- Software that plans and executes business processes related to supply chains
- Includes
  - Supply chain planning
  - Supply chain execution
  - Supplier relationship management
- Distinctions between ERP and SCM are becoming increasingly blurred

Product Lifecycle Management (PLM)

- Software that
  - Incorporates new product design and development and product life cycle management
  - Integrates customers and suppliers in the design process though the entire product life cycle

ERP and Software Systems



Connectivity

- Application programming interfaces (APIs)
  - give other programs well-defined ways of speaking to them
- Enterprise Application Integration (EAI) solutions
- EDI is being replaced by XML, business language of Internet
- Service-oriented architecture (SOA)
  - collection of “services” that communicate with each other within software or between software