CPIM

CERTIFIED IN PLANNING AND INVENTORY MANAGEMENT

MODULE 4: SUPPLY

APICS

ASCM

Module 4 Overview

Supply

- Section A: Creating and Validating the Master Schedule
- Section B: Using and Maintaining the Master Schedule
- Section C: Material Requirements Planning
- Section D: CRP and Scheduling
- Section E: Suppliers and Purchasing
- Section F: Changes and Product Life Cycle Management

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SECTION A:
CREATING AND VALIDATING THE MASTER SCHEDULE

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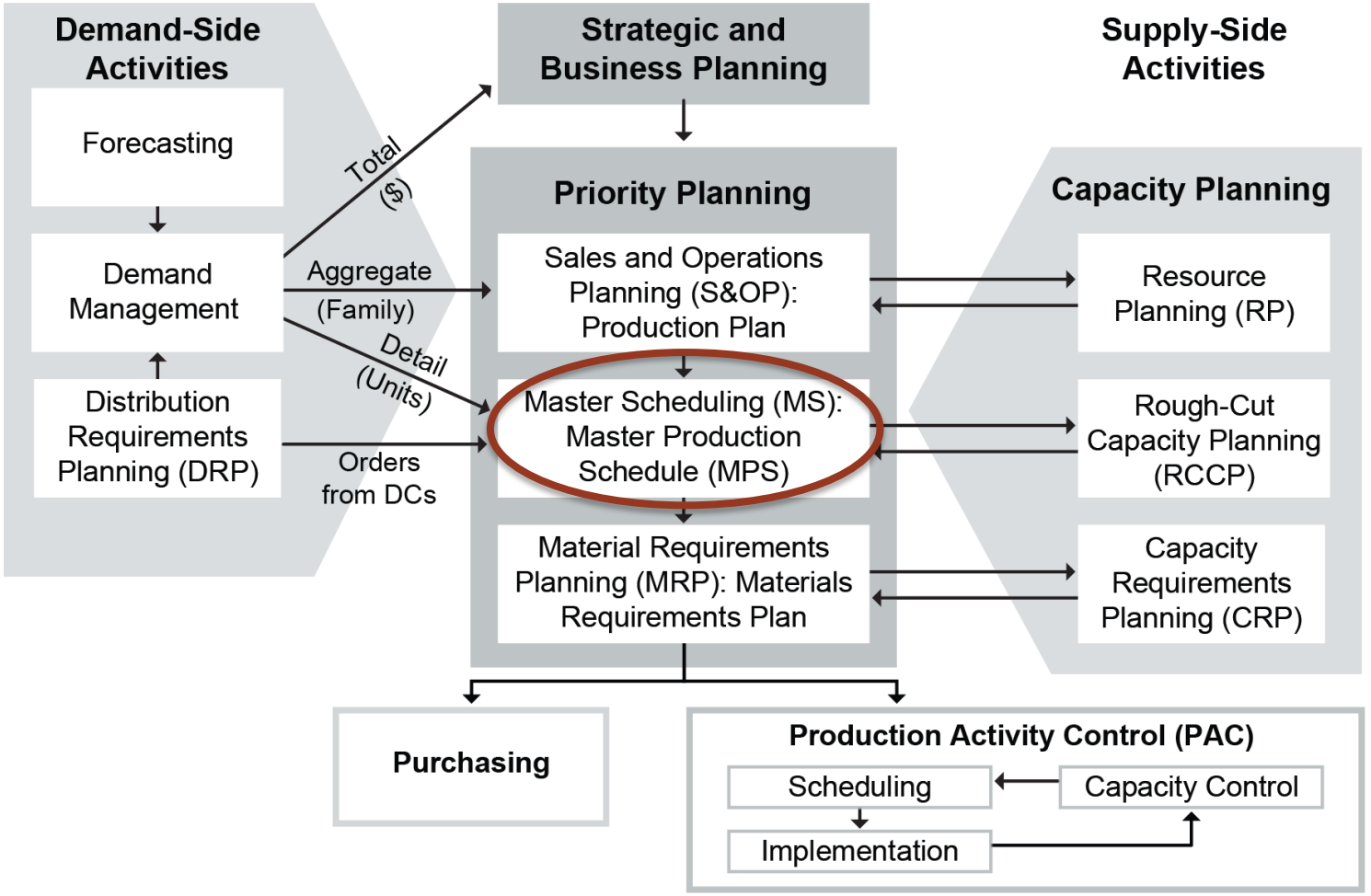
Section A Learning Objectives

- Relationships among master scheduling, capacity management, and materials management
- Elements of master scheduling grid
- Links with other processes
- How different manufacturing environments interact with master scheduling process
- Uses and types of planning bills of material (BOMs)
- Rough-cut capacity planning and capacity planning hierarchy
- Capacity planning using overall factors (CPOF), bill of labor, and resource profile approaches
- Resolving capacity imbalances
- Critical work centers
- Improving work center efficiency and utilization
- Maintenance scheduling

Master Scheduling

Maintaining the master schedule requires	Master scheduling takes into account
▪ A consistent periodic review and update cycle ▪ Timely transaction processing.	▪ Capacity limitations ▪ Production costs ▪ Resource considerations ▪ The sales and operations plan.

Master Scheduling in Manufacturing Planning and Control

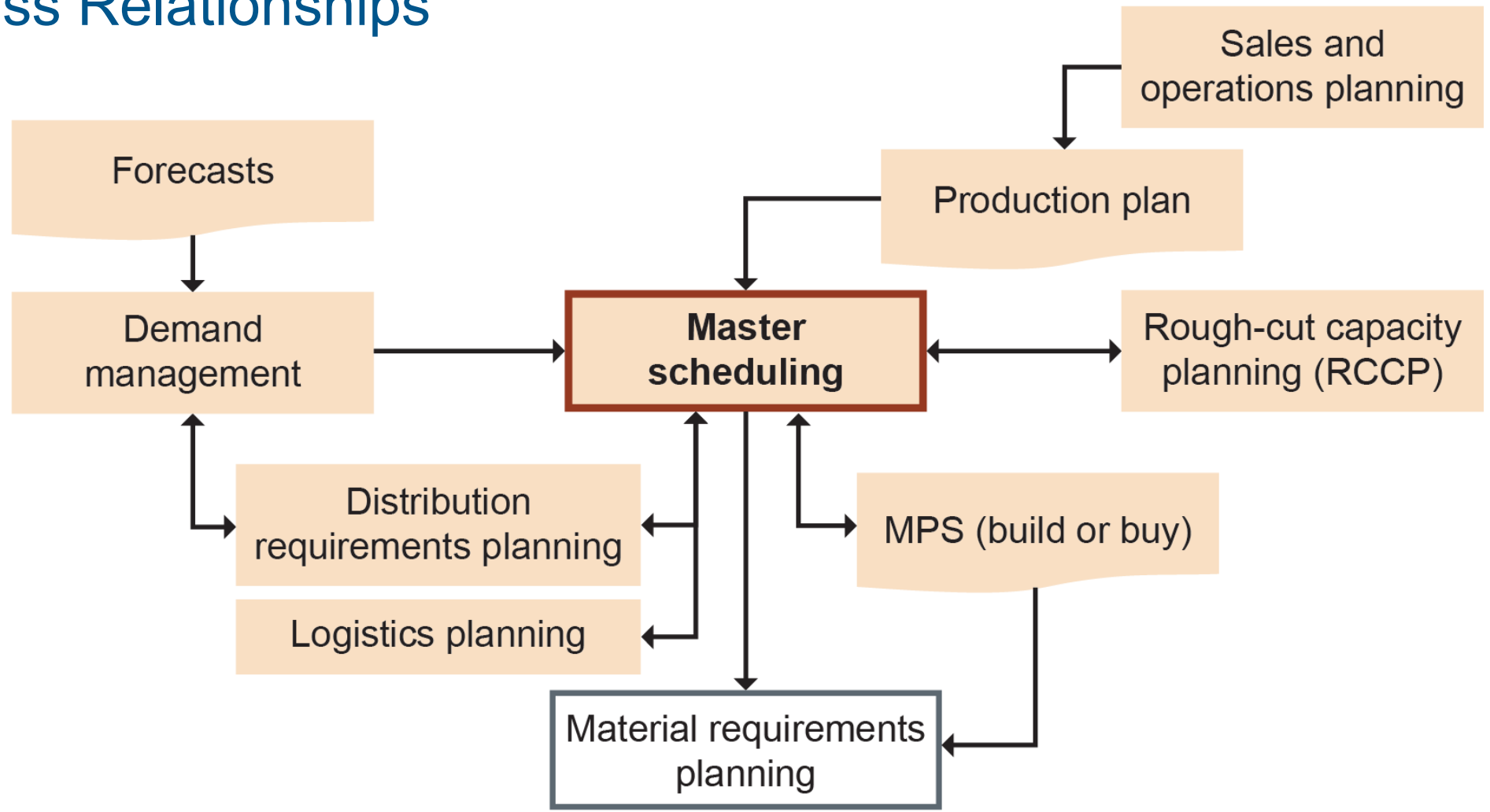


Master Scheduling vs. S&OP

	Master Scheduling	S&OP
Purpose	Build schedule	Production plan
Planning level	End item	Product family
Planning horizon	Longest cumulative lead time	Longest resource lead time
Planning frequency	Daily/weekly	Monthly
Planning focus	Product mix	Volume
Output	Master production schedule	Production plan

Master Scheduling Road Map

Process Relationships



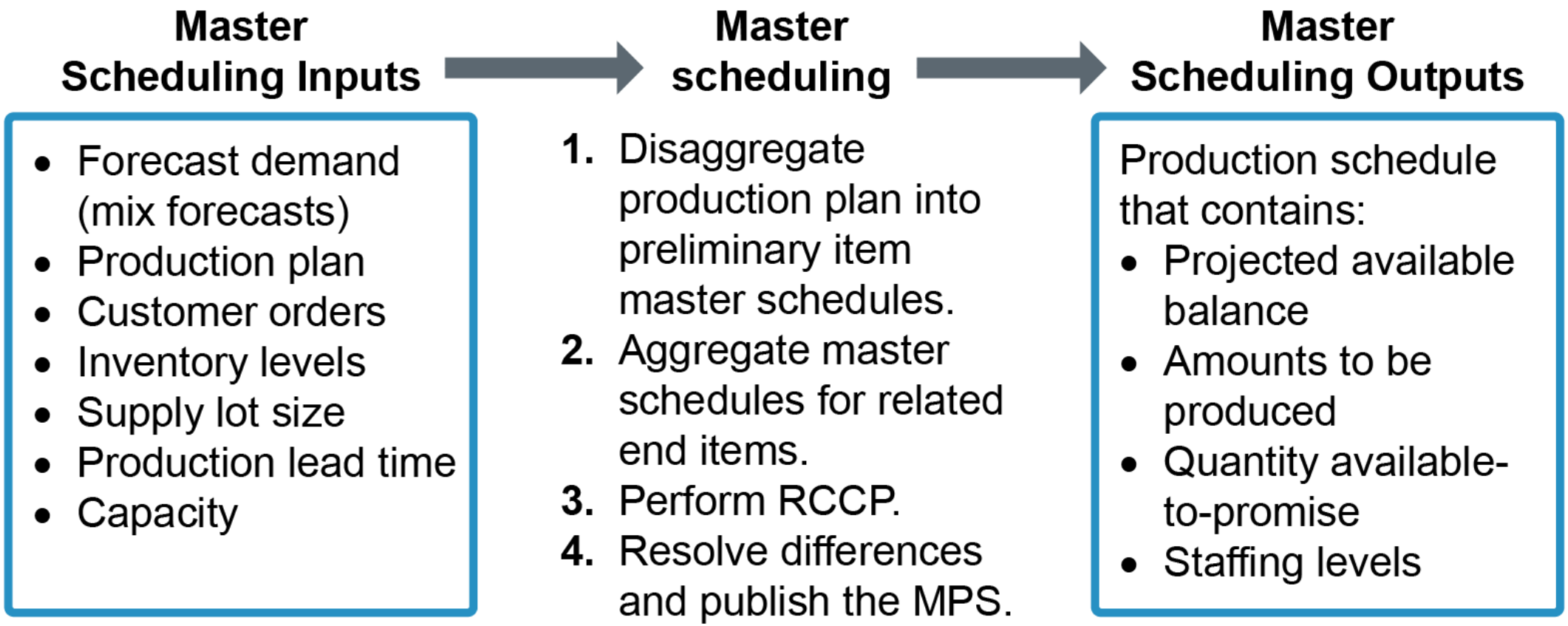
How MPC Components Fit in Business Hierarchy

Level	Horizon	Frequency	Detail Level	Process	Validation
Strategic	>2 years	Annually	Summary	Business planning	Financing
Tactical	~18 months	Monthly	Aggregate	S&OP	Resource planning
	~3 months	Weekly	MTS = end item, ATO = subassembly, MTO = raw materials	Master scheduling	RCCP
Operational	~10 weeks	Daily	Intense	MRP	CRP
	~6 weeks	Shift	Most intense	Work orders, purchase orders	Scheduling

Master Scheduling Purpose and Objectives

- Produce what sales and operations mutually agree on; also agree on priority.
  - Make a build schedule: end items, quantities, due dates.
  - Provide resource and material information.
  - Resolve tradeoffs.
- Maintain customer service and inventories/backlogs at targeted levels.
- Make efficient and effective use of resources.
- Enable valid order promises (manage due dates).

Master Production Schedule Inputs, Process, and Outputs



Master Scheduling Terminology

- Master scheduling
- Master schedule
- Master schedule item
- Master production schedule
- Multilevel master schedule
- Two-level master schedule
- Overstated master production schedule
- Capacity management
- Product load profile
- Materials management
- Master scheduler

Environment and Product Structure Impact on MS

Market Customer Expectations

Impact on master scheduling	Market/Customer Expectations				
	Product			Delivery	
	Design	Variety	Volume per period	Speed/product availability	Reliability
MTS	Standard	Predetermined, narrow	High	In stock, fast	Predictable
ATO	↓	↓	↓	Final assembly lead time	↓
MTO/ETO	Custom	Broad	Low	Slow/variable	As promised

Environment and Product Structure Impact on MS

Manufacturing Requirements Influence Master Scheduling

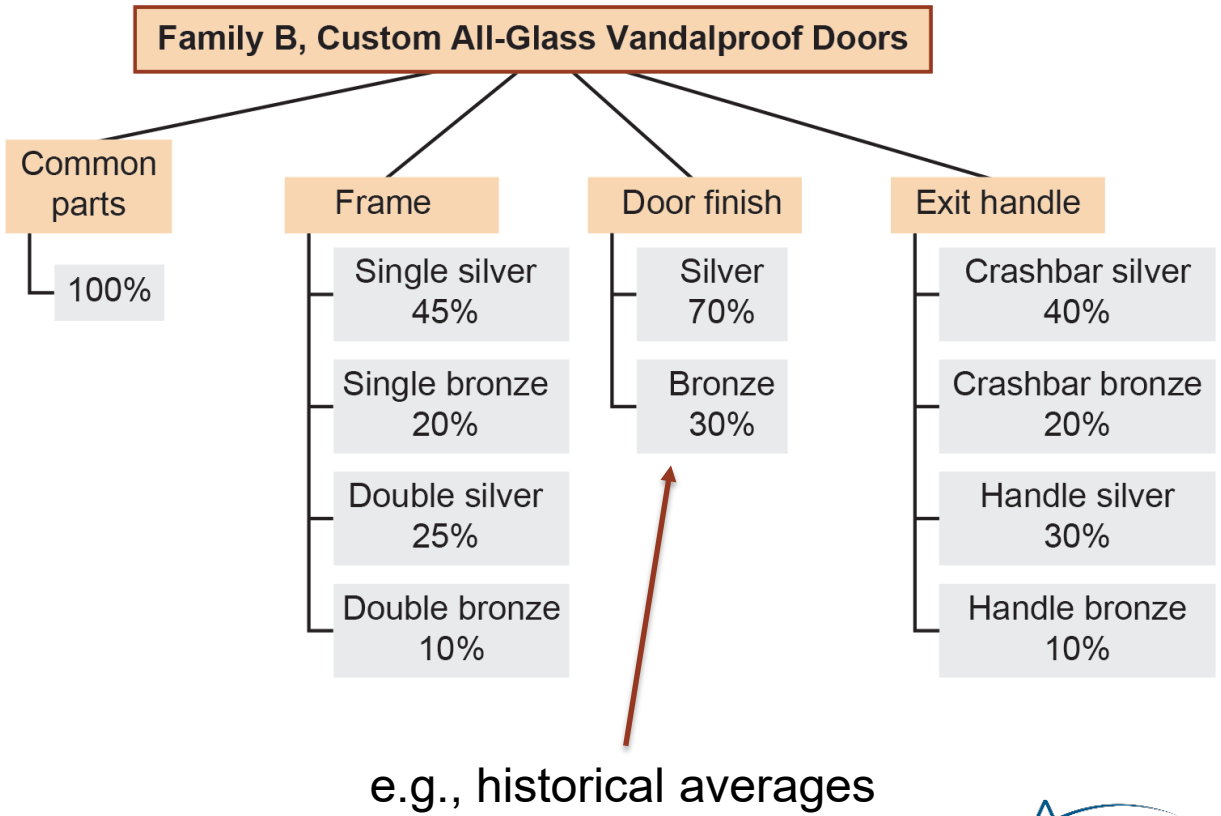
Environment	Process Choice	Order Fluctuations	Choice of Unit Stated in MPS
MTO/ ETO	▪ Needs: Wide variety, low volumes, overlapping schedules, broad production capabilities ▪ Choice: Intermittent job shop and low-volume batch	▪ Sales volume change can be expensive to chase. ▪ Manage fluctuations by adjusting backlog.	▪ MPS: Common raw materials ▪ FAS: End items by customer order
ATO	▪ Needs: Standard/special designs, medium/ high volumes, many item configurations from many options, mix changes, short lead times ▪ Choice: Medium- to high-volume batch or cellular production	Throughput, work-in-process, or finished goods inventory levels	▪ MPS: Options or modules ▪ FAS: End items
MTS	▪ Needs: High volumes, standard designs, narrow variety, flow manufacturing, stable schedule ▪ Choice: High-volume batch or line/repetitive manufacturing	Finished goods inventory and safety stock	FAS: End item

Impact of Product Structure on Master Scheduling

Product structure

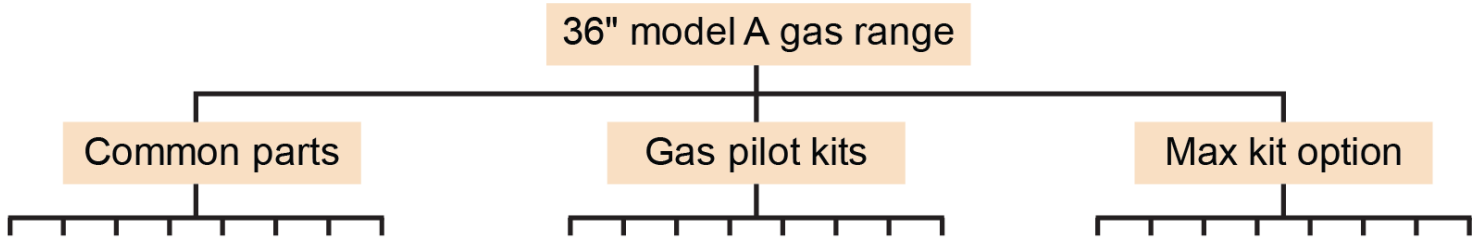
- Product structure: sequence of operations for components
- Priority of jobs
- Takes market and customer expectations and manufacturing requirements into account by prioritizing tradeoffs:
  - Customer service
  - Production efficiency
  - Inventory costs
- Product configuration catalog

Planning BOMs (artificial grouping)



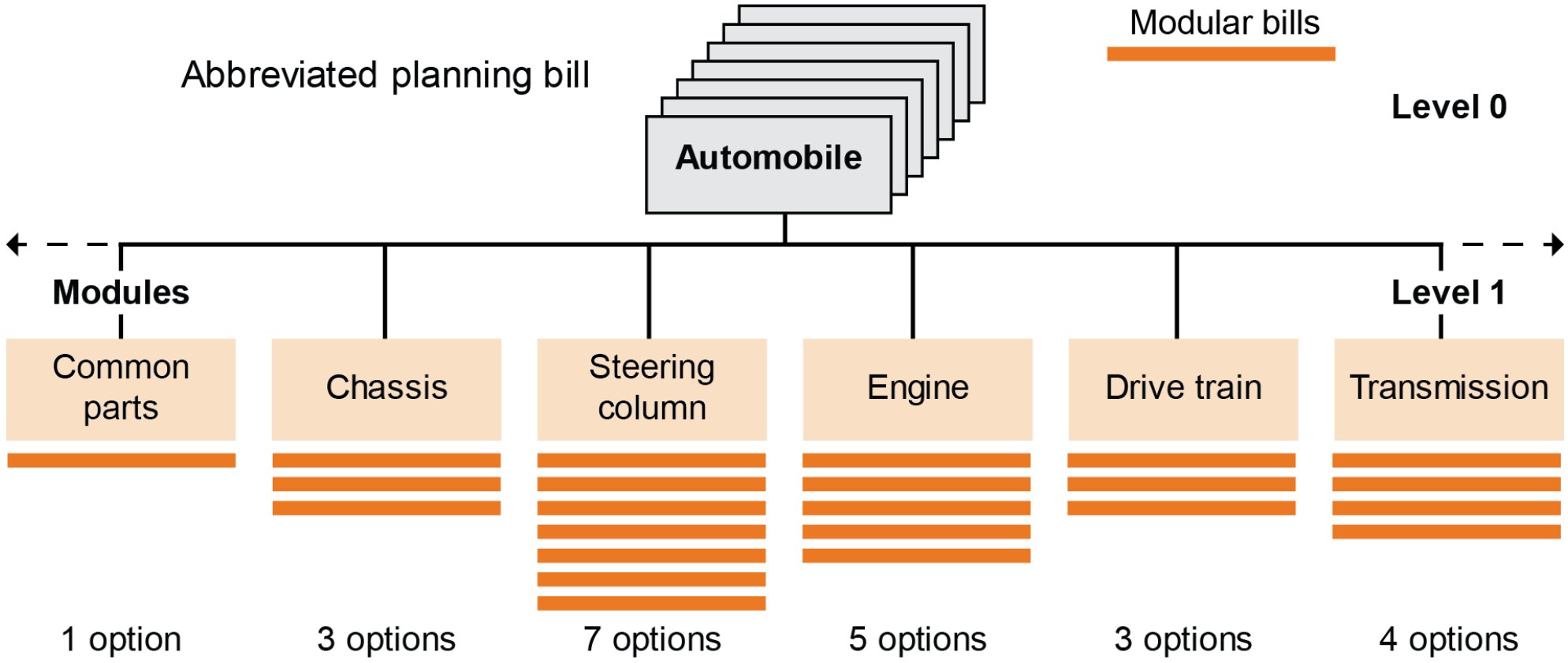
Environment and Product Structure Impact on MS

Common Parts BOM



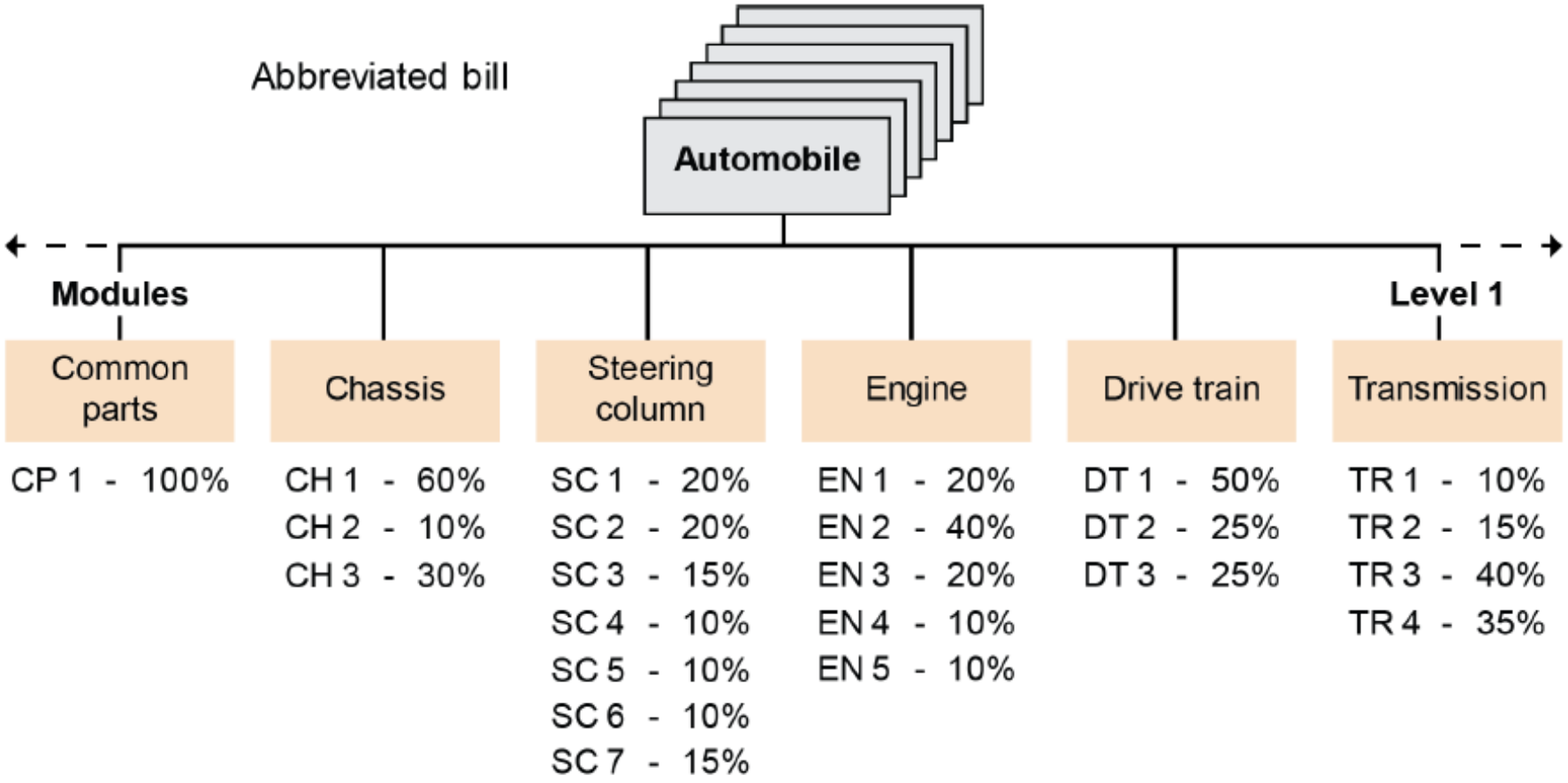
Common parts bill number Item	CP-202 deluxe	CP-201 regular	CP-203 heavy-duty	CP-200 maximum quantity
201 back panel	1	1	1	1
202 left panel	1	1	1	1
203 right panel	1	1	1	1
204 front panel	1	1	1	1
205 oven door	1	1	1	1
206 top panel	1	1	1	1
207 oven liner	1	1	1	1
211 oven shelves	1	2	3	3
221 3" burner assembly	4	3	2	4
222 4" burner assembly	0	1	2	2
242 thermostat	0	1	2	2

Modular BOMs



Environment and Product Structure Impact on MS

Super BOMs



Creators of the Master Schedule

Master scheduler's role

- Disaggregate production plan.
- Maintain and make changes to MPS records.
- Resolve tradeoffs.
- Monitor execution.
- Reconcile MPS.
- Launch final assembly schedule.
- Review and maintain change requests.

Management's role

- Resolve most issues at pre-S&OP meeting.
- Consolidate executive issues:
  - Production and procurement change authorization
  - Adjustment of sales and operations plan to keep on target
  - Customer service performance
  - New product introduction
  - Special projects
- Enforce time fence policies.

Creating the Master Schedule

Techniques to create MPS

- Create time-phased master schedule grid (supply and demand over time).
- Prepare MPS per strategy (chase, level, hybrid).

Item: Chair		Lot size: 80, Safety Stock: 0							
		DTF	OCT			NOV			
	0	1	2	3	4	5	6	7	8
Forecast		20	20	20	20	40	40	40	40
Customer orders		23	15	8	4	0	0	0	0
PAB	45	22	2	62	42	2	42	2	42
MPS quantity		0	0	80	0	0	80	0	80
ATP		7	—	68	—	—	80	—	80

Calculating Projected Available Balance and MPS

Ending PAB = Beginning PAB + Scheduled MPS Receipt − Demand (Orders or Forecasts)

- **Week 2 = 20 + 0 − 60 = − 40**

Master Schedule: Make-to-stock Chase Production Example
Beginning inventory = 70 units Lot size = 100 units

Week	0	1	2	3	4	5	6
Forecast		50	60	70	90	70	20
Projected Available Balance	70	20	-40				
Master Production Schedule							

- Whenever PAB would go negative, schedule lot size MPS.
- Recalculate and find next negative PAB and repeat.

Forecast		50	60	70	90	70	20
Projected Available Balance	70	20	60	90	0	30	10
Master Production Schedule			100	100		100	

Calculating PAB and MPS (Exercise)

Prepare a master schedule.

Opening inventory: 200 units; lot size: 1,000 units

Week		1	2	3	4	5	6
Forecast		100	500	250	500	100	150
Projected available balance	200	100	600	350	850	750	600
MPS			1,000		1,000		

Disaggregating from Family to Item Level

- From monthly forecast (3 months shown)…

Month	0	1	2	3
Sales Plan		460	450	410
Production (Leveled)		300	300	300
Ending Inventory	520	360	210	100
Average Inventory		440	285	155

- …to weekly forecast (13 weeks).

Individual products

Family A: Vandalproof Commercial Doors, In-Stock All-Glass									January 1 to March 31					
Weekly Forecast by Product	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**SUM**
In-Stock Single (ISS)	50	70	70	60	70	60	60	70	40	70	50	40	30	740
In-Stock Double (ISD)	50	40	60	40	50	60	50	40	50	30	30	40	40	580
SUM	100	110	130	100	120	120	110	110	90	100	80	80	70	1,320

- Sum of MPSs for items in family must equal production plan for that family.
- First three months in monthly forecast: 460 + 450 + 410 = 1,320 units.

Master Schedules for Two Items in Family A

Family A: Vandalproof Commercial Doors, In-Stock All-Glass											Batch: 100			1/1-3/31	
Master Schedules	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**SUM**
Days in Week		4	5	4	5	5	5	5	4	5	5	5	5	5	62
Weekly Leveled Production		57	72	57	72	72	72	72	57	72	72	72	72	72	889
In-Stock Single (ISS) Forecast		50	70	70	60	70	60	60	70	40	70	50	40	30	740
ISS Projected Available	310	317	290	220	218	190	132	144	100	62	64	40	18	59	
ISS MPS		57	43		58	42	2	72	26	2	72	26	18	71	489
In-Stock Double (ISD) Forecast		50	40	60	40	50	60	50	40	50	30	30	40	40	580
ISD Projected Available	210	160	149	146	120	100	110	60	51	70	40	56	70	30	
ISD MPS			29	57	14	30	70		31	69		46	54		400
Forecast SUM		100	110	130	100	120	120	110	110	90	100	80	80	70	1,320
Projected Available SUM	520	477	439	366	338	290	242	204	151	132	104	96	88	89	
Production SUM		57	72	57	72	72	72	72	57	71	72	72	72	71	889

Workable Preliminary Master Schedule Criteria

Master schedule should be realistic and achievable.

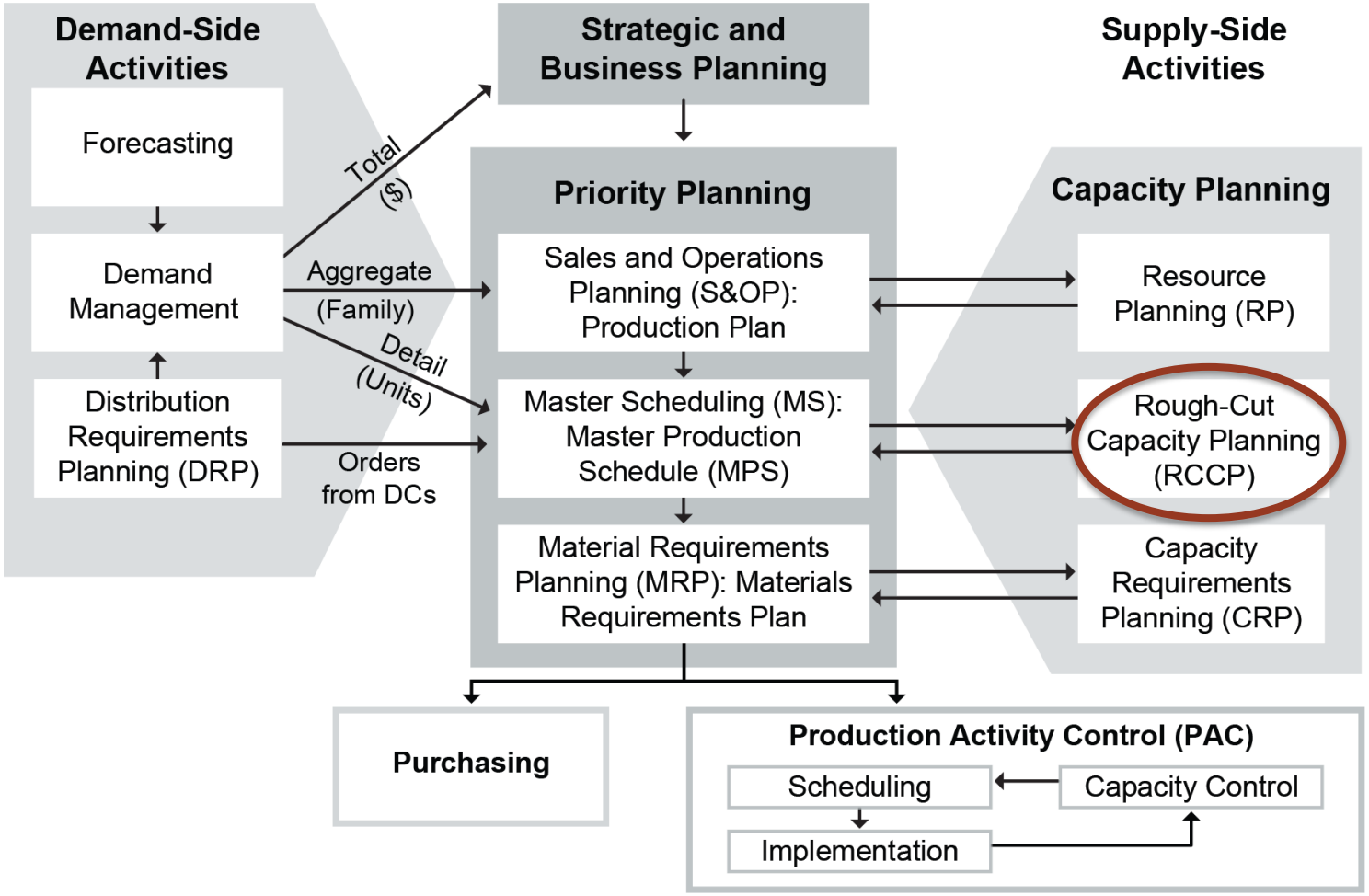
- Valid schedule
- Valid capacity
- Valid inventory or backlog
- Valid changeovers
- Valid batches and lots (honors batch and lot size policies)

RCCP Preparation: Aggregating Master Schedules for Related Items

- Often this aggregates units back into families.
- Sums used for total load on critical resources.

Families A, B and C: Vandalproof Doors												1/1-3/31		
Master Schedules	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**SUM**
Family A (In Stock)														
ISS MPS	57	43		58	42	2	72	26	2	72	26	18	71	**489**
ISD MPS		29	57	14	30	70		31	69		46	54		**400**
Family B (Custom)														
B Single MPS		50	50	50	30	10		20	20	30	20	20	20	**320**
B Double MPS	20	20		20		30	40	20	10	20	40	20	10	**250**
Family C (Custom)														
C Single MPS		30	20	20	20	30	20	30	20	20		40	50	**300**
C Double MPS	50			10	50	30	40		50	30	40	20	20	**340**
MPS SUM	**127**	**172**	**127**	**172**	**172**	**172**	**172**	**127**	**171**	**172**	**172**	**172**	**171**	**2,099**

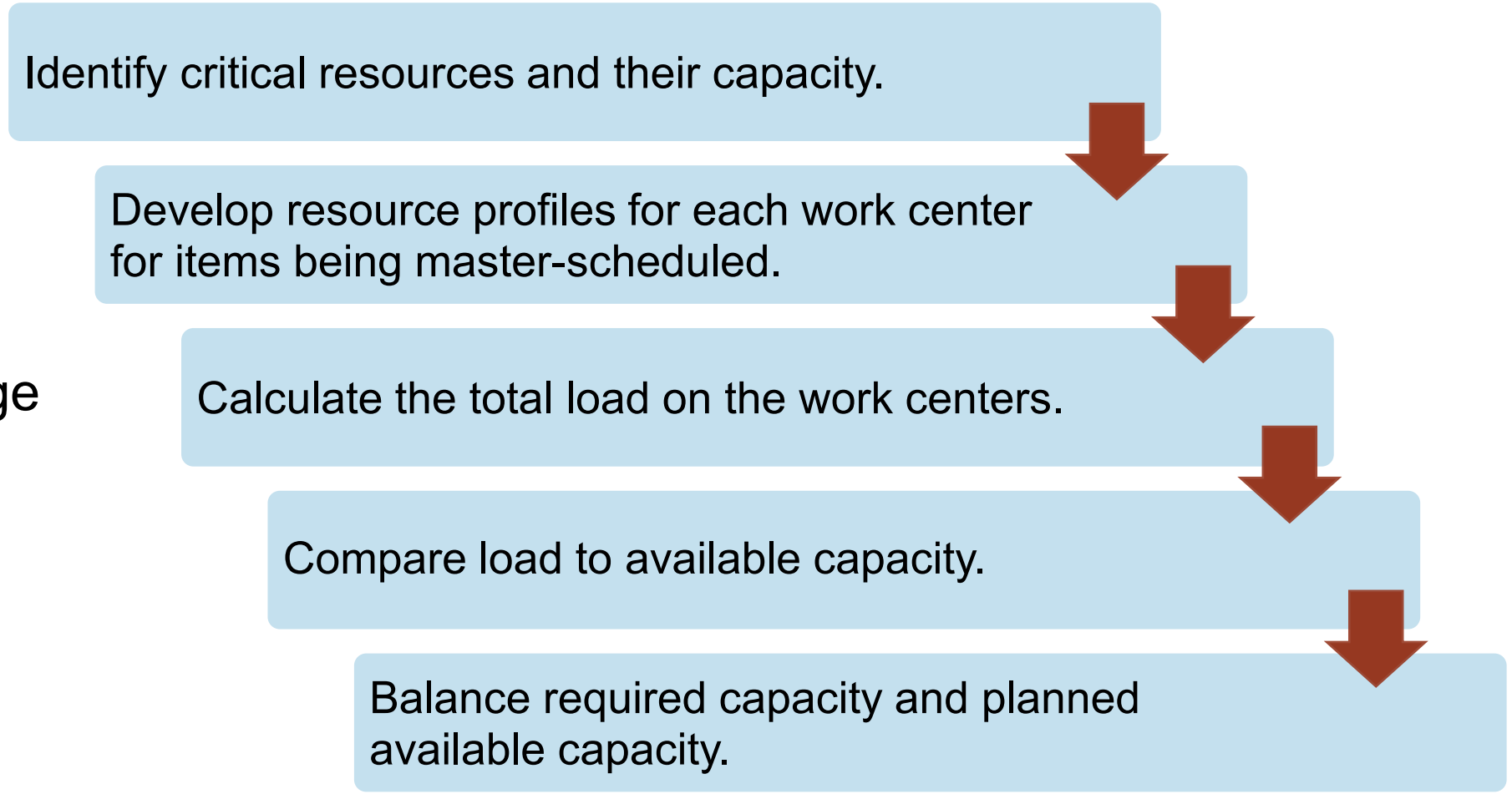
RCCP in Manufacturing Planning and Control



Rough-Cut Capacity Planning and MPS Validation

RCCP Purpose and Process

- Validate critical resource availability for MPS.
- Specific models rather than average unit of family.
- Items might still have variants, so still rough-cut.



RCCP Approaches

CPOF

- Least detailed
- MS quantities x total time per item
- Historical work center % applied to total hours
- Not sensitive to mix changes

Bill of Labor

- Structured listing of all labor requirements
- Standard hours
- Portions per work center
- Detects mix shifts but not lead time differences

Resource Profile

- Like bill of labor but considers lead-time offsets
- Needs data on production lead times for end units and components
- Lot-for-lot

Resource Profile Approach

Bill of resources

Families A, B and C: Vandalproof Glass Commercial Doors

Product	Polycarbonate, Recycled (tons)	Labor (standard hours)	Work Center 23 (standard hours)
Family A: In-Stock All-Glass	**0.0036**	**3.3**	**0.6**
In-Stock Single (ISS)	0.0024	2.2	0.4
In-Stock Double (ISD)	0.0048	4.4	0.8
Family B: Custom All-Glass	**0.0038**	**3.9**	**0.7**
B Single	0.0025	2.6	0.5
B Double	0.0051	5.2	0.9
Family C: Custom Small Window	**0.0009**	**2.7**	**0.2**
C Single	0.0003	1.8	0.1
C Double	0.0015	3.6	0.3

Calculating load on critical resources

Families A, B & C: Vandalproof Glass Commercial Doors

Product	Week 1 MPS	Rate	Polycarbonate, Recycled (tons) Load	Rate	Labor Load (standard hours)	Rate	Week 1 23 Load (standard hours)
Family A: In-Stock All-Glass							
In-Stock Single (ISS)	57	0.0024	0.1368	2.2	125.4	0.4	22.8
In-Stock Double (ISD)	0	0.0048	0	4.4	0	0.8	0
Family B: Custom All-Glass							
B Single	0	0.0025	0	2.6	0	0.5	0
B Double	20	0.0051	0.102	5.2	104.0	0.9	18
Family C: Custom Small Window							
C Single	0	0.0003	0	1.8	0	0.1	0
C Double	50	0.0015	0.075	3.6	180.0	0.3	15
SUM			**0.3138**		**409.4**		**55.8**

Resolving Capacity Imbalances

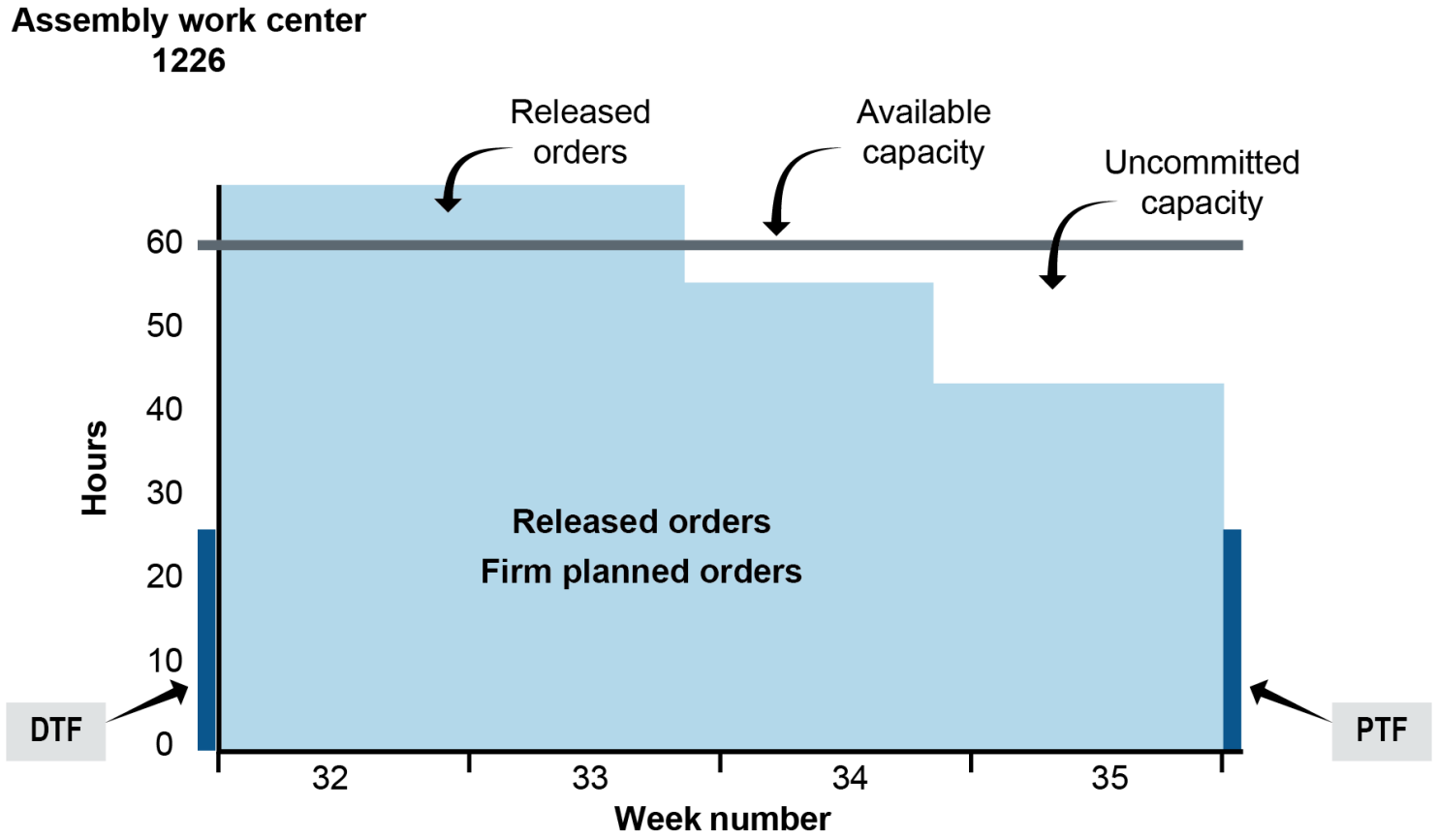
If required capacity (load) exceeds available capacity:

- Rebalance load to periods with available capacity.
- Increase capacity.
  - Overtime.
  - Shifting workers to other tasks.
  - Hire part-time workers or subcontract.

Workable master schedule:

- Publish for use in MRP.

Resolving Capacity Imbalances: Load Profile



Note: The schedule prior to period 32 is frozen.

- Actions focused on
  - Modification of MPS dates and quantities
  - Communication with customers on delivery flexibility
  - Changes in available capacity.

Overload and Underload Solutions

- Bill of resources (standard hours/unit):
  - Product 1: 0.36
  - Product 2: 0.31
  - Product 3: 0.221
- Original RCCP report:
  - Capacity available per week: 58.25 hours
  - Weeks 32 and 33: 0.36 × 180 = 64.8 hours (overload)
  - Week 34: 55.8 hours
  - Week 35: 42.98 hours
- Solutions
  - 19 units of product 1 moved from weeks 32, 33 to week 34
  - 38 units of product 1 set back to week 35

MPS for weeks 32 to 35, in units

Work center 1226	32	33	34	35	Total
Product 1	180	180			360
Product 2			180	36	216
Product 3				144	144
Total	180	180	180	180	720

Revised MPS for weeks 32 to 35, in units

Work center 1226	32	33	34	35	Total
Product 1	161	161	38		360
Product 2			142	74	216
Product 3				144	144
Total	161	161	180	218	720

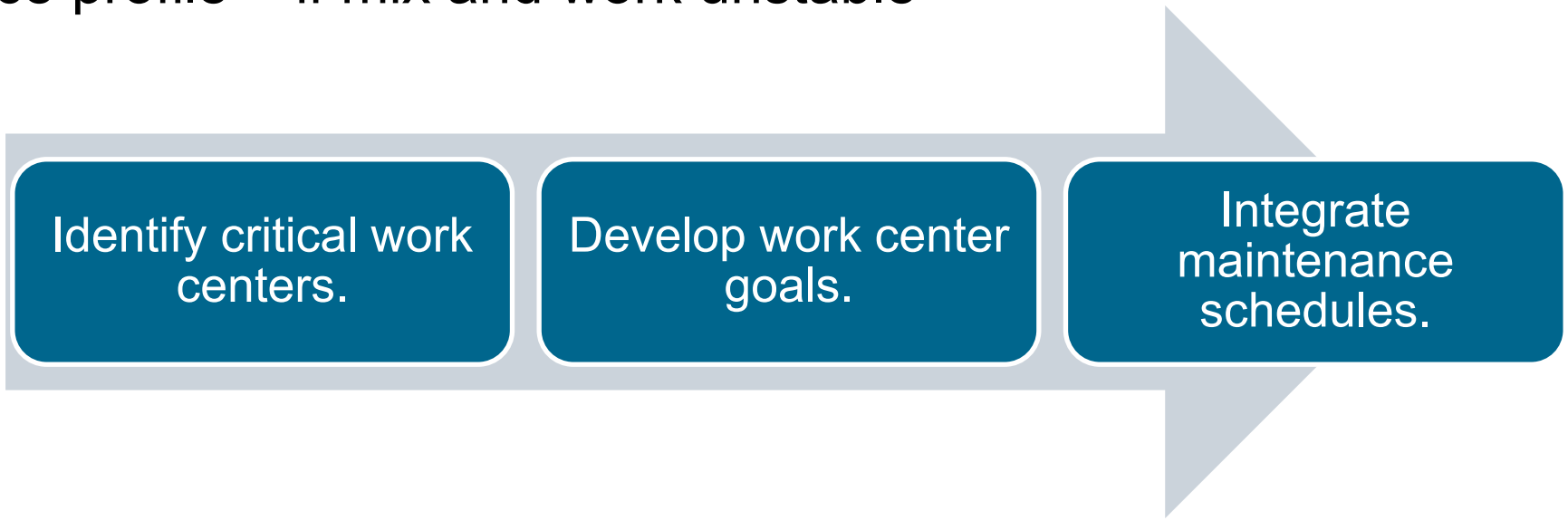
RCCP report
Adjusted load and capacity: weeks 32 to 35, in hours per week

Work center 1226	32	33	34	35	Total
Standard hours	57.96	57.96	57.70	54.76	228.38
Capacity available	58.25	58.25	58.25	58.25	233.00
Over (under) load	(.29)	(.29)	(.55)	(3.49)	(4.62)

Managing Work Centers

Methods of identifying critical work centers

- CPOF = manual
- Bill of labor = if mix shifts but stable work pattern
- Resource profile = if mix and work unstable



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SECTION B:
USING AND MAINTAINING
THE MASTER SCHEDULE

APICS

ASCM

Section B Learning Objectives

- Master schedule process flow
- Time fences and zones
- Projected available balance (PAB)
- Available-to-promise (ATP)
- Inventory/backlog maintenance
- Engineering changes
- Consequences of not abiding by master schedule
- Master scheduling performance

Stability of Master Schedule

Relates to

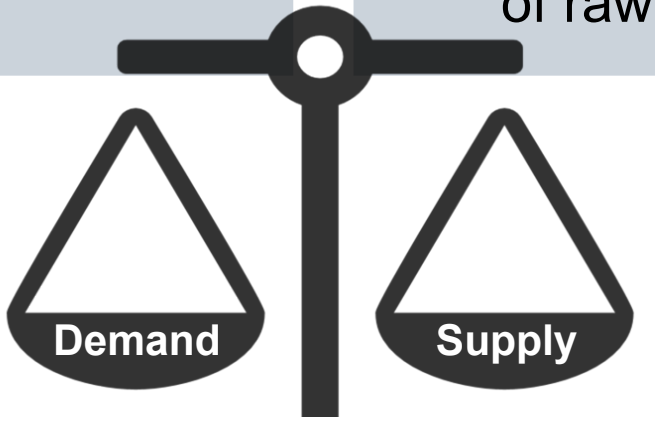
- Frequency of changes in timing and quantity
- Discipline of organization
- Organizational goals/objectives.

Increasing stability

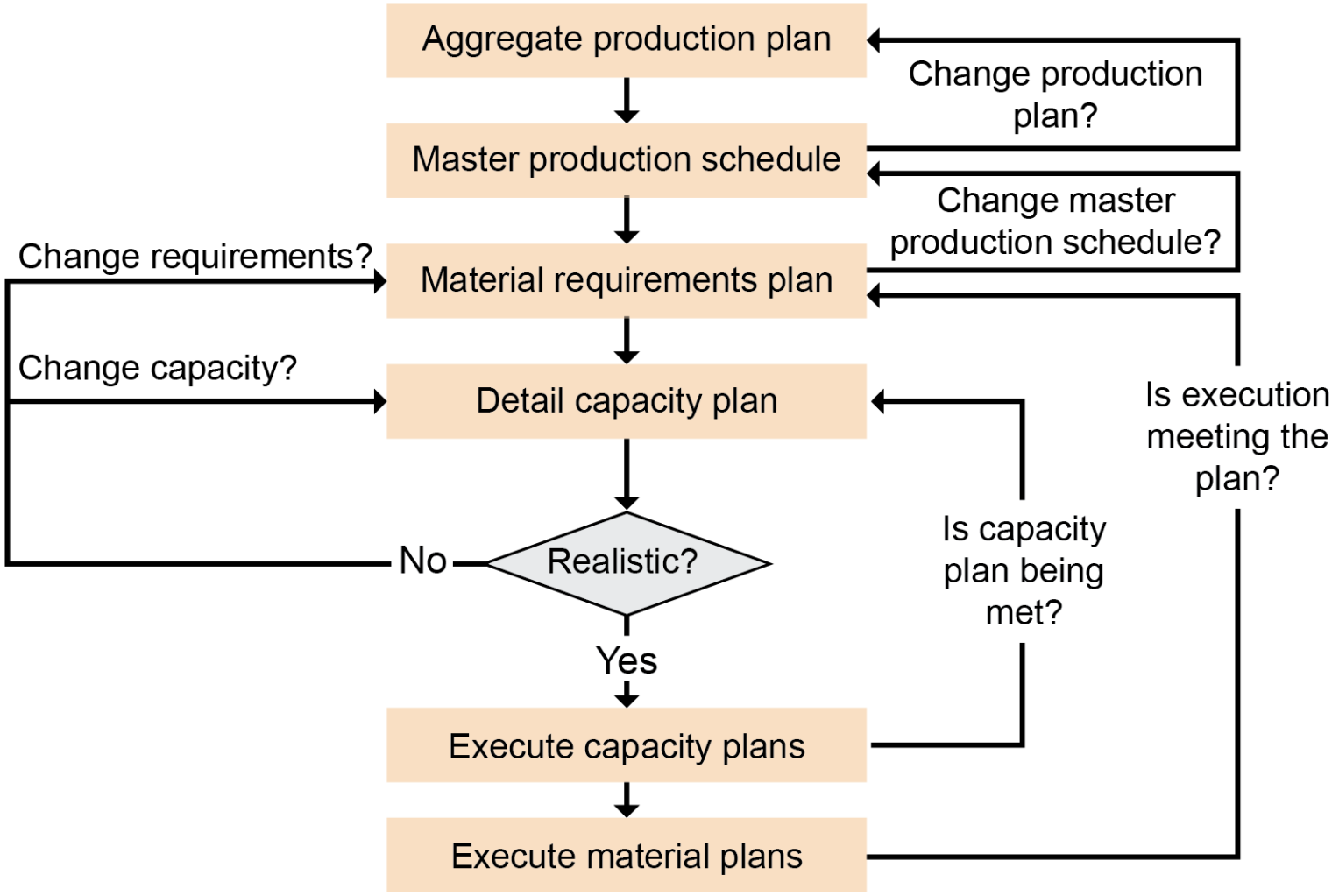
- Discipline in creating production forecast
- Balance between too many/too few changes
- Be responsive but avoid cost/productivity issues
- Stable component schedules and operations performance

Master Scheduling Change Drivers

Demand	Supply
▪ Competition in marketplace ▪ Variations in product transportation ▪ Supply chain partners ▪ Sales and marketing initiatives	▪ Quality issues in processes and products ▪ Reliability of supplier ▪ Supply-demand balance ▪ Manufacturing flexibility ▪ Product mix ▪ Ripple effect from untimely deliveries of raw materials

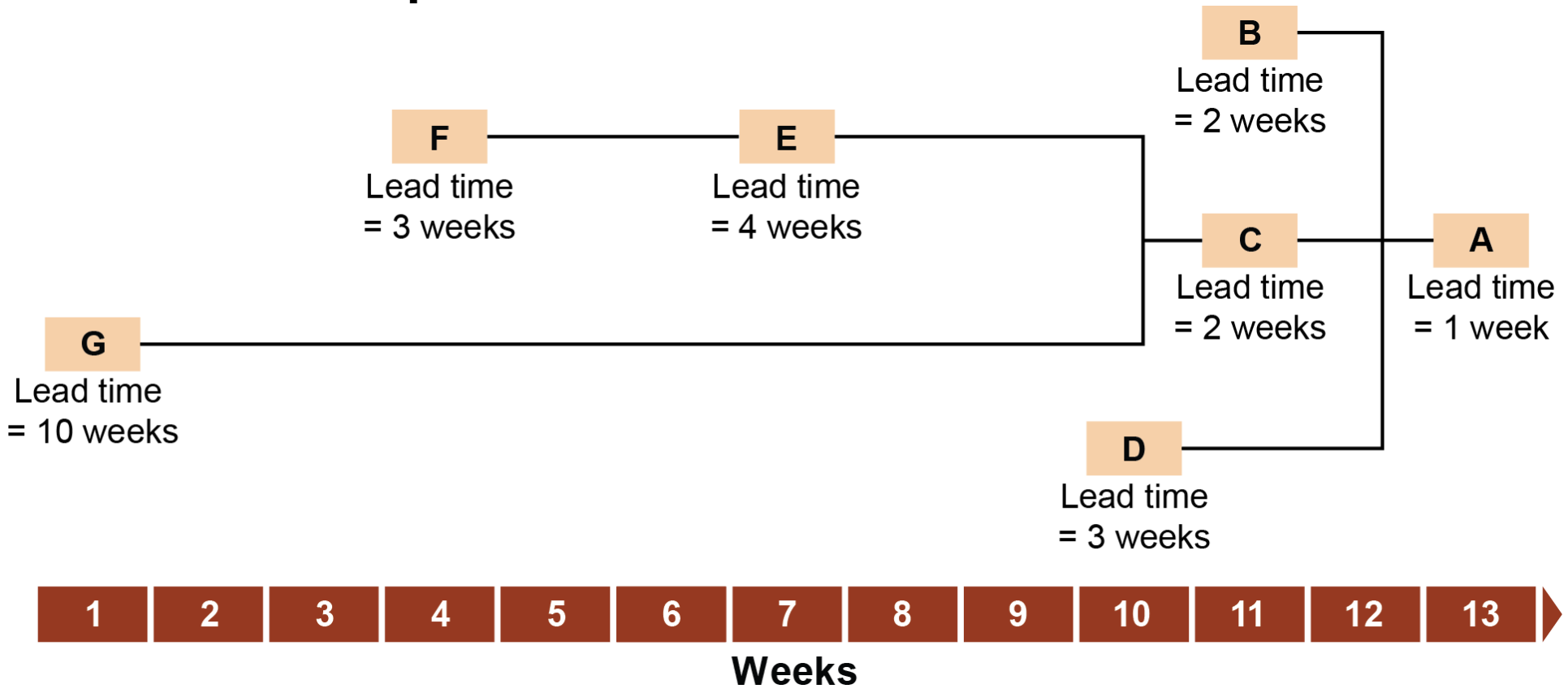


Master Scheduling Flowchart

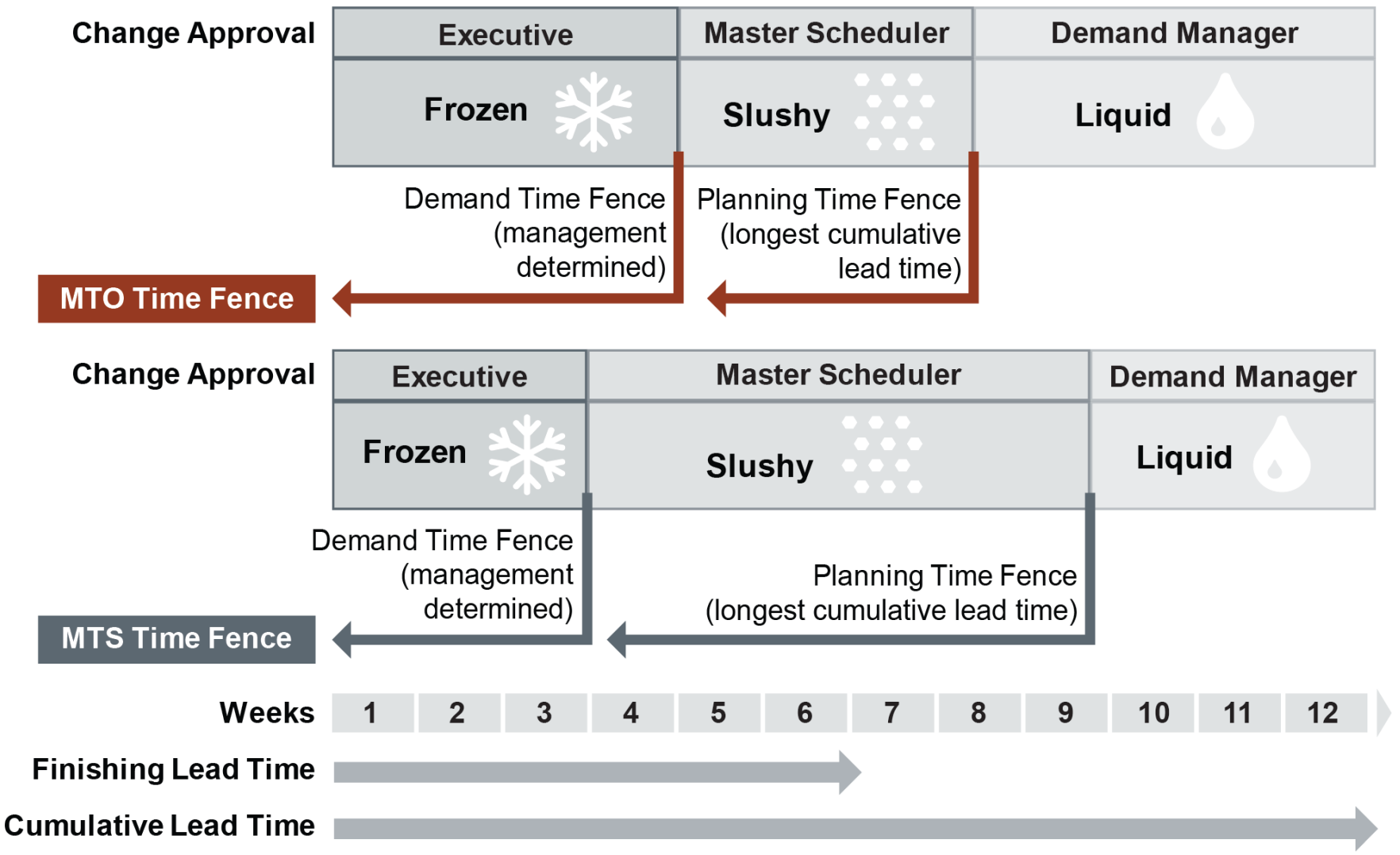


Determining Planning Horizon

Cumulative lead time plus slack time



Planning and Coordinating MPS Changes



Calculating PAB When Time Fences Are Used

- Objective is to determine projected inventory levels and their sufficiency at end of each period.
- Ending PAB Before Demand Time Fence = Prior Period PAB + Scheduled MPS Receipt − Customer Orders; Week 2 = 22 + 100 − 66 = 56 Units
- Ending PAB After Demand Time Fence = Prior Period PAB + Scheduled MPS Receipt − Greater of Customer Orders or Forecast; Week 5 = 9 + 100 − 70 = 39 Units

Master Schedule: Make-to-stock Chase Production Example

Beginning inventory = 70 units Lot size = 100 units

Week	0	1	2	3	4	5	6	...	12	13	14	15	16
Forecast		50	60	70	90	70	20		20	20	20	20	20
Customer Orders		48	66	57	62	30	0		0	0	0	0	0
Projected Available Balance	70	22	56	99	9	39	19		99	79	59	39	19
Master Production Schedule			100	100		100			100				

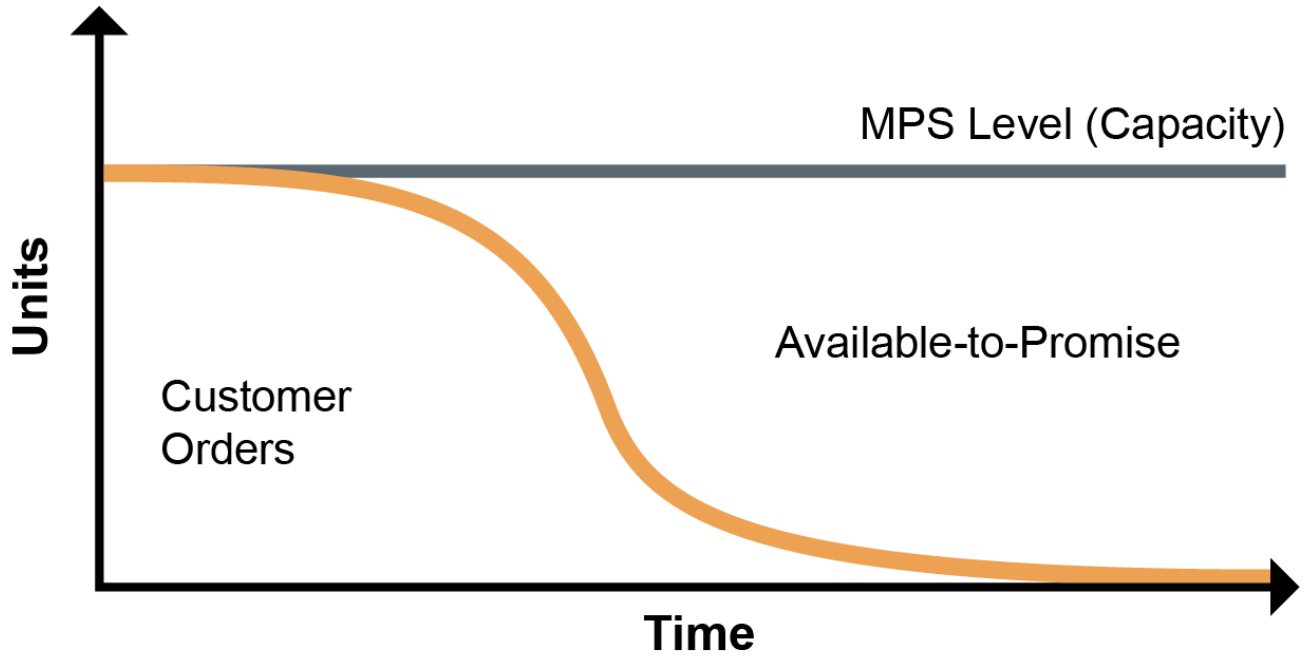
Demand Time Fence Planning Time Fence

Available-to-Promise (ATP)

- Uncommitted portion of inventory and planned production maintained in the MS to support customer order promising
- Calculating ATP
  - Ignores forecast and focuses on customer orders only
  - Calculated for first period of master schedule grid
  - Subsequently calculated only for periods with an MPS receipt
  - Uses discrete and cumulative methods of calculation

Available-to-Promise and Order Promising

- Order entry and order promising (quantity, lead time).
- Orders that exceed available inventory (if any) look next to MPS (anticipated build schedule).
- Consensus from S&OP: realistic, achievable.



Calculating ATP: Discrete and Cumulative With/Without Look-Ahead

ATP period 1, all methods

$$ATP_{\text{Period 1}} = \text{On-Hand Quantity} + \text{MPS} - \sum \text{Customer Orders}_{\text{Before Next MPS}}$$

Discrete ATP

$$\text{Discrete ATP}_{\text{Periods with MPS}} = \text{MPS} - \sum \text{Customer Orders}_{\text{Before Next MPS}}$$

Cumulative ATP with look-ahead

$$\text{Cumulative ATP With Look-Ahead}_{\text{Next MPS Period}} = \text{Previous Cumulative ATP} + \text{MPS} - \sum \text{Customer Orders}_{\text{Before Next MPS}}$$

Cumulative ATP without look-ahead

$$\text{Cumulative ATP Without Look-Ahead}_{\text{Next MPS Period}} = \text{Previous Cumulative ATP} + \text{MPS} - \text{Customer Orders}_{\text{Current Period Only}}$$

ATP Methods Compared

Lot size = 50 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 (backlog)		19	17	15	11	9	5	2	1	0	0
Projected available balance (PAB)	50	31	14	49	24	50	27	6	35	10	35
Discrete ATP		14		24		34			49		50
Cumulative ATP with look-ahead		14		38		72			121		171
Cumulative ATP without look-ahead		14		49		90			139		189
Master production schedule (MPS)				50		50			50		50

Demand Time Fence (management determined)

Planning Time Fence (longest cumulative lead time)

Calculating Discrete ATP Given Projected Negative ATP

$ATP_{Period\ 1}$ = 70 on hand + 0 units MPS − 48 units in orders = 22 units

$ATP_{Period\ 3}$ = 100 units MPS – (57 units + 62 units) = -19 units

If negative, reduce prior ATP by negative amount:
34 units − 19 units = 15 units for period 2, with period 3 now at 0 units.

Master Schedule: Make-to-stock Chase Production Example
Beginning inventory = 70 units Lot size = 100 units

Week	0	1	2	3	4	5	6	...	12	13	14	15	16
Forecast		50	60	70	90	70	20		20	20	20	20	20
Customer Orders		48	66	57	62	30	0		0	0	0	0	0
Projected Available Balance	70	22	56	99	9	39	19		99	79	59	39	19
Master Production Schedule			100	100		100			100				
Available-to-Promise		22	34	-19		70			100				

Demand Time Fence Planning Time Fence

Master Schedule: Make-to-stock Chase Production Example
Beginning inventory = 70 units Lot size = 100 units

Week	0	1	2	3	4	5	6	...	12	13	14	15	16
Forecast		50	60	70	90	70	20		20	20	20	20	20
Customer Orders		48	66	57	62	30	0		0	0	0	0	0
Projected Available Balance	70	22	56	99	9	39	19		99	79	59	39	19
Master Production Schedule			100	100		100			100				
Available-to-Promise		22	15	0		70			100				

Demand Time Fence Planning Time Fence

Cumulative ATP with Look-Ahead Exercise

Calculate cumulative ATP for periods 1 and 3.

On hand = 20; lot size = 30; safety stock (SS) = 5

Period		1	2	3	4	5
Forecast		5	5	8	10	15
Customer orders		5	4	7	5	0
Projected available balance	20	15	10	32	22	7
Available-to-promise (discrete)		11		18		
Available-to-promise (cumulative)		11		29		
Master production schedule				30		

$$\text{Cumulative ATP}_{\text{Period 1}} = \text{On-Hand Quantity} + \text{MPS} - \Sigma\ \text{Customer Orders}_{\text{Before Next MPS}}$$

$$\text{Cumulative ATP}_{\text{Next MPS Period}} = \text{Prev. Cumulative ATP} + \text{MPS} - \Sigma\ \text{Customer Orders}_{\text{Before Next MPS}}$$

Time Fences Exercise

Calculate the new PAB, MPS, and ATP quantities using the demand time fence.

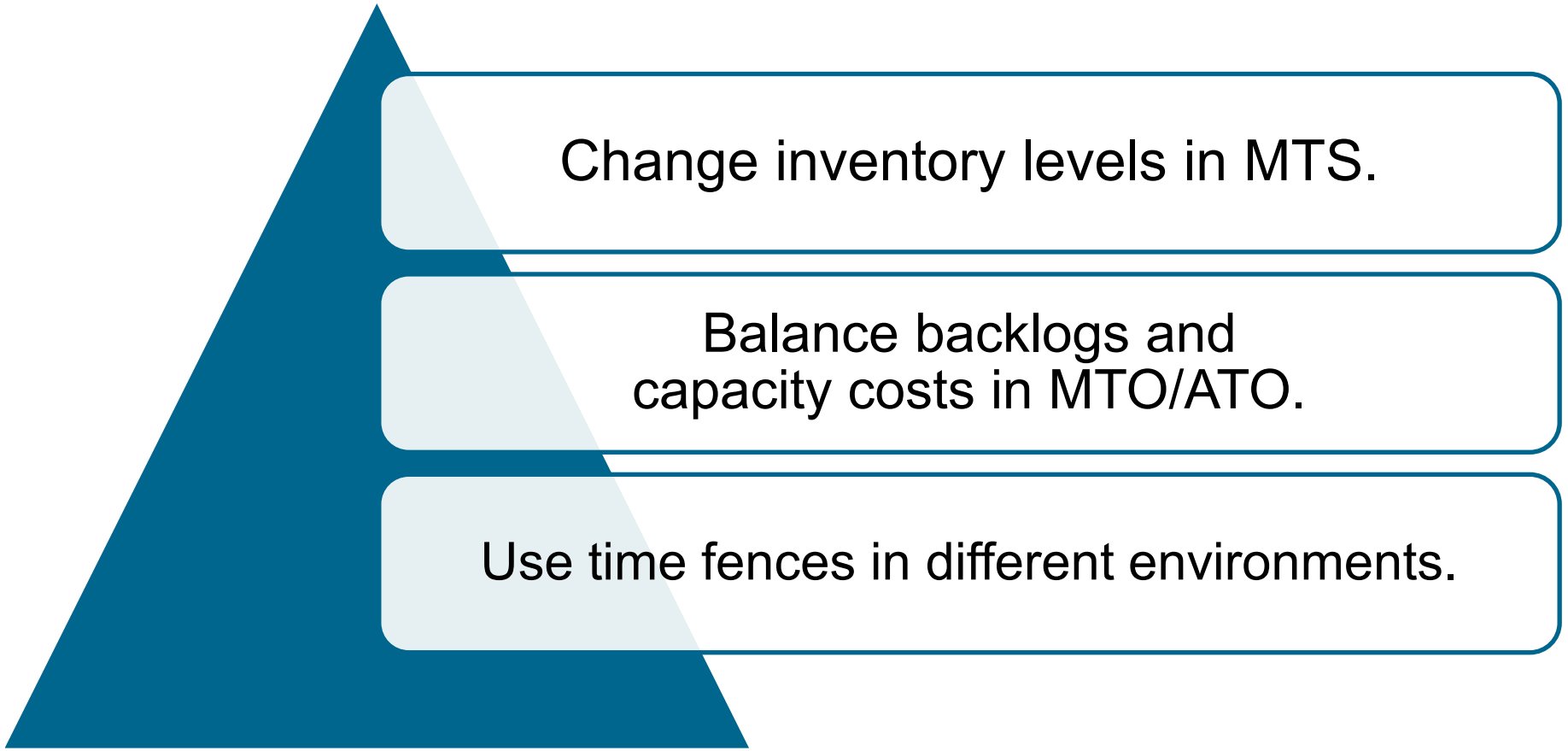
On hand = 20; lot size = 30; safety stock (SS) = 5; demand time fence = 2

Period		1	2	3	4	5
Forecast		5	5	8	10	15
Customer orders		5	3	2	0	0
Projected available balance	20	15	12	34	24	9
Available-to-promise (discrete)		12		28		
Master production schedule				30		

Product Delivery: Key Component Is Order Promising.

ATP aids product delivery by	ATP can establish if
▪ Providing valid customer delivery dates ▪ Holding products before delivery ▪ Providing warnings on components to prevent over-promising on delivery dates ▪ Providing sales with up-to-date information to manage delivery expectations.	▪ Product is available at time of order ▪ Items can be shipped by customer's requested date ▪ Items are available for single shipment.

Fine-Tuning Techniques Related to Environment



General Fine-Tuning Techniques

Establish criteria for accepting an unexpected new customer order or expediting an existing customer order.

Coordinate engineering configuration changes.

Maintain schedule integrity.

Understand the consequences of an unrealistic schedule.

Respond proactively to changes in suppliers' capabilities, availability of materials or parts, timely delivery, and overall performance.

Maintaining Schedule Integrity

- Safety stock with PTF decision rule
- Hedges
  - Volume hedge
  - Product mix hedge

Action message: Reschedule MPS period 6 to period 5?

		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	35	25
Customer orders (backlog)		19	17	15	11	9	5	2	1	0	0
Projected available balance (PAB)	50	31	14	49	24	0	27	6	35	50	25
Master production schedule (MPS)				50			50		50	50	

Safety stock = 5 units

Lot size = 50 units

Demand Time Fence (management determined)

Planning Time Fence (longest cumulative lead time)

Master Scheduling Performance: KPIs for Master Scheduling

- MPS aggregate performance
  - Variance of sum of MPSs from production plan by family
  - Variance of RCCP from resource plan at S&OP level
  - Variance of master schedule from financial plan or budget
- MPS stability
  - % of MPS orders that change
  - % of orders past due
- MPS lead time
  - % of planned orders violating time fence rules
  - Reduction in customer lead times over period of time
- MPS execution
  - % of perfect orders
  - Line-item fill-rate %

Master Scheduling Performance Measurement

Problem indicators	Key policies and procedures
▪ Unreliable delivery promises ▪ Persistent past-due orders ▪ Excess inventory ▪ Many schedule changes ▪ Top management intervention	▪ Clearly defined master scheduler role – Disaggregation role ▪ Senior management collaborates ▪ Time fences enforced ▪ Lot size, safety stock, lead time, etc., updated ▪ RCCP and APS

CPIM

CERTIFIED IN PLANNING
AND INVENTORY MANAGEMENT

SECTION C:
MATERIAL REQUIREMENTS PLANNING

APICS

ASCM

Section C Learning Objectives

- MRP and service parts
- MRP in different manufacturing environments
- MRP planning horizons, time buckets, inputs, and outputs
- Types of bills of material (BOMs)
- Elements of the MRP grid
- Actions in BOM explosions, low-level coding, offsetting lead time, and gross to net requirements calculation
- Metrics used to assess MRP performance

MRP Basics

MRP: “Set of techniques that uses BOM data, inventory data, and MPS to calculate requirements for materials.”

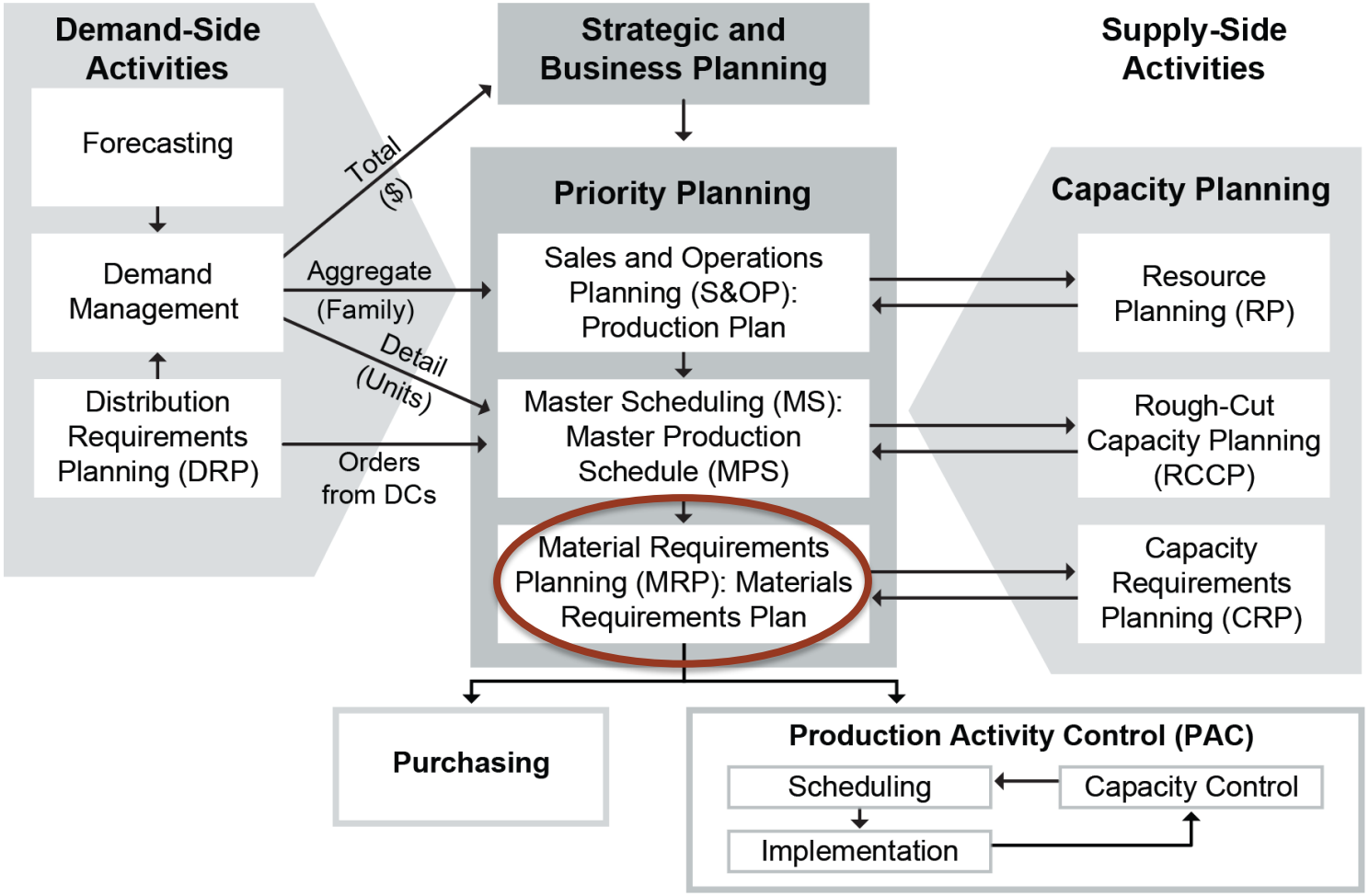
Functions of MRP

- Plan and control inventories.
- Plan and control order releases.
- Provide accurate input into capacity planning process.

Objectives of MRP

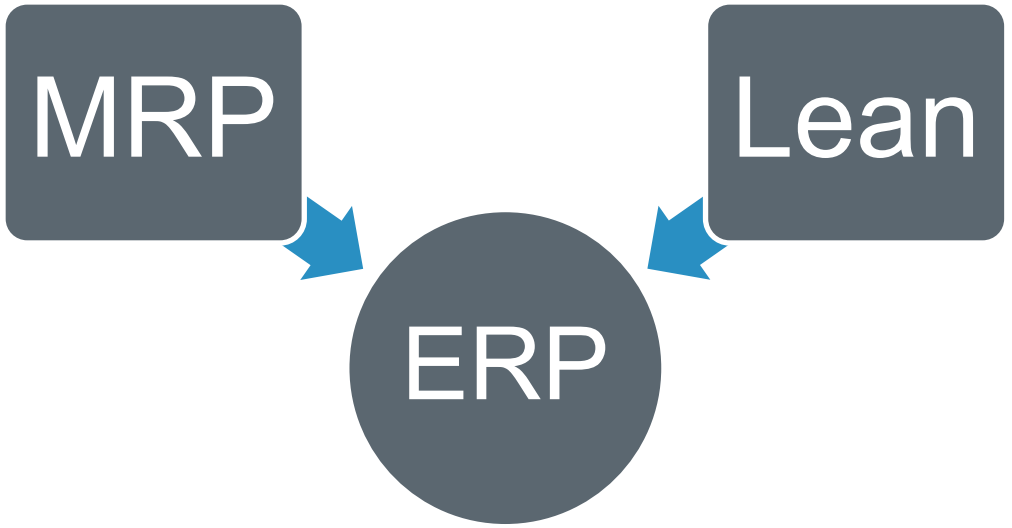
- **Planning**
  - Precise material requirements
  - What, how much, and when
  - What to get from inventory
  - What, when to order; when to schedule delivery
- **Control**
  - Adapt to changing priorities
  - Demand changes, supply issues, errors
  - Update multiple details
  - Planners able to expedite, de-expedite, add, cancel, or change planned orders

Material Requirements Planning in Context



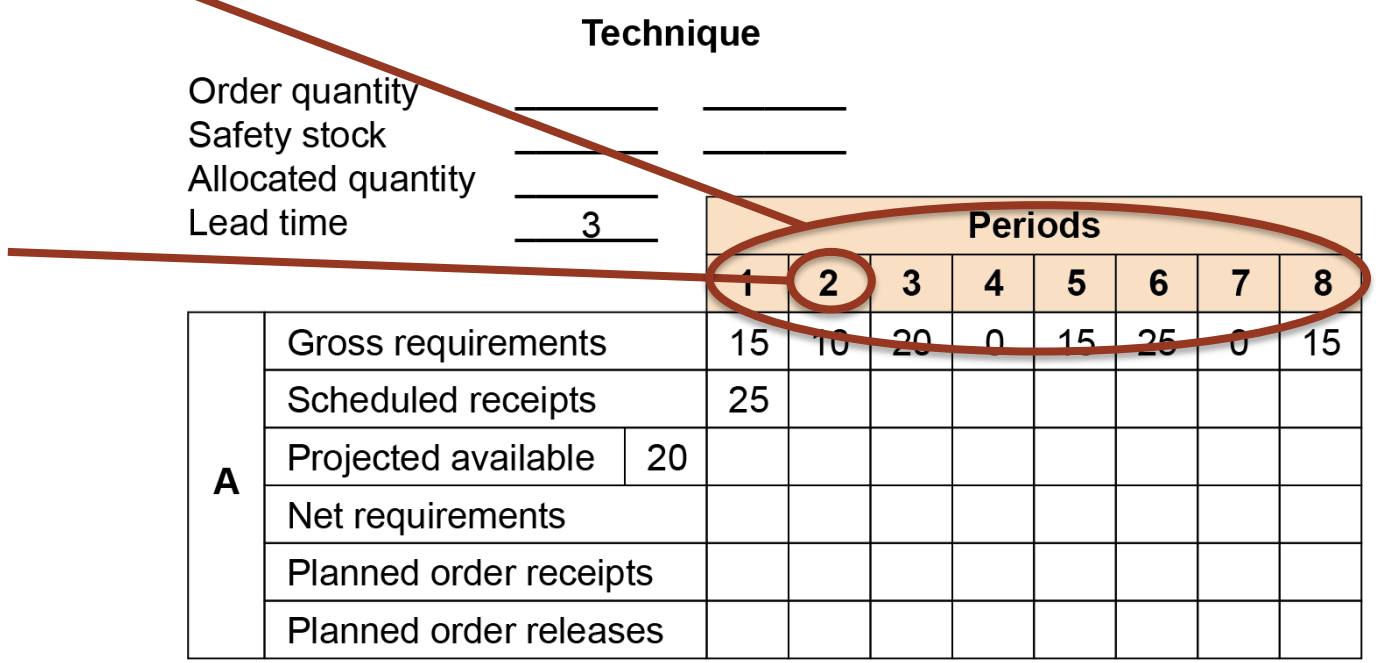
Manufacturing Environments and Production Systems

- MRP has been traditionally been used
  - In push, rather than pull, environments
  - For items with dependent, rather than independent, demand.
- ERP systems can
  - Incorporate functionality of both MRP and lean.
  - Manage parts with both dependent and independent demand (service parts).



MRP Planning Horizon Time Buckets

- Planning horizon at least as long as cumulative lead time for end item.
- Time buckets contain defined number of days of data.



			Technique							
Order quantity										
Safety stock										
Allocated quantity										
Lead time			3							
			Periods							
			1	2	3	4	5	6	7	8
A	Gross requirements		15	10	20	0	15	25	0	15
	Scheduled receipts		25							
	Projected available	20								
	Net requirements									
	Planned order receipts									
	Planned order releases									

Bucketless MRP Systems

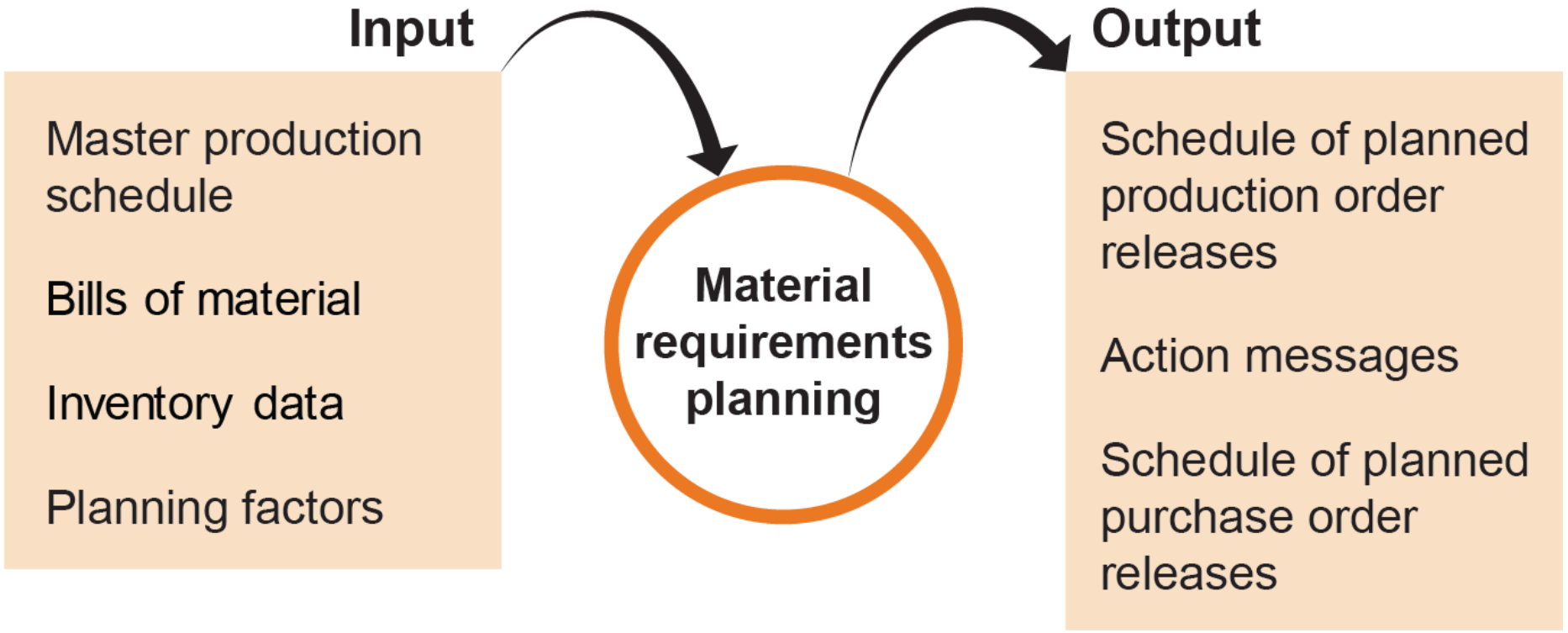
Planning bucket is one day.

Only days with events are displayed.

Fewer timing problems, better activity time phasing.

Part Number: 12345			
Lead Time (Days): 5		Safety Stock: 10	
Description: Widget		Lot Size: 50	
Date	**Transaction**	**Quantity**	**PAB**
Beginning of June			100
1-Jun	Forecast	20	80
3-Jun	MPS Receipt	50	130
4-Jun	Customer Order	100	30
5-Jun	Customer Order	25	5
5-Jun	Planned MPS Receipt	50	55

MRP Inputs and Outputs



Inputs, Process, and Outputs

Input	Description	Source
MPS	Quantities, due dates as planned and scheduled orders	Master schedule
BOMs	Quantity of each uniquely identified part to make one item	Product structure file
Planning factors	Static inventory data (lot size, lead time, yield/scrap factors, safety stock level)	Inventory records: item master file
Inventory status	Dynamic inventory data for components/items (on hand, allocated, on order with due date)	Inventory records: inventory record file

Process: time-phased priority plan with release/receipt plan

Outputs: POs to suppliers (purchasing); CRP-validated production orders to shop floor

MRP Inputs, Process, and Outputs

Bill of Material Concepts

Unique ID: All parts get unique part number. (If form, fit, or function changes, part gets new number.)

Single unit: All parts to make exactly one unit of Part Number 100.

Family A: In-Stock All-Glass Vandalproof Commercial Doors
Product: In-Stock Double (ISD) Part Number: 100
Description: Vandalproof glass double doors, silver trim

Part Number	Description	Quantity	Units
202	Door, Family A	2	Each
422	Handle and crashbar, silver	2	Kit
323	Lockset	2	Kit
735	Door frame, double, silver	1	Each
682	Hydraulic closer, silver	2	Each
502	Hardware Kit	1	Kit

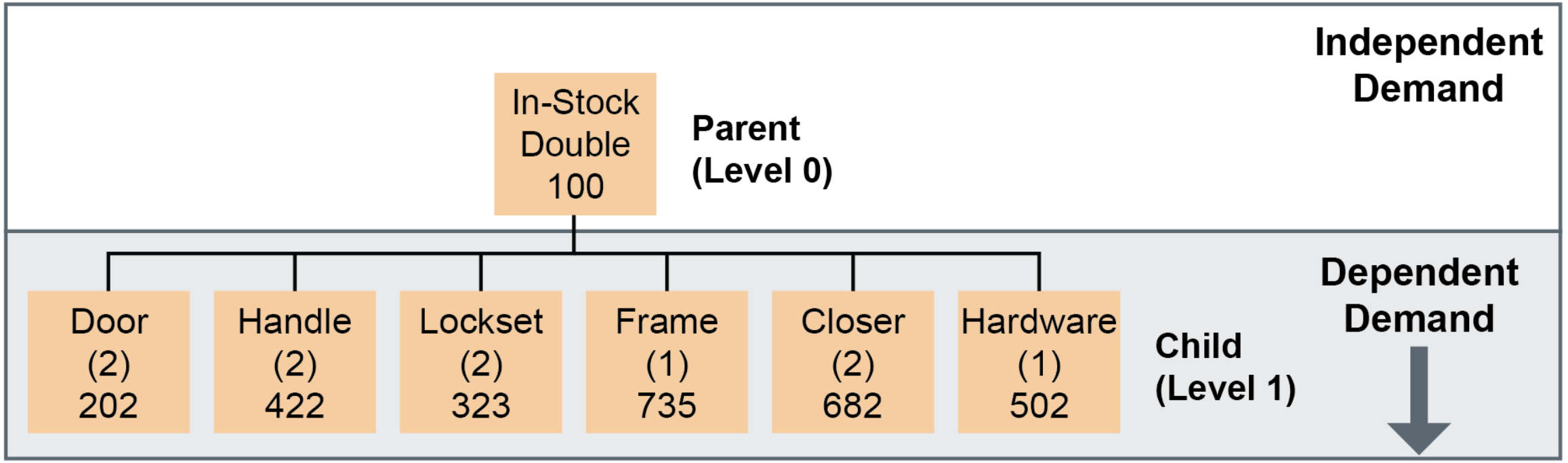
Scope: If it isn't listed, it isn't used (but some MRO supplies might be used but not listed).

Quantities

Unit of measure

Independent vs. Dependent and Parent-Child

Part 100 is available for sale and thus represents independent demand. All components used to create part 100 represent dependent demand.



How BOMs Are Used in Organizations

Engineering

- Part of specifications for new or improved products
- For example, chemical formula BOMs
- Engineering change control and start/stop dates for new BOMs or components

Customer service and service parts

- Right replacement part
- Customer options (ATO): custom BOM maybe with costs

Finance

- Direct materials costing, direct labor estimates, overhead allocation

Single-Level BOMs

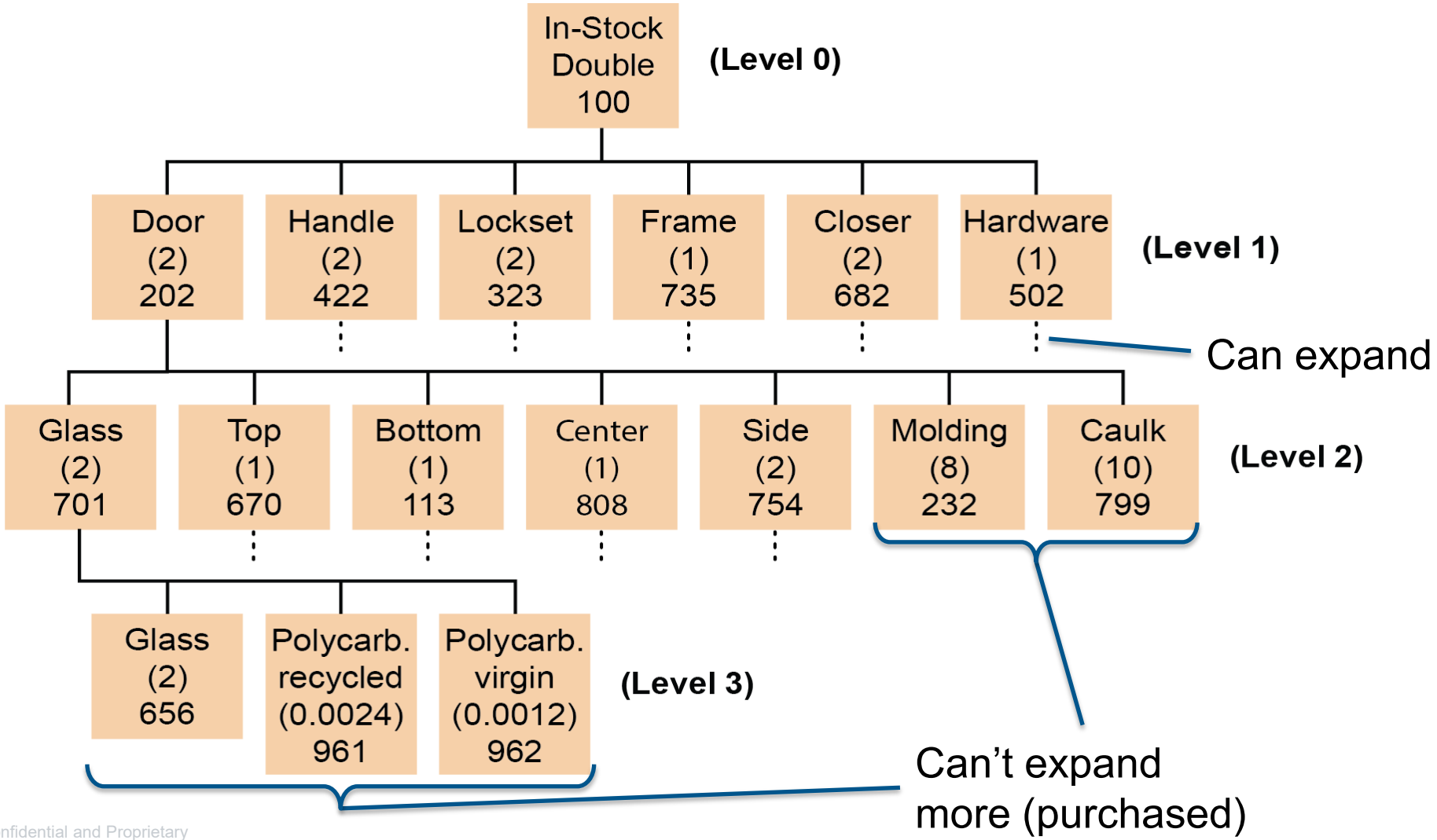
- Data in only one place, available for multiple products.
- Each part can have its own single-level BOM. (Part 202 is a child of Part 100.)

Product: Door, Family A — Part Number: 202
Description: Vandalproof glass door, silver trim

Part Number	Description	Quantity	Units
701	Vandalproof glass, 0.8m x 1.2m	2	Each
670	Top frame, silver	1	Each
113	Bottom frame, silver	1	Each
808	Center frame, silver	1	Each
754	Side frame, silver	2	Each
232	Molding, gray	8	Meters
799	Caulk, silicone, clear	10	Meters

Children (components) of Part 202

Multilevel BOMs: Product Tree Format



Multilevel BOMs: Indented Bill Format

- Series of single-level bills
- All final children (no levels below) are purchased.
- Shows logical order of assembly from bottom up.

Family A: In-Stock All-Glass Vandalproof Commercial Doors
Product: In-Stock Double (ISD) Part Number: 100
Description: Vandalproof glass double doors, silver trim

Part Number	Description	Quantity	Units
►202	Door, Family A	2	Each
►701	Vandalproof glass, 0.8m x 1.2m	2	Each
656	Glass, 0.8m x 1m x 0.0005m	2	Each
961	Polycarbonate, recycled	0.0024	Tons
962	Polycarbonate, virgin	0.0012	Tons
▲670	Top frame, silver	1	Each
▲113	Bottom frame, silver	1	Each
▲808	Center frame, silver	1	Each
▲754	Side frame, silver	2	Each
232	Molding, gray	8	Meters
799	Caulk, silicone, clear	10	Meters
▲422	Handle and crashbar, silver	2	Kit
▲323	Lockset	2	Kit
▲735	Door frame, double, silver	1	Each
▲682	Hydraulic closer, silver	2	Each
▲502	Hardware Kit	1	Kit

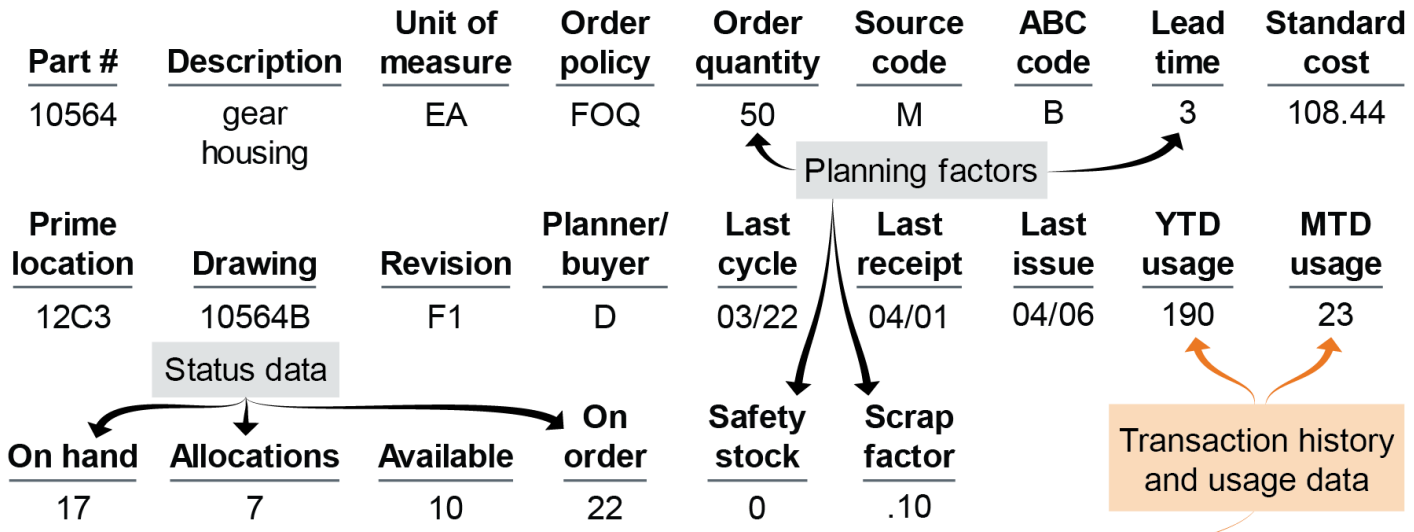
Planning Factors

Information about ordering, policy, and use

- Lot size or order quantity
- Lead time
- Safety stock
- Scrap and yield

Inventory Data

- Current inventory status
  - On-hand
  - Allocation
  - Scheduled receipts
- Historical demand and usage
- Inventory item record



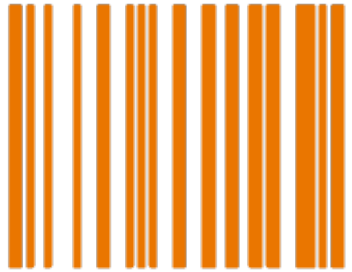
Transaction history:

Date	Reference	Initials	Receipts	Issues	Adjust	Stores	Location	Balance
03/13	M1056	VXS	49			S2	12C3	52
03/20	A357	MOM		15		S2	12C3	37
03/22	C87	REC			-1	S2	12C3	36
03/27	A412	MOM		22		S2	12C3	14
04/01	M1103	VXS	26			S2	12C3	40
04/06	A415	MOM		23		S2	12C3	17

Item Numbering

System goals

- Uniformity across organization
- Free of confusion
- Few errors
- Expandable



What are some good practices in designing an item numbering system?

Significant vs. Nonsignificant Part Numbering Systems

Significant part number

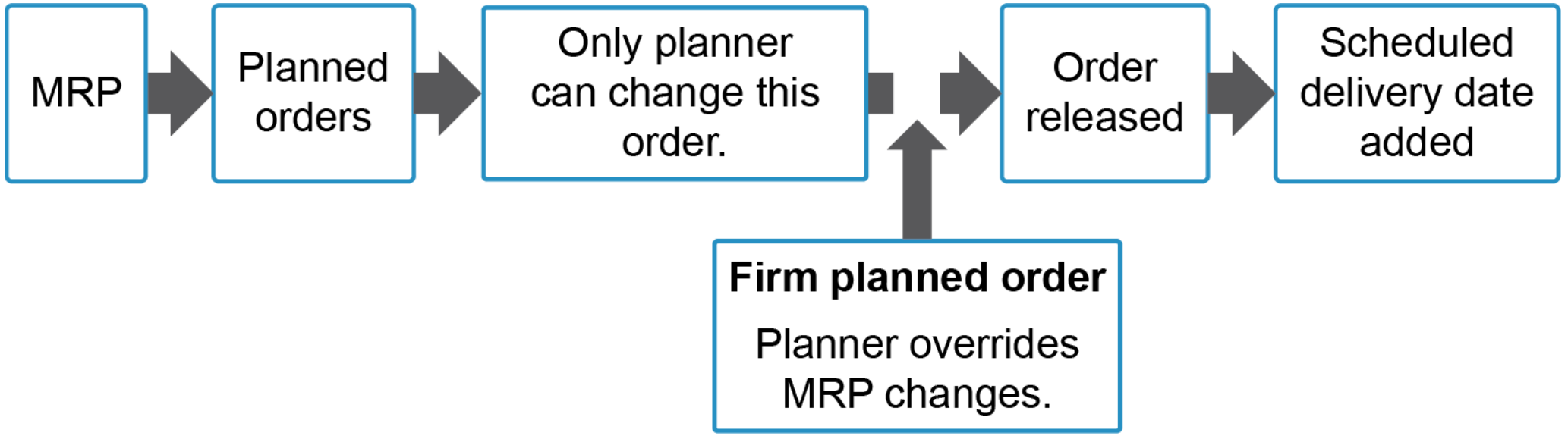
- Conveys some information about the part
- For example, U-GU-15-L-O indicates
  - Umbrellas
  - Golf umbrellas
  - Model number
  - Size large
  - Orange

Non-significant part number

- Randomly generated numbers
- For example, 488926

MRP Outputs

- Purchase and production orders
- Action messages and exception codes



Firm Planned Orders

Example (lot size = 50 units)

Under normal MRP logic, 50 units would be released in week 3 (planned order release with 2-week lead time).

Ordered early after the scheduler was informed by the supplier of a scheduled production line shutdown on their end.

Part Number	Time		Week 0	1	2	3	4	5	6
C		Gross Requirements		40	50	60	40	50	
		Scheduled Receipts			50				
		Projected Available	40	0	0	40	0	0	0
		Net Requirements				60		50	
		Planned Order Receipt				100		50	
	2	Planned Order Release		100	50F				

Action Messages and Exception Codes

Action messages

System alerts planner to need to take action to keep system updated:

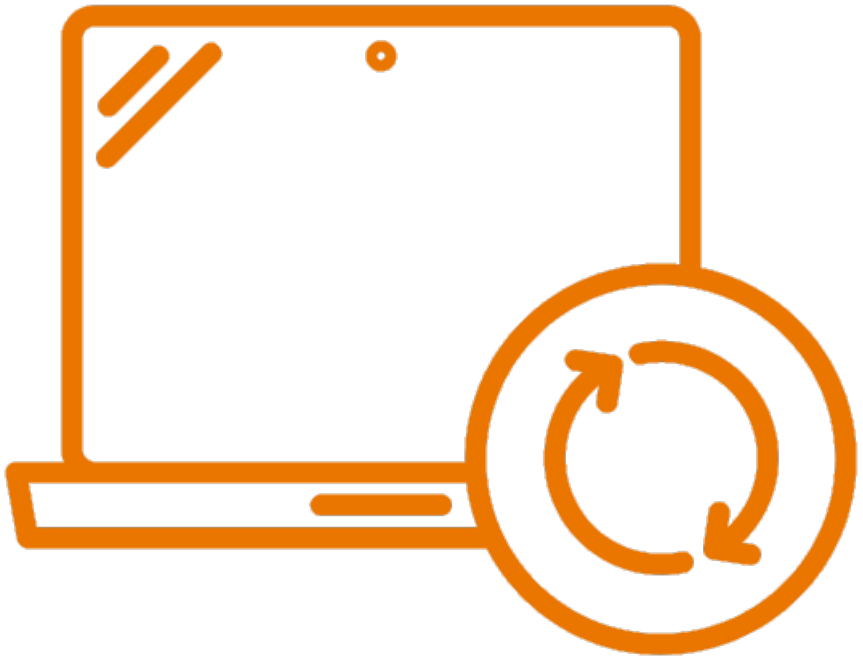
- Release order
- Reschedule in
- Reschedule out
- Cancel

Exception codes

- Codes that draw attention to rule conflicts, mistakes, missing data
- A problem-solving tool so that issues can be resolved within the system rather than informally

Regenerating or Net Change MRP

- Updating the MRP records to maintain accuracy of plan
- Regeneration MRP systems
- System nervousness



MRP Grid

On item master record:

- Lead time: 2 weeks
- Lot size: 100 units

Available at beginning of period shown

Time bucket

Part Number 202	Week				
MRP	**0**	**1**	**2**	**3**	**4**
Gross requirements		57	101	114	86
Scheduled receipts		100	100		
Projected available	130	173	172	58	72
Net requirements					28
Planned order receipt					100
Planned order release			100		

From parent item planned order releases →

Released orders (committed) →

Inventory balance into future →

After inventory and receipts →

Due date (still just plans) →

When to order or make →

Lead time offset

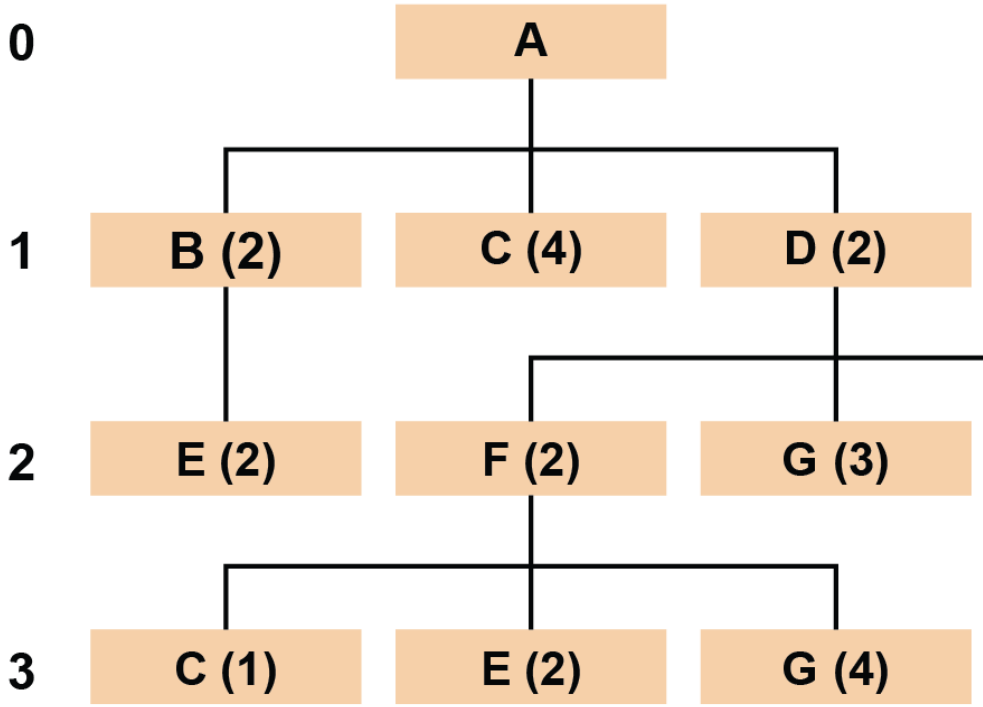
Production is scheduled only when there is demand.

MRP Planning Logic

1. Calculate gross requirements at end-item level, based on MPS and service parts schedules.
2. Calculate net requirements using netting process at level 0:
   - Gross requirements
   - MINUS scheduled receipts
   - MINUS prior period projected available balance (or on-hand balance), which may be adjusted downward by allocations or have a minimum balance based on safety stock
3. If net requirement exists, create planned order release and receipt data, applying lead offsetting to accommodate lead time.
4. Multiply the planned order receipt by the quantity per in the BOM. This becomes the gross requirements for level 1 components. Repeat process through to the lowest level of the BOM.

Bill-of-Material Explosion (Exploding)

Parent	A	B	D	F
Child	B (2)	E (2)	F (2)	C (1)
Child	C (4)		G (3)	E (2)
Child	D (2)		H (1)	G (4)

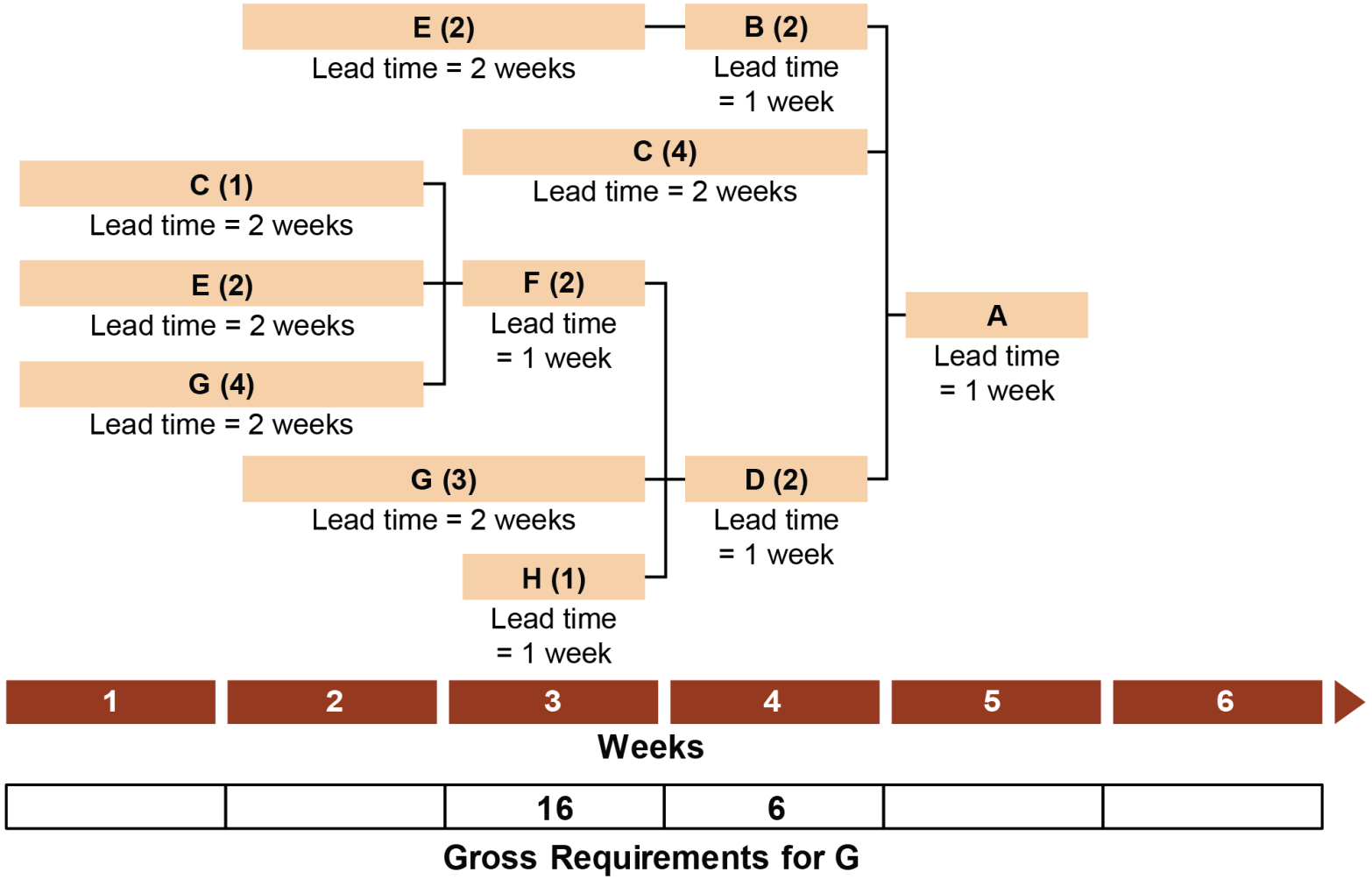


1 × 4 Cs = 4 Cs

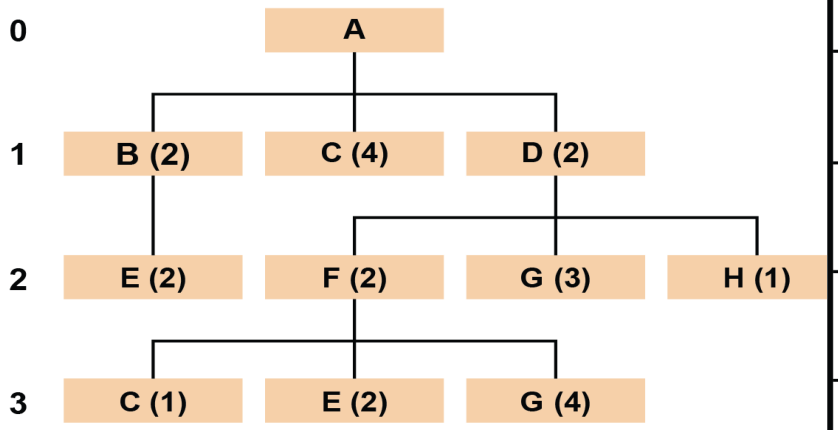
2 Bs × 2 Es = 4 Es
2 Ds × 3 Gs = 6 Gs
2 Ds × 1 H = 2 Hs

2 Ds × 2 Fs × 1 C = 4 Cs
2 Ds × 2 Fs × 2 Es = 8 Es
2 Ds × 2 Fs × 4 Gs = 16 Gs

Lead-Time Offset (Offsetting)

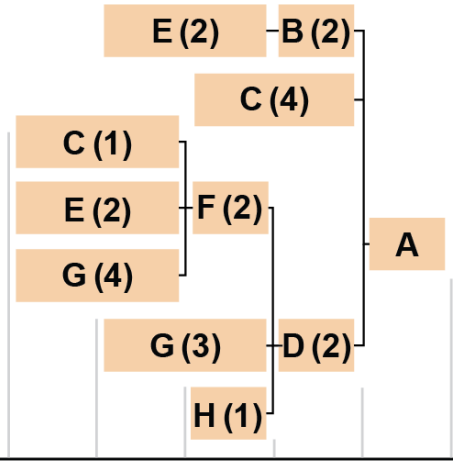


Offsetting Planned Order Releases from Receipts



Part Number	Lead Time		Week 1	2	3	4	5	6
A	1	Planned Order Receipt						1
		Planned Order Release					1	
B	1	Planned Order Receipt					2	
		Planned Order Release				2		
C	2	Planned Order Receipt			4		4	
		Planned Order Release	4		4			
D	1	Planned Order Receipt					2	
		Planned Order Release				2		
E	2	Planned Order Receipt			8	4		
		Planned Order Release	8	4				
F	1	Planned Order Receipt				4		
		Planned Order Release			4			
G	2	Planned Order Receipt			16	6		
		Planned Order Release	16	6				
H	1	Planned Order Receipt				2		
		Planned Order Release			2			

Preliminary MRP with Projected Available



Projected Available = Prior Projected Available + Scheduled Receipts + Planned Order Receipts − Gross Requirements

Part C, Week 3:
7 + 0 + 0 − 4 = 3

Part E, Week 2:
4 + 5 + 0 − 0 = 9

Part Number	Lead Time		Week 0	1	2	3	4	5	6
C		Gross Requirements				4		4	
		Scheduled Receipts			5				
		Projected Available	2	2	7	3	3	-1	-1
		Net Requirements							
		Planned Order Receipt							
	2	Planned Order Release							
E		Gross Requirements				8	4		
		Scheduled Receipts			5				
		Projected Available	4	4	9	1	-3	-3	-3
		Net Requirements							
		Planned Order Receipt							
	2	Planned Order Release							

Gross to Net Requirements

Net Requirements =

Gross Requirements − Scheduled Receipts − Prior Projected Available

Part C, Week 5:
4 − 0 − 3 = 1

Part Number	Lead Time		Week 0	1	2	3	4	5	6
C		Gross Requirements				4		4	
		Scheduled Receipts			5				
		Projected Available	2	2	7	3	3	-1	-1
		Net Requirements						1	1
		Planned Order Receipt							
	2	Planned Order Release							

Part G, Week 3:
16 − 0 − 13 = 3

G		Gross Requirements				16	6		
		Scheduled Receipts			5				
		Projected Available	8	8	13	-3	-9	-9	-9
		Net Requirements				3	9	9	9
		Planned Order Receipt							
	2	Planned Order Release							

Completed MRP

Lot size rule = 5 units

Part E, Week 4, projected available:
1 + 0 + 5 − 4 = 2

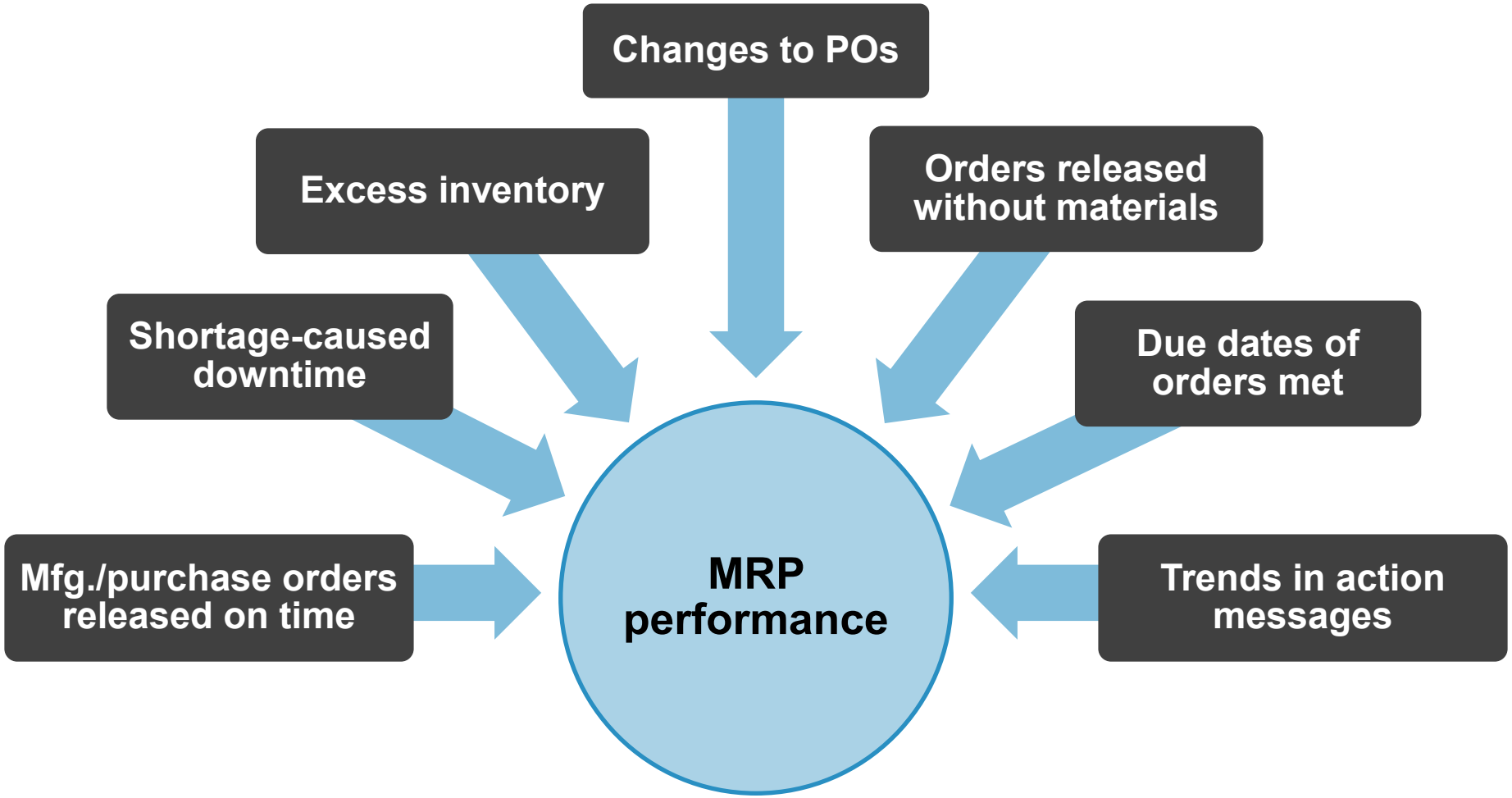
Part G, Week 4, net requirements:
6 − 0 − 2 = 4

Part Number	Lead Time		Week 0	1	2	3	4	5	6
C		Gross Requirements				4		4	
		Scheduled Receipts			5				
		Projected Available	2	2	7	3	3	4	4
		Net Requirements						1	
		Planned Order Receipt						5	
	2	Planned Order Release				5			
E		Gross Requirements				8	4		
		Scheduled Receipts			5				
		Projected Available	4	4	9	1	2	2	2
		Net Requirements					3		
		Planned Order Receipt					5		
	2	Planned Order Release			5				
G		Gross Requirements				16	6		
		Scheduled Receipts			5				
		Projected Available	8	8	13	2	1	1	1
		Net Requirements				3	4		
		Planned Order Receipt				5	5		
	2	Planned Order Release		5	5				
H		Gross Requirements					2		
		Scheduled Receipts							
		Projected Available	1	1	1	1	4	4	4
		Net Requirements					1		
		Planned Order Receipt					5		
	1	Planned Order Release				5			

Planner's Role in MRP Management

- Keep materials flowing into, through, and out of operations processes.
- Maintaining priorities under changing conditions:
  - Changes in MPS
  - Changes to work in process
  - Actions by suppliers
- Releasing orders from action bucket
- Rescheduling open orders as needed
- Analyzing and revising planning factors
- Reconciling errors and inconsistencies
- Proactive problem solving
- Creative problem solving within the system to resolve material shortages
- Improving the process

Evaluating MRP Performance



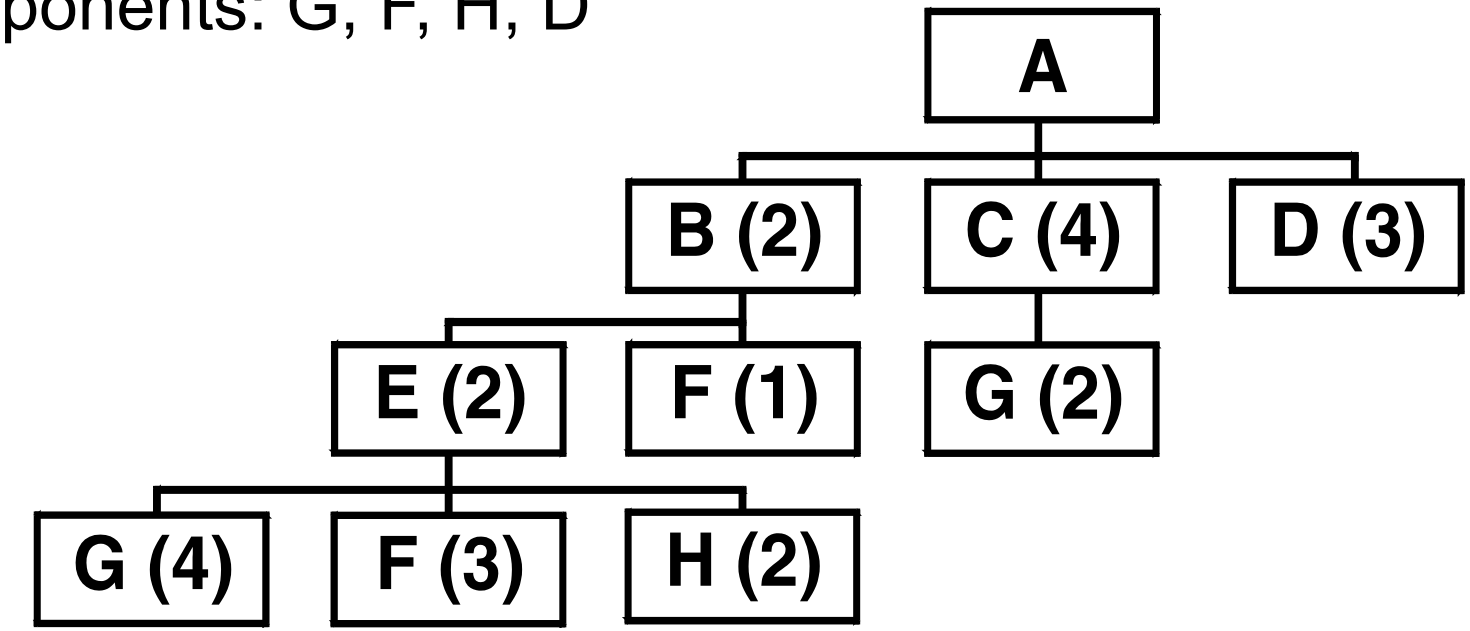
Bill of Material Product Tree Exercise

Parent	A	B	C	E
Component	B (2)	E (2)	G (2)	G (4)
	C (4)	F (1)		F (3)
	D (3)			H (2)

Given the parents and components, construct a product tree. Figures in brackets show the quantities per item.

Bill of Material Product Tree Solution

- Number of subassemblies: 3 (child)
- Number of Gs needed: 24
- Purchased components: G, F, H, D



Net Requirements and Planned Orders Exercise 1

Item F Lot size = L4L Lead time = 1	1	2	3	4	5	6	7	8
Gross requirements					20	20		10
Scheduled receipts								
Projected available					0	0		0
Net requirements					20	20		10
Planned order receipts					20	20		10
Planned order releases				20	20		10	

Net Requirements and Planned Orders Exercise 2

Item D Lot size = 160 Allocation = 120 Lead time = 1		1	2	3	4	5	6	7	8
Gross requirements			20		220	20	20	10	
Scheduled receipts		160							
Projected available	170	210	190	190	130	110	90	80	80
Net requirements					30				
Planned order receipts					160				
Planned order releases				160					

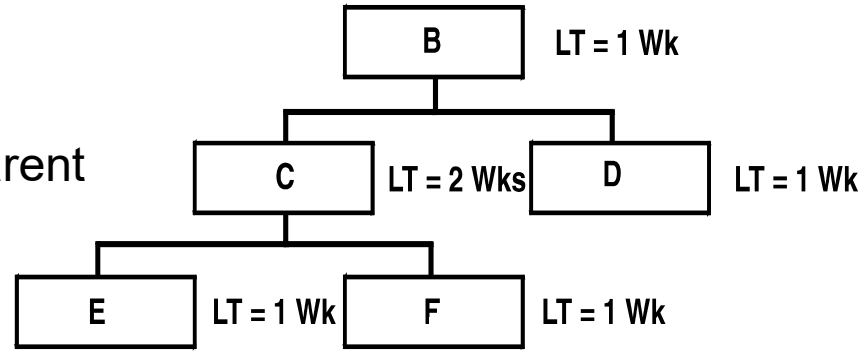
Net Requirements and Planned Orders Exercise 3

Item E Lot size = 140 Lead time = 1		1	2	3	4	5	6	7	8
Gross requirements				90	80	50	30	10	
Scheduled receipts									
Projected available	120	120	120	30	90	40	10	0	0
Net requirements					50				
Planned order receipts					140				
Planned order releases				140					

Planned Order Release Exercise 1

Quantity per parent in all cases = 1

Wk = week;
LT = lead time



What is the cumulative lead time for item B?

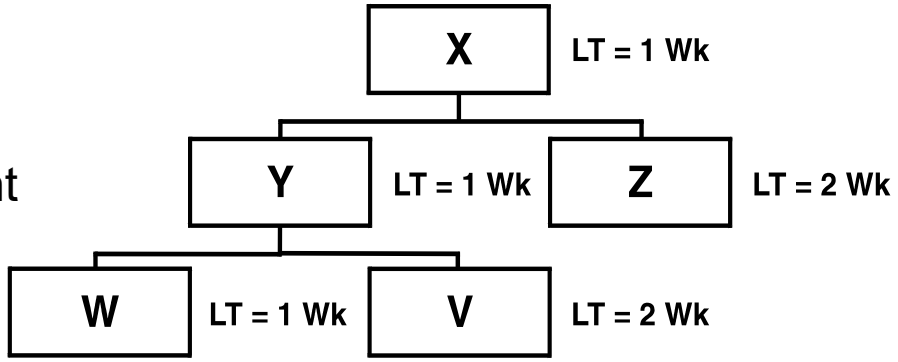
Cumulative lead time:
4 weeks

Item number	Planned order	Week 1	2	3	4	5
B	Receipt					50
	Release				50	
C	Receipt				50	
	Release		50			
D	Receipt				50	
	Release			50		
E	Receipt		50			
	Release	50				
F	Receipt		50			
	Release	50				

Planned Order Release Exercise 2

Quantity per parent in all cases = 1

Wk = week;
LT = lead time



Item number	Planned order	Week				
		1	2	3	4	5
X	Receipt					200
	Release				200	
Y	Receipt				200	
	Release			200		
Z	Receipt				200	
	Release		200			
W	Receipt			200		
	Release		200			
V	Receipt			200		
	Release	200				

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SECTION D:
CRP AND SCHEDULING

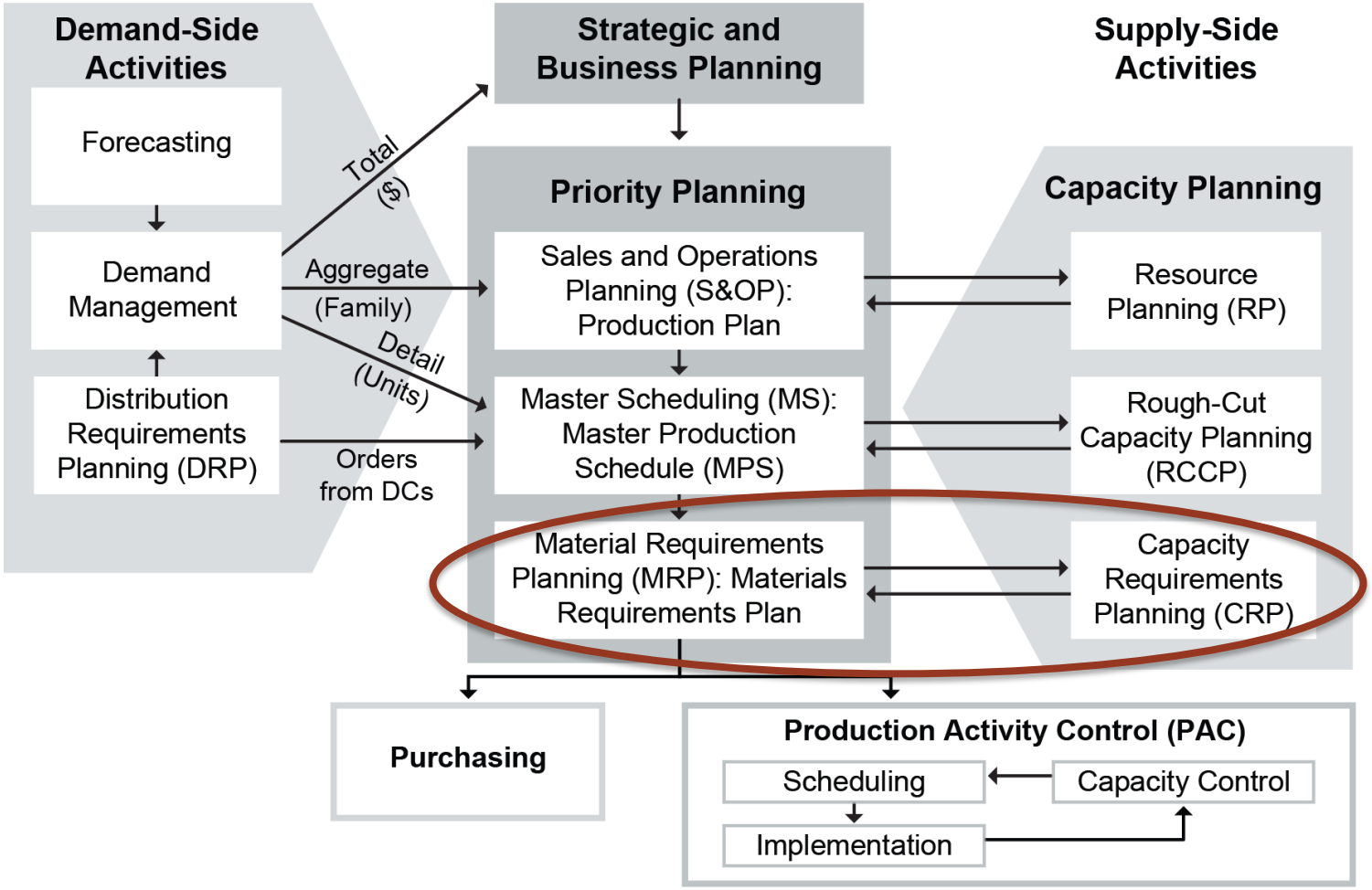
APICS

ASCM

Section D Learning Objectives

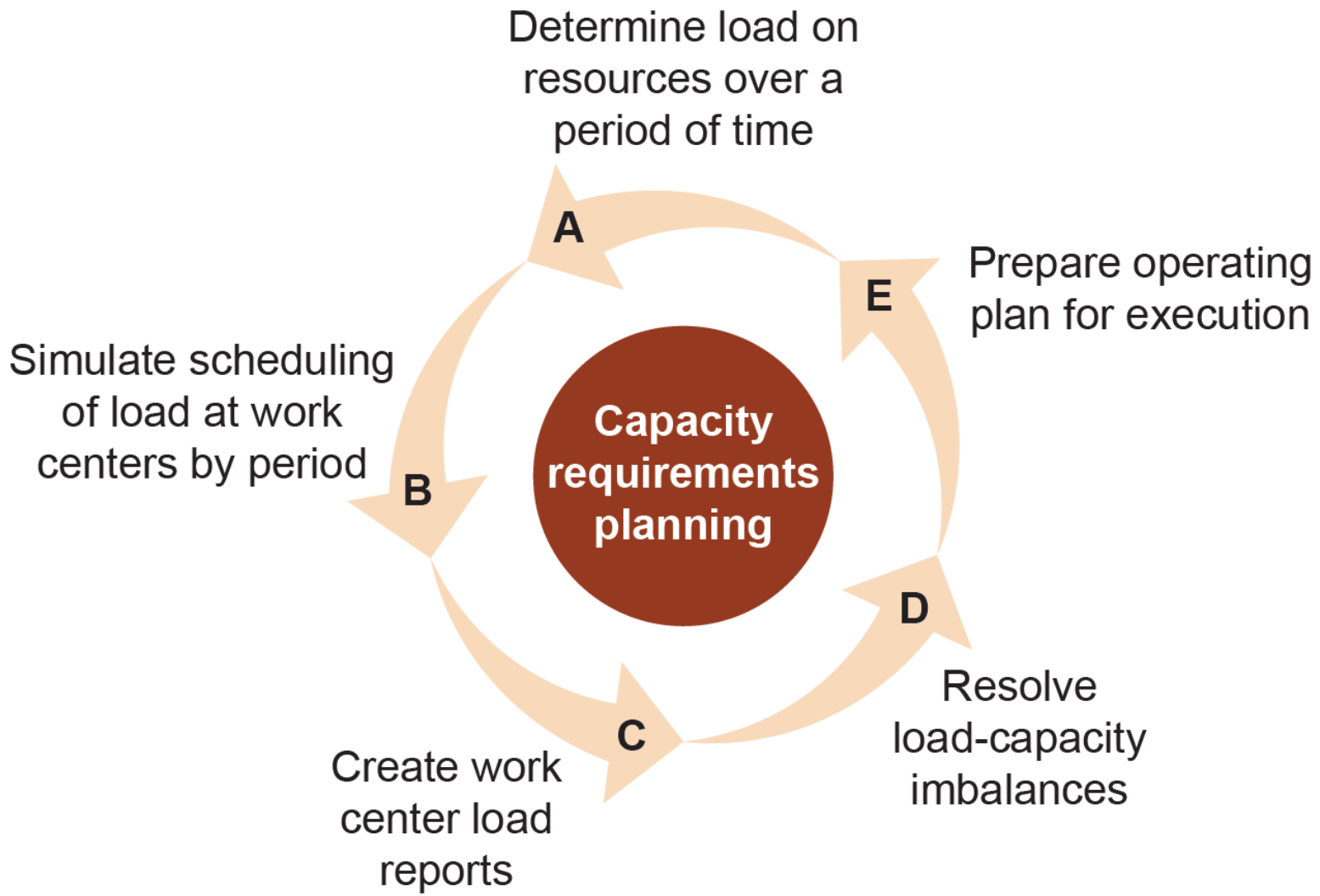
- Relation of CRP and MRP-based scheduling to planning hierarchy
- Basic process used in CRP
- Advantages and limitations of CRP
- MRP-based scheduling
- Finite and infinite capacity loading
- Authorizing production
- Steps in final assembly scheduling (FAS)
- Sources of demand considered in FAS
- Managing consequences of unrealistic FAS
- Coordinating changes to inventory, backlog, capacity, orders, time fences, designs
- Measuring actual performance against the FAS

CRP and MRP-Based Scheduling in Planning Hierarchy



Capacity Requirements Planning

CRP Model



Advantages and Limitations of CRP

Advantages

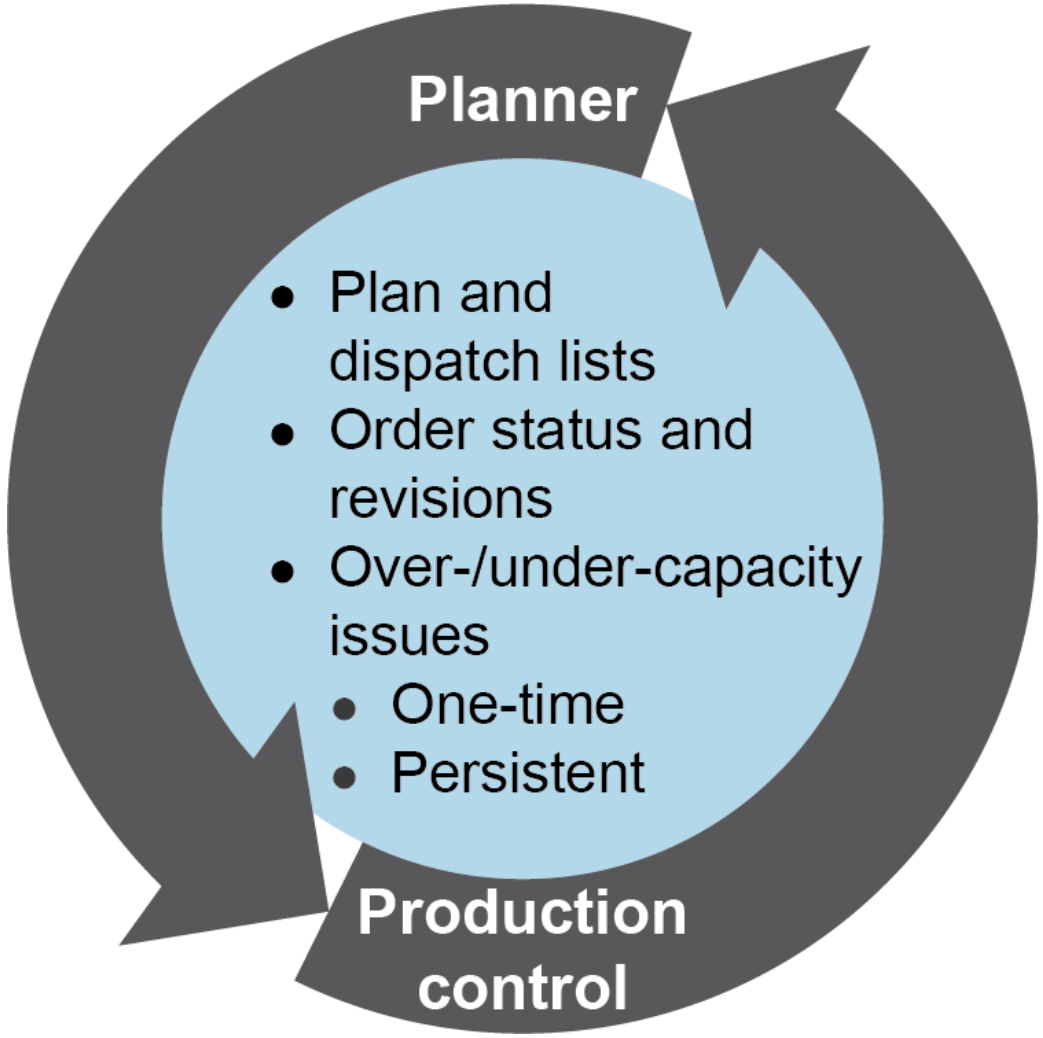
- Reveals potential load imbalances
- Simulates effect of changes in planning factors
- Is more detailed than MRP
- Supports lead-time leveling

Limitations

- Not intended for daily operations
- Requires extensive data
- Provides approximations
- Is subject to changes in MPS
- Assumes infinite loading

Capacity Requirements Planning

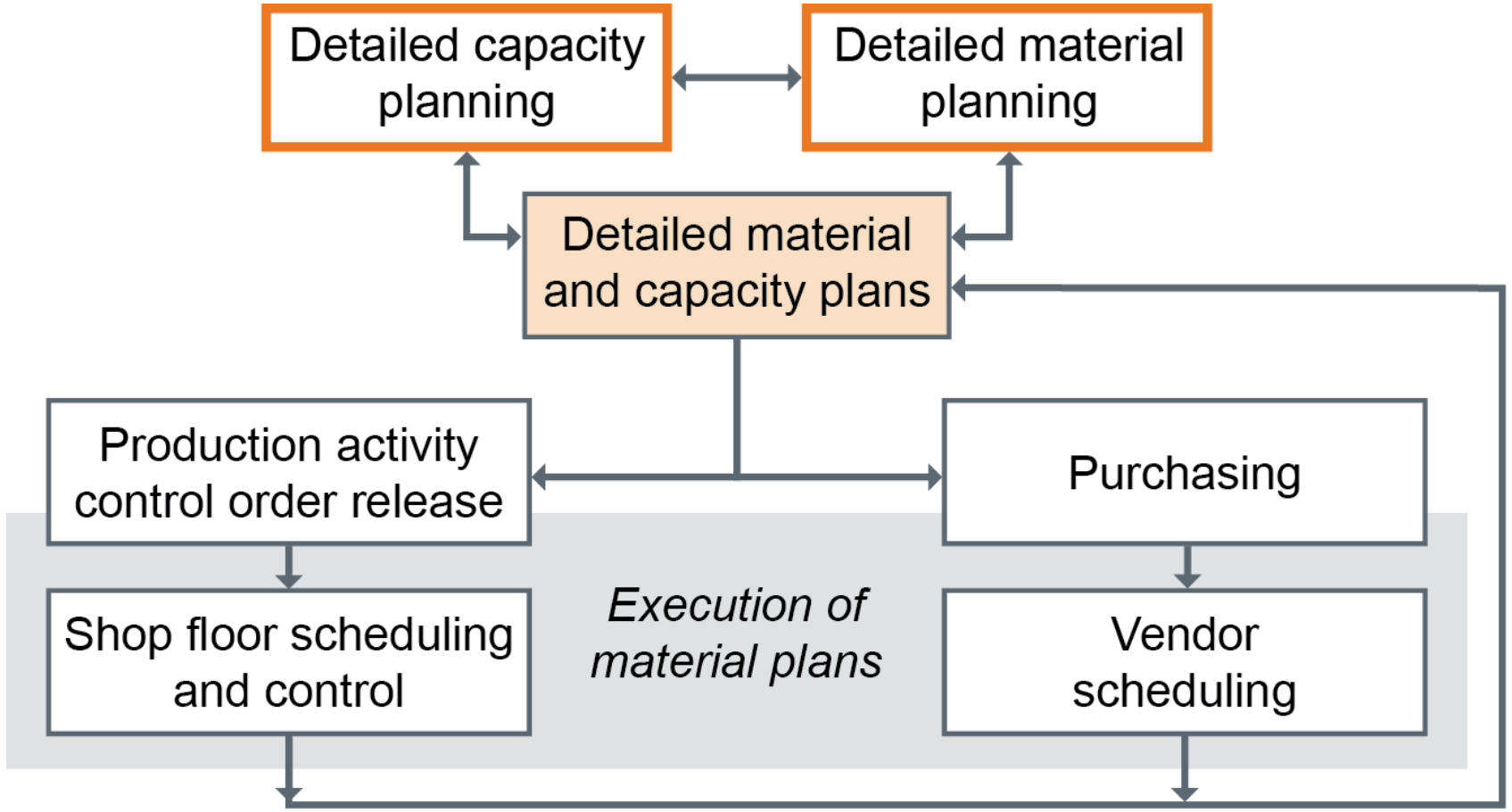
CRP in Finite Capacity Scheduling Systems



MRP-Based Scheduling in PAC

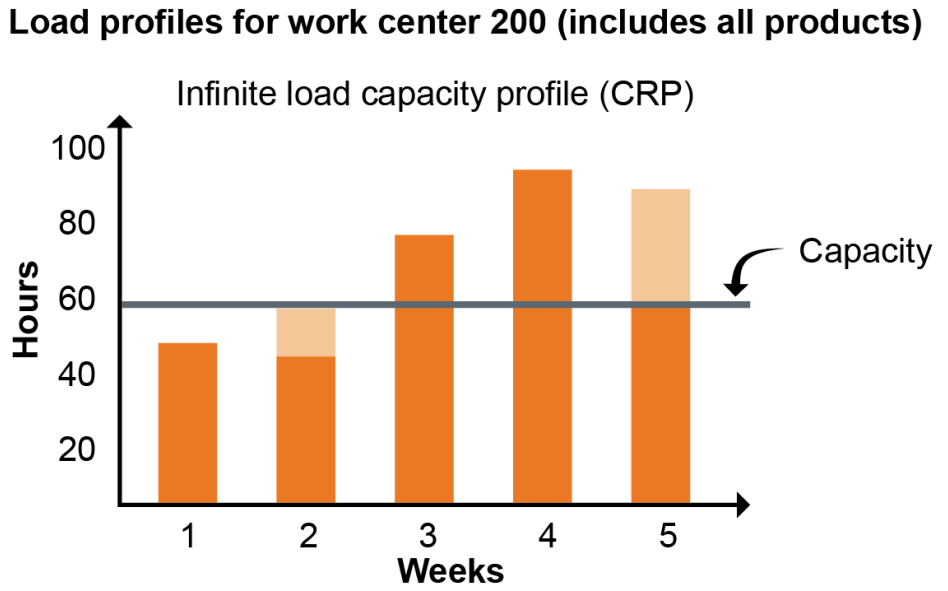
- Moving MRP into realm of plan execution
- Transaction-intensive work center scheduling using work orders
- Used in both intermittent and flow manufacturing process types
- For MTS environments, driven by an MPS based on forecast
- For MTO, driven by an MPS that is continually updated after each order receipt

MRP and CRP Scheduling Interfaces

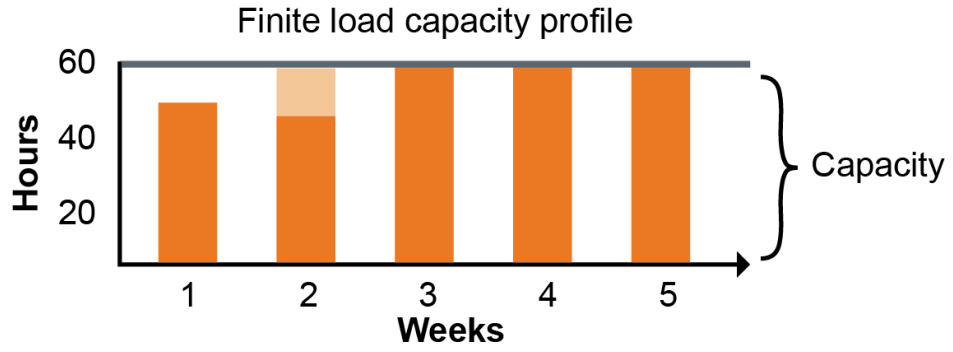


Capacity and Loading

Infinite loading

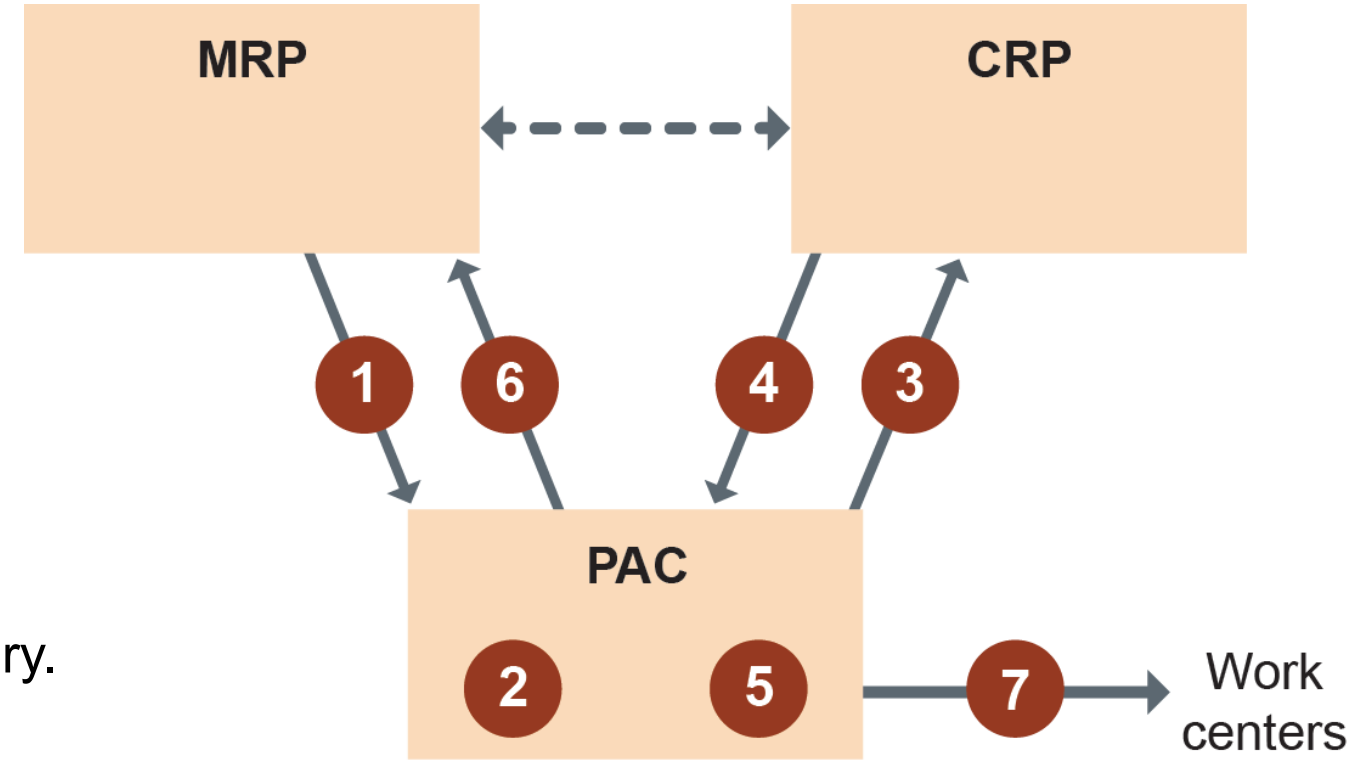


Finite loading



PAC Scheduling and Dispatching Processes and Interfaces

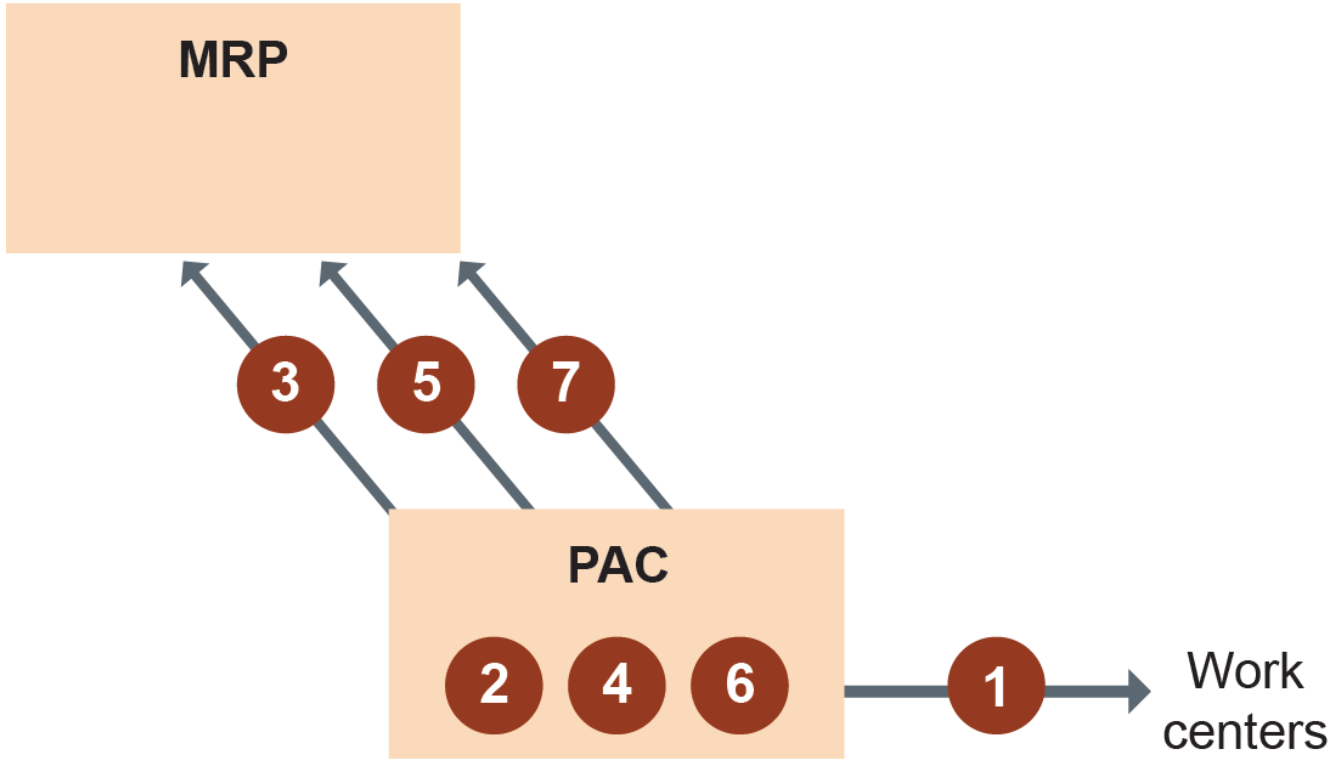
1. Update schedules and authorize release of planned orders.
2. Convert planned orders into work center schedules and load profiles.
3. Request validation of capacity availability.
4. Validate load profile.
5. Adjust capacity or schedule as necessary.
6. Inform MRP, as necessary.
7. Release work orders to work centers.



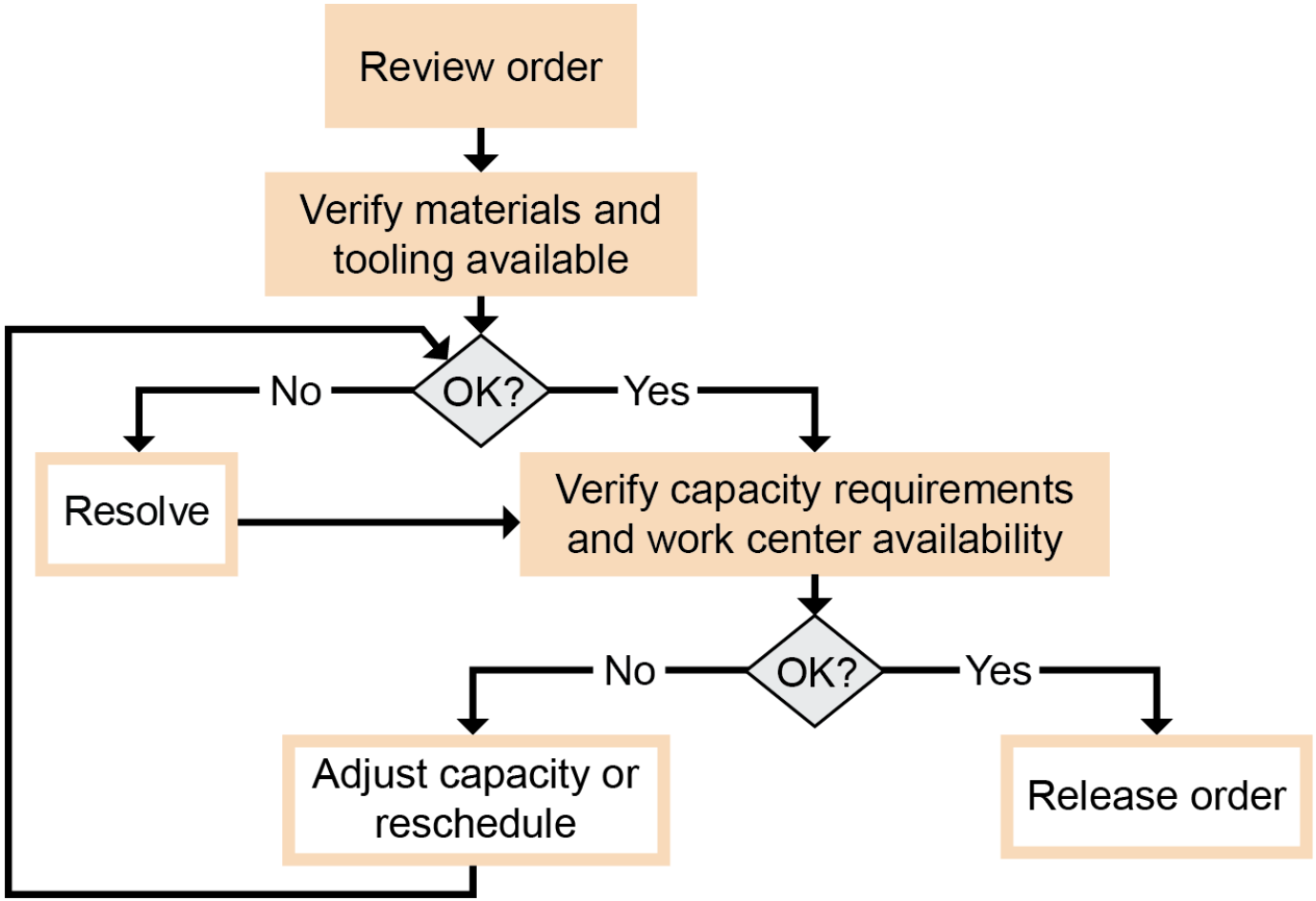
MRP-Based Scheduling

PAC Control Interfaces

1. Release (dispatch) orders to work center of production.
2. Gather data on performance of work orders compared to planned schedules.
3. 5 7 Feedback to MRP.
4. Gather work-in-process, lead-time, and queue data.
6. Gather work center efficiency, operation times, order quantities, and scrap data.



Executing: Authorizing Production



Resources Committed to Timetable

Require adjustment to committed resources

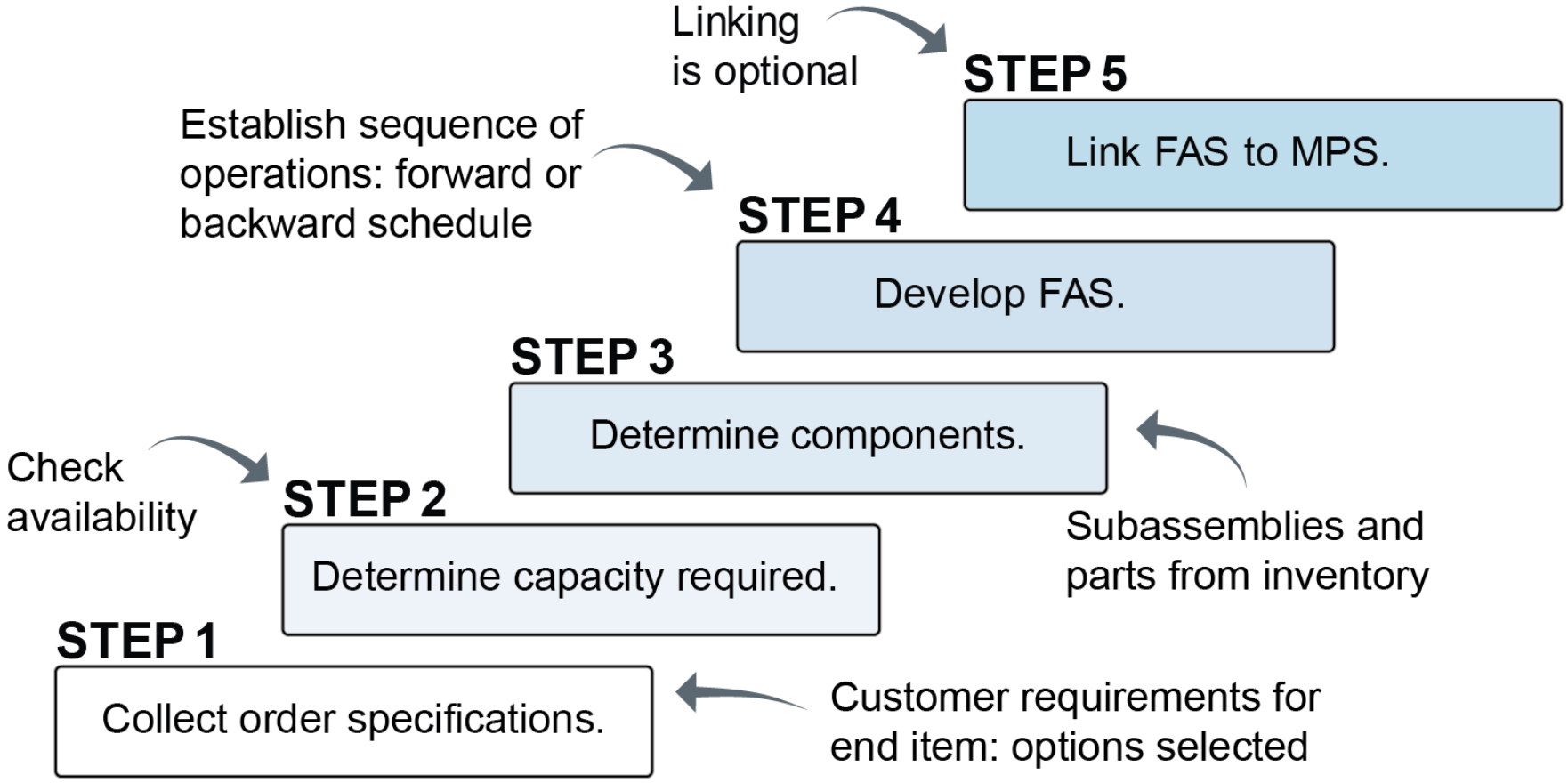
- Rush/expedited orders
- Resolving imbalances
- Schedule composition
- Capacity-constrained resource (CCR)

Prepare for or prevent adjustments

- Manufacturing lead time
- Time fence policies
- Time standard
- Final assembly scheduling
- Maintenance on equipment
  - Preventive
  - Predictive
  - Remedial

Final Assembly Scheduling

FAS Process



Options and Availability

Step 1:

Collecting Order Specifications

- Orders can come from any point of contact with the customer.
- Constraints on order specifications help ensure
  - Availability to customer
  - Organizational profitability.

Step 2:

Determining Capacity

- Uses RCCP.
- Reviews work center capacity against FAS projected load.
- Reviews external supplies to ensure availability.

Materials, Sequence, and Optional Validation

Step 3:

Determining Availability of Components

- Two-level MPS adds level of component planning for common configurations.

Step 4:

Developing the FAS

- FAS involves determining and sequencing necessary operations.

Step 5:

Linking FAS to MPS

- Linking helps validate that MPS priorities are being honored.

Final Assembly Scheduling

Planning and Coordinating Changes

- Short-term issues may lead to re-prioritizing orders.
- May require
  - Discussions with customers
  - Review and adjustment of incoming supplies.
- Longer-term issues may involve changes in
  - Inventory levels
  - Backlog sizes
  - Capacity
  - Time fences
  - Product/process designs
  - Supply factors.

Measuring FAS Performance

Assessing and potentially improving the FAS requires identifying the frequency and magnitude of variances from the schedule.

- Order accuracy
- Product quality
- Order lead time
- Order profitability
- Number of orders requiring rescheduling

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SECTION E:
SUPPLIERS AND PURCHASING

APICS

ASCM

Section E Learning Objectives

- Insourcing versus outsourcing
- Procurement and purchasing objectives
- Sustainability specifications
- Criteria used in selecting suppliers
- Customer-supplier relationships
- Risk versus profit matrix for sourcing strategy
- Collaborative relationships with suppliers
- Contracts and negotiating with suppliers
- Purchasing process
- Purchase orders
- Vendor involvement in inventory management

Insource or Outsource? Factors to Consider

- Quality (gain expertise but potentially lose control)
- Speed (possible reduction in lead times but more complex scheduling)
- Dependability (need for communication)
- Flexibility (greater capacity and response to changes)
- Cost (lower capital and personnel costs but excess internal capacity)

Procurement and Purchasing Objectives

Procurement objectives

- Capable suppliers
- Right quantity and quality at right time
- Reduced cost, considering best cost and total cost of ownership
- Lower risks
- Responsible and sustainable procurement

Conventional purchasing objectives

- Obtain goods in desired quantity and with specified quality.
- Buy at best possible price (e.g., landed cost or total cost of ownership).
- Receive desired service level, including delivery lead time.
- Maintain reputation as good customer.
- Purchase products with sustainable goals in mind.

Procurement and Purchasing Objectives

Supply chain management and lean procurement/purchasing objectives

- Invest in key suppliers.
  - Develop their potential.
  - Develop and maintain ongoing relationships.
- Fulfill social responsibility and sustainability goals.
- Use supplier relationship management (SRM).

Sustainable purchasing objectives

- Reduce overall use of materials, from production through disposal.
- Avoid use of limited or threatened resources.
- Avoid items that can harm workers and communities.
- Guarantee that sustainable product claims can be substantiated.

Types of Purchases

Capital expenditures

- Property, plant, and equipment; uses a request-for-quote (RFQ) process

Materials, supplies, and services

- Raw materials (includes subcomponents)
- Direct materials
- Indirect materials (maintenance, repair, and operating [MRO] supplies)
- Services (may be part of direct labor)

Value-Added Role of Procurement/Purchasing

Which is more profitable, a 10% increase in sales or a 10% reduction in direct materials (or production) cost?

Scenario: $10/unit price, 1,000 units/month, $5/unit direct materials, $1/unit direct labor, $3,000 overhead

	Per Unit		As Is	To Be Scenarios	
	As Is	-10% DM		+10% Sales	-10% DM
Units			1,000	1,100	1,000
Sales Price and Revenue	$10	$10.00	$10,000	$11,000	$10,000
Direct Materials (DM)	$5	$4.50	$5,000	$5,500	$4,500
Direct Labor (DL)	$1	$1.00	$1,000	$1,100	$1,000
Overhead			$3,000	$3,000	$3,000
Gross Profit			$1,000	$1,400	$1,500
Gross Profit Margin			10%	13%	15%

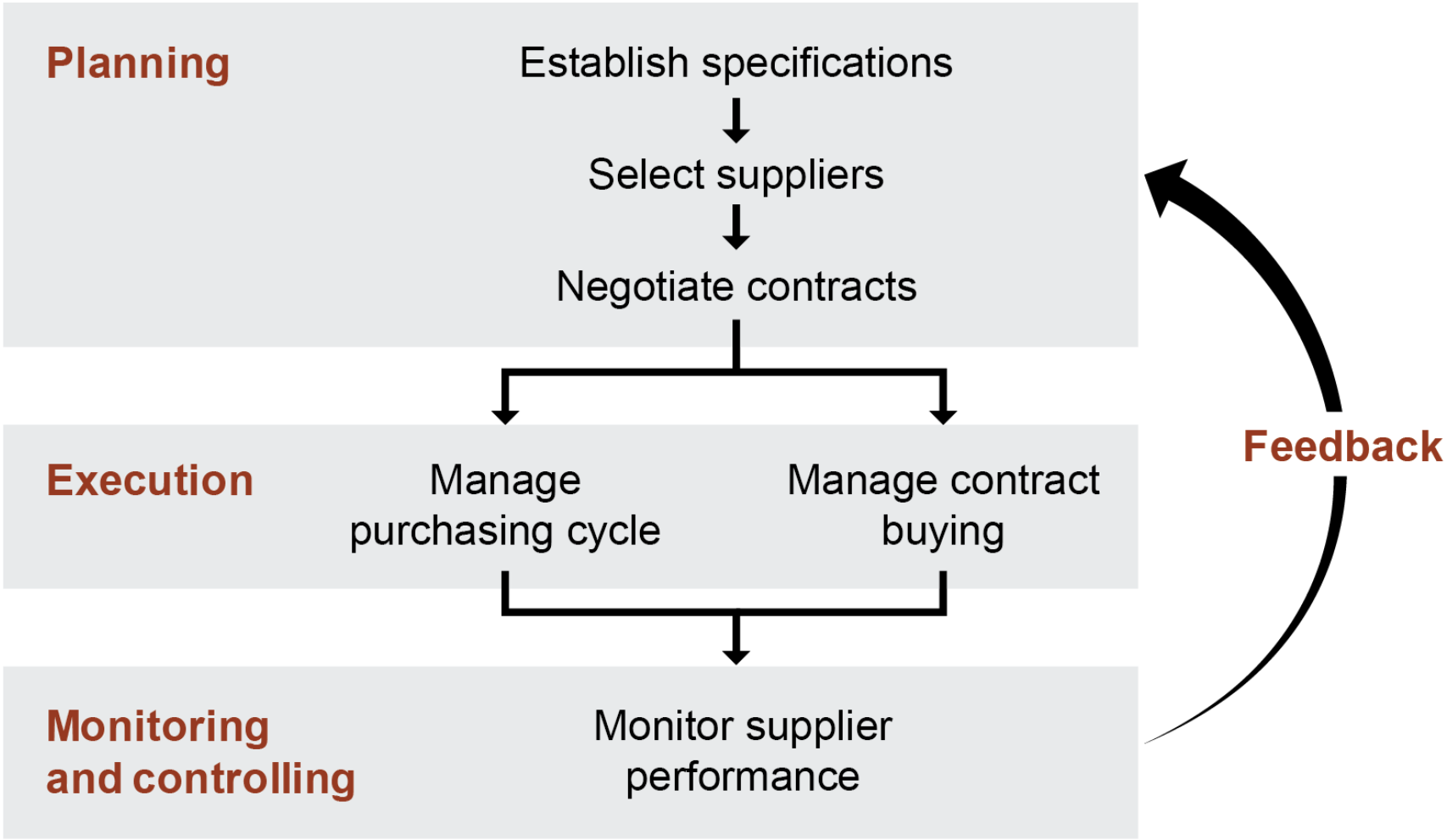
Procurement and Other Participants Need to Collaborate

- Traditionally, purchasing was sole responsibility of purchasing department, but this led to disconnects.
- Objectives for marketing, engineers, and production planners need to be met.

- Marketing: Reflect customer requirements (order qualifiers and winners).
- Engineers: Clearly specify requirements.
- Production planners/shop floor:
  - Right things received when needed.
  - Do rejects, scrap, rework, or inventory holding outweigh cost savings from cheaper supply or ordering in bulk?

Supply and Purchasing Planning

Procurement Process



Establish Specifications: Value Analysis for Functional Requirements

- Form, fit, function
- Purpose and how it integrates
- Quality
  - Fitness for use and value for money
  - Conformance to requirements
  - Allowed number of nonconforming items
  - Inspections or trust?
- Specifications for use
- Value analysis
- Description versus what it needs to do
  - Brand name
  - Characteristics
  - Engineering drawings
  - Miscellaneous attributes

Establish Specifications: Quantity and Price Requirements

- Quantity
  - Units per order
  - Order frequency
  - Best cost: economies of scale, full truckload discounts
- Price
  - What market will pay
  - Material and service costs face this constraint
  - Based on how much value it adds in eyes of consumer

Select Suppliers

Existing or new suppliers

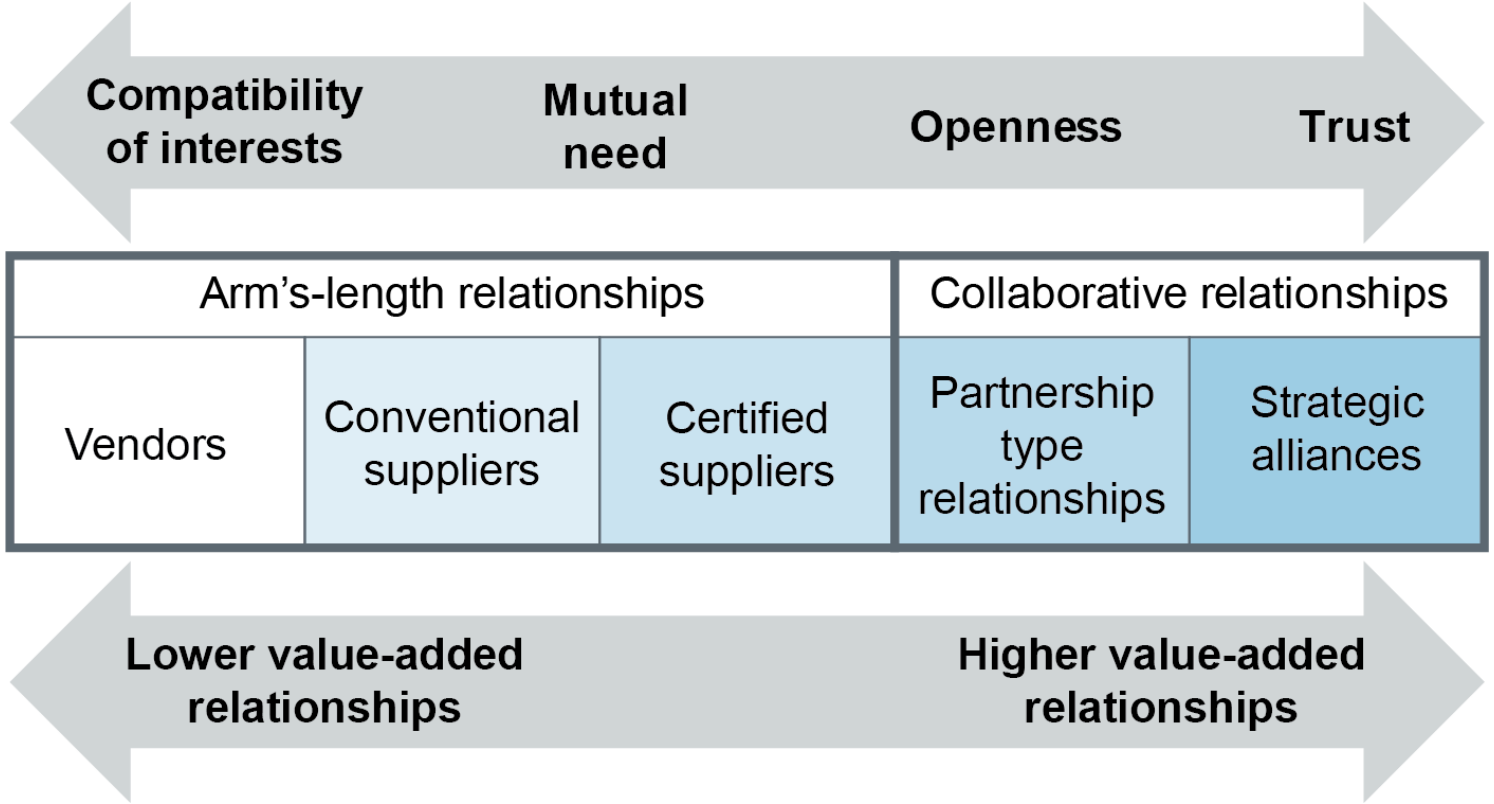
- Preapproved suppliers
- Supplier search advice/sources:
  - Engineering and design function
  - Supplier salespersons
  - Internal salespersons
  - Internet, trade magazines, etc.

Selection criteria

Assign weight, rank suppliers per factor:

- Technical/manufacturing capabilities
- Location
- Price
- Reliability
- Supply chain maturity
- Service offerings/service level
- Management attitude and culture fit
- Financial stability
- Sustainability commitment

Range of Supplier-Customer Relationships



Types of Sourcing

Sole sourcing

- Only source available
- High risk for buyer

Single sourcing

- Supplier reduction strategy
- More risk for buyer

Multi-sourcing

- Needed to manage risk or procurement needs

Single Sourcing Advantages Discussion

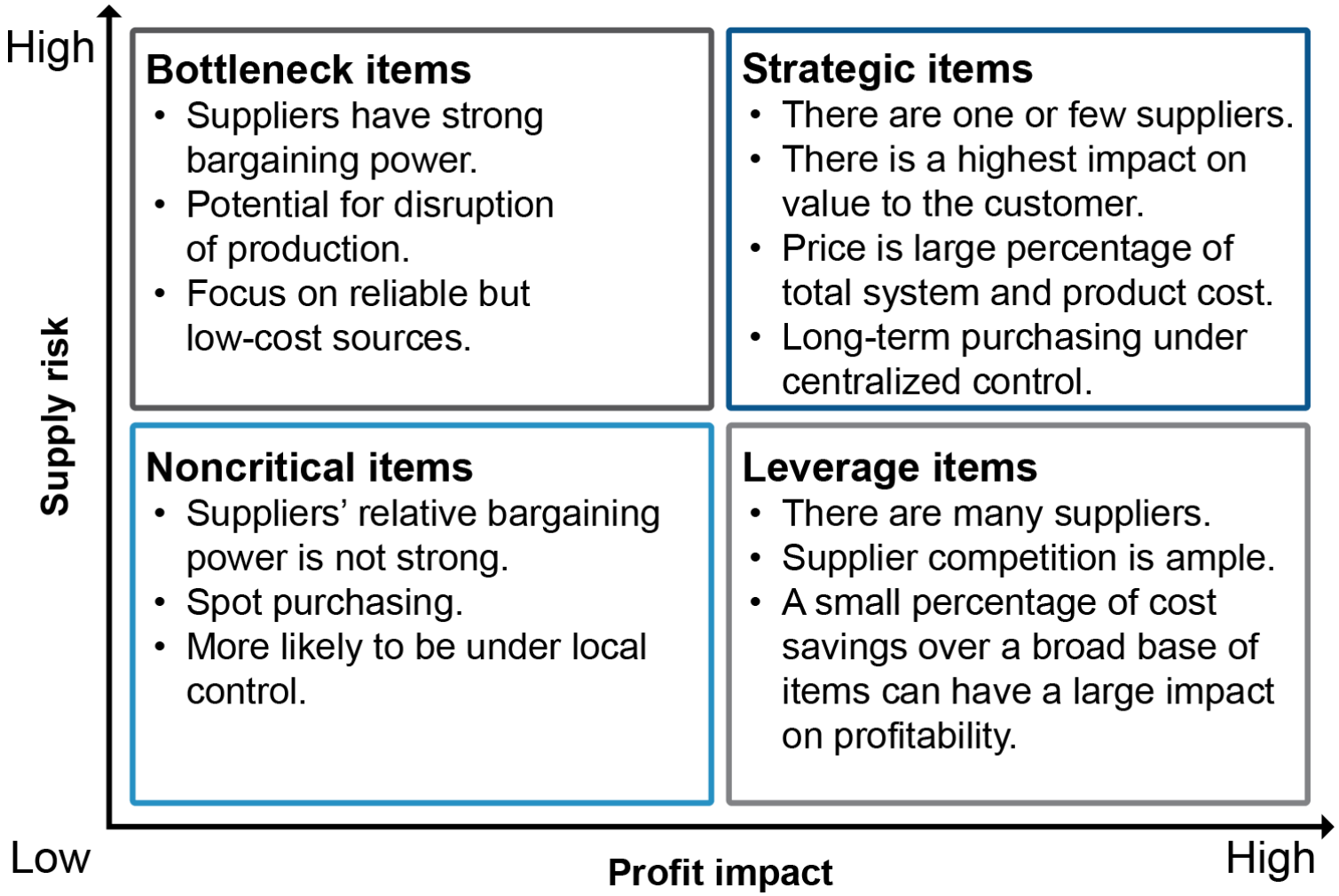
Advantage	Reason
Better pricing	▪ *It enables volume pricing.* ▪ *There is greater leverage over one supplier than over many.*
Improved quality	▪ *Supplier commitment is an incentive to improve yields and processes, reduce costs, and reduce rework and return rates.*
Increased buyer leverage	▪ *Buyer has greater influence on source of supply.*
Delivery	▪ *Supplier is motivated to deliver on time in order to maintain the relationship and income.*
Reliability	▪ *Reliability of both quality and on-time delivery can be negotiated as a service requirement for renewal of the partnership.*

Single Sourcing Disadvantages Discussion

Disadvantage	Reason
Cannot respond quickly to changes in demand	▪ *Supplier capacity may not be available due to full utilization.* ▪ *Supplier may be reluctant to commit capacity to one customer.*
Excess demand on supplier	▪ *Suppliers may have commitments to other customers that affect their capabilities.*
Possible loss of focus on market competitive price	▪ *Pricing may not remain competitive since price comparisons are not done as regularly.*
Susceptible to catastrophic event at the supplier	▪ *Buyer is susceptible to major events, such as bankruptcy, loss of goods and facilities, or other financial problems.*

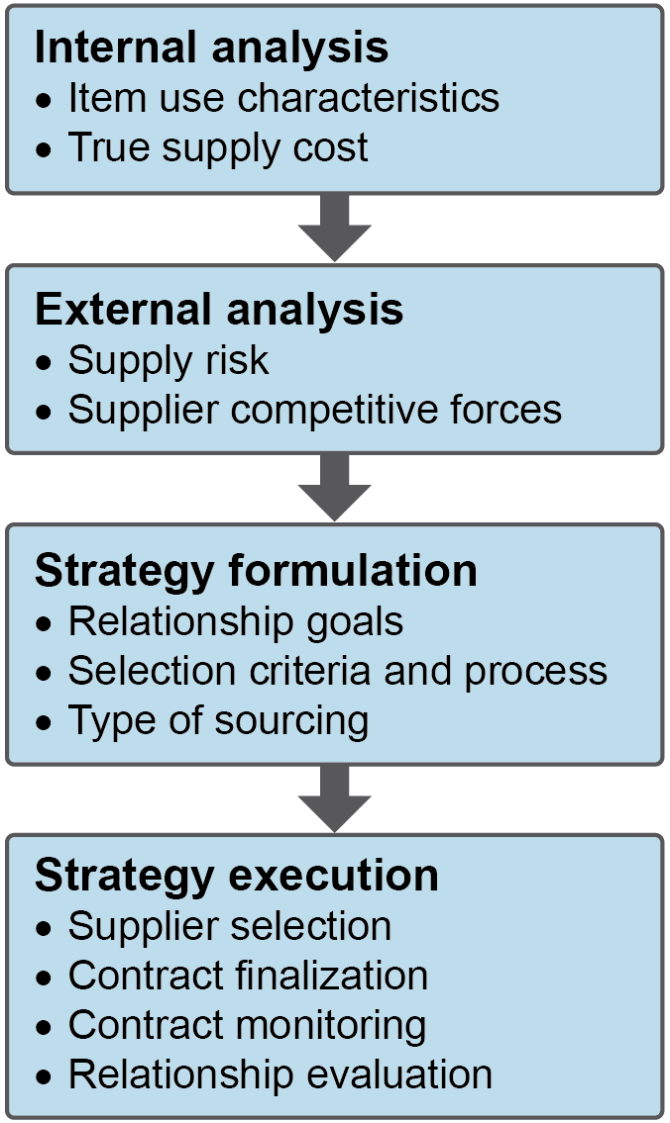
Supplier Relationships and Strategies

Risk versus Profit Matrix



Strategic Sourcing Process

Comprehensive approach to locate and source key materials suppliers, focusing on long-term relationships with trading partners to meet profitability and service goals



Sourcing Management

- Risks are high, but profit impact is low—bottleneck items.
- Goals
  - Reliability
  - Best total cost of ownership
- Results
  - Shorter relationships
  - Global supply networks

Factors to consider in using global suppliers:

- Currency exchange rates
- Transportation
- Longer lead time
- Difficulty in monitoring
- Cultural fluency

Tactical Buying

Purchasing process focused on transactions and nonstrategic material buying

- Presence of many competing suppliers allows competitive bidding.
- Standard products at comparable costs and reliable quality.
- Stable usage rates and schedules.

When to Use Strategic Sourcing and Tactical Buying

Tactical Buying	Criteria	Strategic Sourcing
Stable prices and favorable currency exchange rates	**Price**	Volatile prices and currency rates
Reliable availability	**Service**	Greater need for control over delivery
Standard, consistent quality levels	**Quality**	Greater need for quality control
Well established	**Technology**	Sharing necessary
Stable, flat, predictable	**Market trends**	Volatile, competitive rivalry

Alliances, Partnerships, and Joint Ventures

Can increase scope with less investment and risk

Strategic alliance	Strategic partnership	Joint venture
▪ Formal commitment to share information, participate in joint investments, and develop linked processes.	▪ Informal alliance with suppliers or buyers to increase performance.	▪ Two or more firms invest equity to create another entity and share in profits.

Participative Design/Engineering

Benefits

- Better quality
- Shorter design phases and earlier market entry
- Increased revenue

Simultaneous participation in product design of all functional areas of a firm and often suppliers and customers

Logistics Improvement

Goal of outsourcing logistics

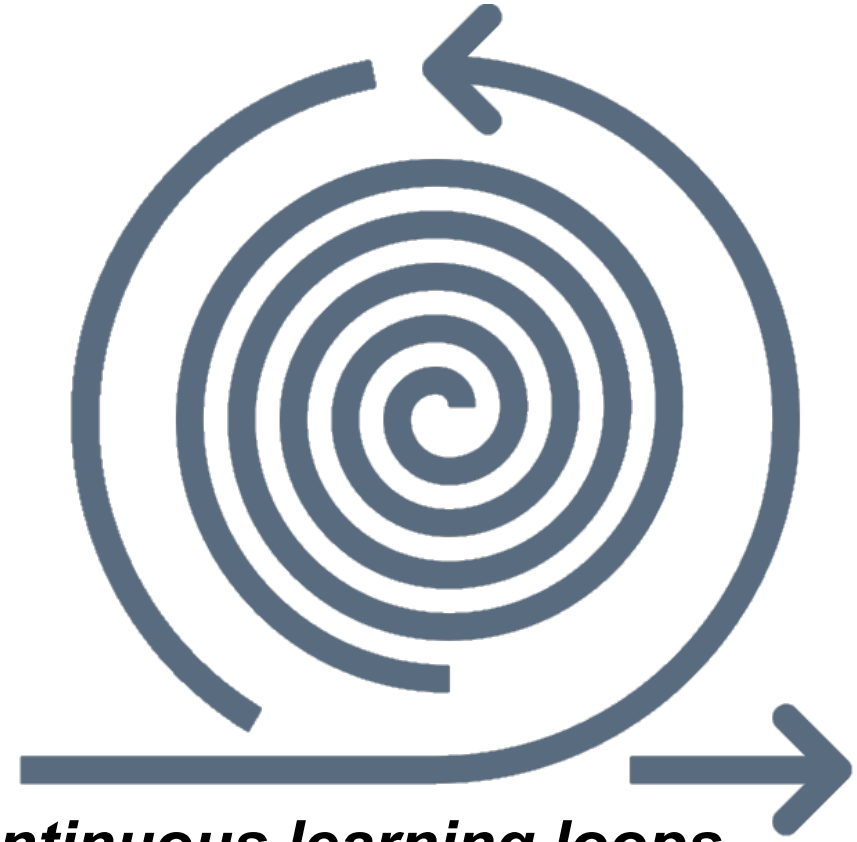
- Create competitive advantage.
- Lower costs and shorten lead times.
- Improve logistics upstream and downstream.

Benefits of 3PL

- Focus on core competencies.
- Divest transportation, warehousing, and/or order fulfillment to 3PL.
- Get 3PL's expertise in logistics.

Supply Chain Continuous Improvement

- Investing resources to achieve mutual goals—e.g., supplier quality accreditation
- Designing communication and business processes for better integration
- Achieving sustainable goals—e.g., reduced material use
- Providing training and technical support to supply chain partners



Continuous learning loops

Supplier Capability Assessment

Qualifying designs

Both buyer and supplier have vested interest in fulfilling all requirements.

- Detailed product definition
- Production of samples
- Approval of test procedure
- Qualification testing
- Analysis of test results

Qualifying manufacturing process

- Evaluation of experience
- Process capability analysis
- Quality survey
- Surveillance of supplier quality
- Average outgoing quality limit (AOQL)
- Evaluating product (how much inspection, if any)

Supplier Capability Evidence

Supplier audits	Supplier certification
▪ Stability of supplier management system and importance they place on it ▪ Security for proprietary data ▪ Supplier's quality commitment ▪ Supplier's customer service level and goals	▪ Certified as to effective procedures related to customer's requirements ▪ Lower cost of quality ▪ Stable processes, quality system, no lot rejections, etc.

Capable Suppliers and Contracts

Supplier Contract Types

- Buy-back
- Revenue-sharing
- Pay-back
- Cost-sharing
- Pricing agreements
- Capacity reservation

Negotiating Contracts

- Purchase order (PO): one-time contract
- Contract buying (complex or frequent need)
  - Blanket POs: release materials at predetermined delivery dates
  - Longer-term contracts: e.g., for trusted partners
- Relative negotiating power (good alternatives?)
- Best alternative to negotiated agreement (e.g., cost of doing it in house, others on short list)

Negotiate on

- Terms and conditions
- Delivery and quantity
- Quality
- Price.

Negotiating Prices

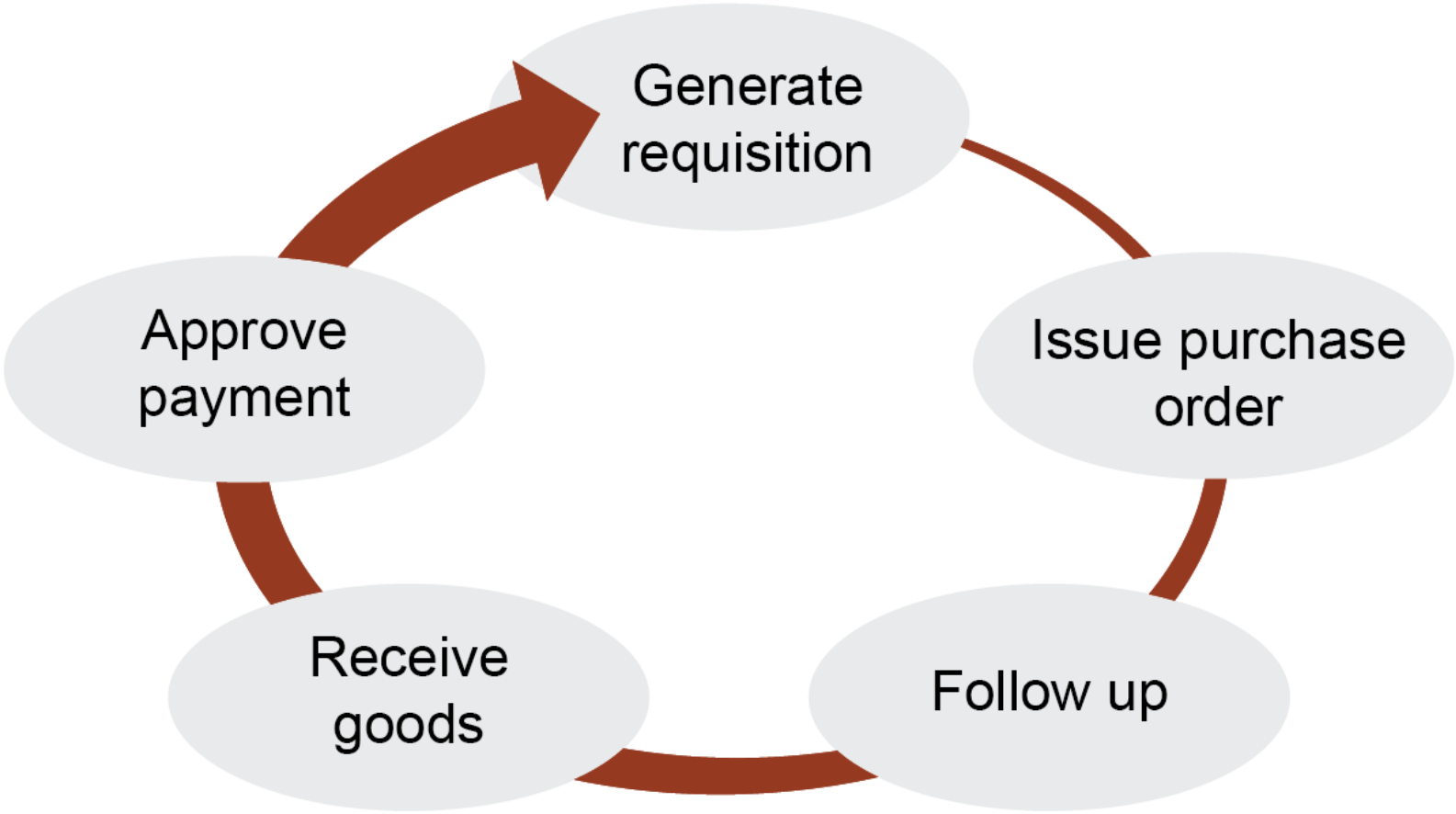
- Acquisition costs can account for half of COGS.
- Volume discounts may help lower unit cost.
- Break-even point formula

$$\text{Price per Unit} \times \text{Number of Units Sold} = \text{Fixed Cost} + (\text{Variable Costs per Unit} \times \text{Number of Units})$$

- Solved for number of units (X)

$$X = \frac{\text{Fixed Cost}}{(\text{Price per Unit} - \text{Variable Cost per Unit})}$$

Purchasing Cycle

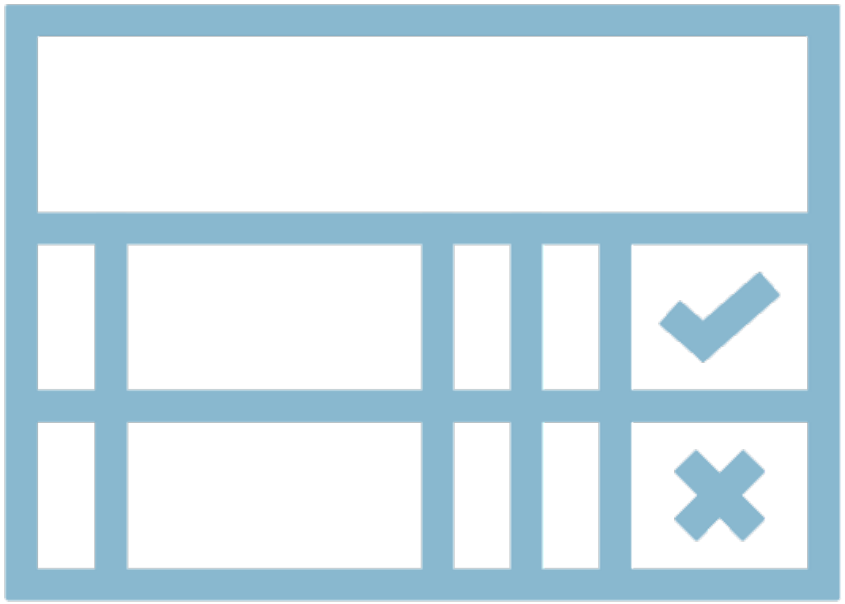


Contract Buying and Other Ordering Approaches

- Purchasing cycle
  - Purchase order
- Contract buying
  - Blanket purchase order
  - Lean purchasing
- Managed inventories
  - Vendor-managed inventory
  - Consignment inventory

Supplier Success: Best Practices

- Continual coordination with suppliers
- Consistent supplier performance criteria and practices across the organization
- Visibility into supplier systems and exception alerting
- Use of current technology to automate communication and control
- Use of performance scorecards with most suppliers



Rating System Requirements

Effective supplier performance rating systems

- Communicate metrics to suppliers
- Collaborate on ways to achieve performance targets
- Use short feedback loops aimed at improving supplier performance
- Select metrics aligned with organization's strategic goals.

Supplier Performance Metrics

Quantitative	Qualitative
▪ Certifications ▪ Product quality ▪ On-time delivery performance ▪ Cost ▪ Technological capabilities ▪ Data quality	▪ Willingness to share information and collaborate ▪ Buyer's experience of service ▪ Responsiveness to requests

GRI Standards for Sustainable Supply Chains

Sustainability reporting framework	Performance indicators
▪ People: Treatment of workers and community well-being ▪ Planet: Energy, emissions, carbon footprint, waste, and pollution ▪ Profit: Reputation and liability for supplier behavior	▪ General: Supplier locations and conflict-of-interest measures ▪ Economic: Degree of local sourcing ▪ Environmental: Energy, greenhouse gases, environmentally screened suppliers ▪ Social: Health, labor practices, human rights, and societal impact

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SECTION F:
CHANGES AND PRODUCT LIFE CYCLE MANAGEMENT

APICS

ASCM

Section F Learning Objectives

- Responding to supply and demand changes
- Supply and demand timing and quantity variability
- Revising planning parameters
- Using what-if analysis and simulations
- Monitoring buffer status
- Product life cycle management
- New product introduction (NPI) schedule
- End-of-life plan

Replanning Order Priorities

MRP systems can be affected by variability in

- Demand quantity
- Demand timing
- Supply quantity
- Supply timing.

Original MRP

Part	Lead time (weeks)	Lot size	MRP	Week 0	1	2	3	4	5	6	7	8	9
221			Gross requirements		20	20			20	20		20	
			Scheduled receipts		20	20							
			Projected available	10	10	10	10	10	0	0	0	0	0
			Net requirements						10	20		20	
			Planned order receipt						10	20		20	
	2	L4L	Planned order release				10	20		20			

Demand variability Projected vs. actual

Supply variability Planned vs. actual

1. **Requirements** quantity shifts x units higher/lower

MRP	Week 0	1	2	3	4	5	6	7	8	9
Gross requirements		20	20			12	35		12	
Scheduled receipts		20	20							
Projected available	10	10	10	10	10	0	0	0	0	0
Net requirements						2	35		12	
Planned order receipt						2	35		12	
Planned order release				2	35		12			

2. **Requirements** timing shifts earlier/later by X periods

Week 0	1	2	3	4	5	6	7	8	9
	20	20		20	20			20	
	20	20							
10	10	10	10	0	0	0	0	0	0
				10		20			20
				10		20			20
		10		20			20		

3. Supplier or prior manufacturing step provides X too few/many (e.g., scrap)

MRP	Week 0	1	2	3	4	5	6	7	8	9
Gross requirements		20	20			20	20		20	
Scheduled receipts		22	16							
Projected available	10	12	8	8	8	0	0	0	0	0
Net requirements						12	20		20	
Planned order receipt						12	20		20	
Planned order release				12	20		20			

4. Supplier or production provides orders X periods late/early

Week 0	1	2	3	4	5	6	7	8	9
	20	20			20	20		20	
	20		20						
10	10	-10	10	10	0	0	0	0	0
		10			10	20		20	
					10	20		20	
			10	20		20			

Quantity variability **Timing variability**

Lot-Sizing Changes

Lot-sizing models	Key points
▪ Economic order quantity (EOQ) ▪ Period order quantity (POQ) ▪ Least total cost ▪ Part period balancing (PPB) ▪ Wagner-Whitin algorithm	▪ Minimize sum of ordering and carrying costs. ▪ Lot-for-lot can be expensive when there is low but not zero demand. ▪ Cost savings can be significant when used on all MRP items. ▪ Users need to be able to make sense of the logic.

Revising Buffers

- Safety lead time
  - Timing uncertainty
- Safety stock
  - Quantity uncertainty
- Yield factors
  - Clarify it is starting quantity.
- Kanban quantity changes
  - Regular demand items may get buffers.

- Buffers absorb minor variability and avoid system nervousness.
- Buffers are inherently problematic because they give the system false inputs.

Checking Feasibility and Validating Execution

What-if analysis and simulation

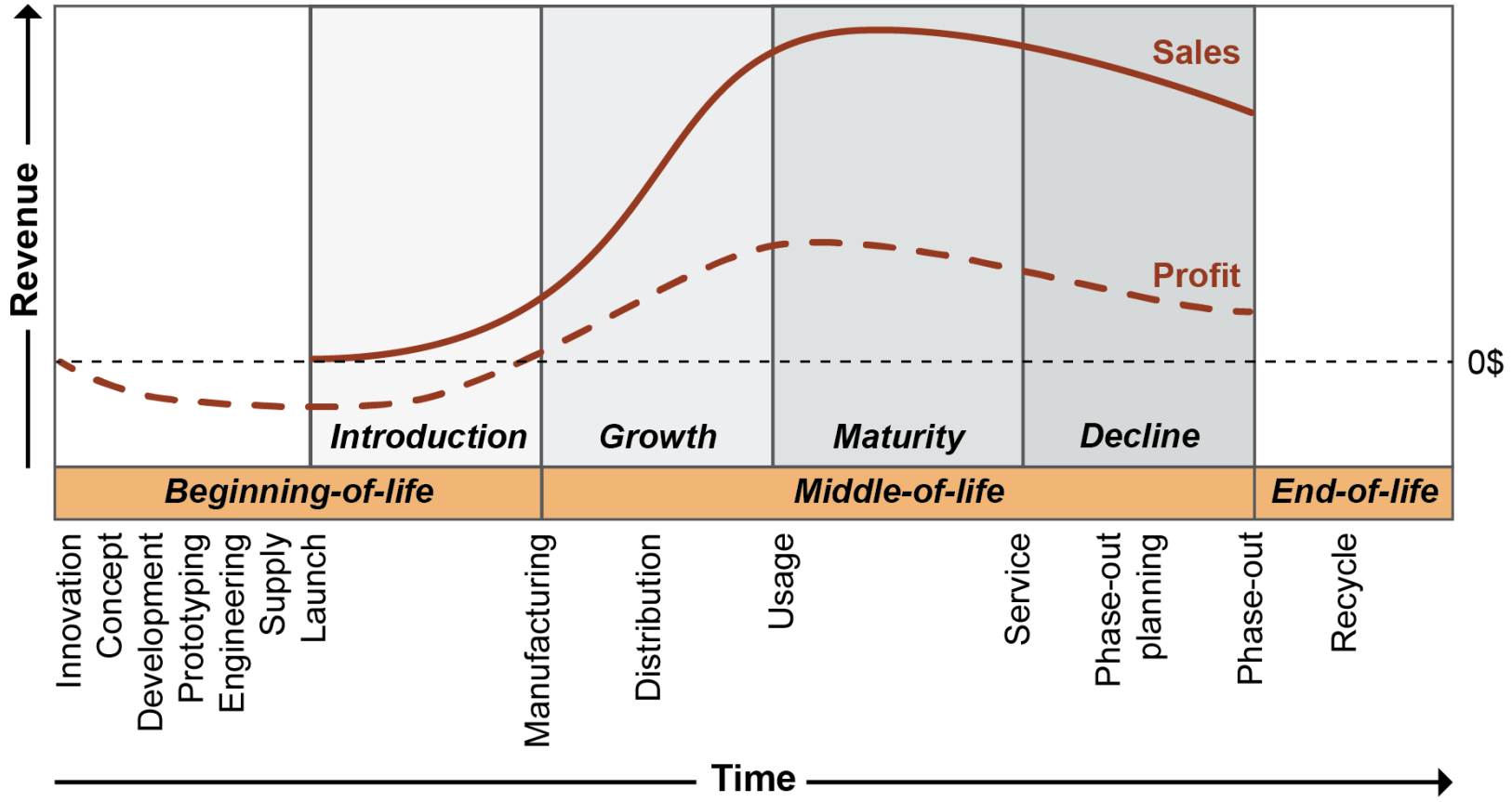
- What-if analysis examines impact of changes to a single factor (e.g., longer lead time).
- Simulation includes multiple inputs within defined ranges to describe a possible scenario.

Monitoring buffer status

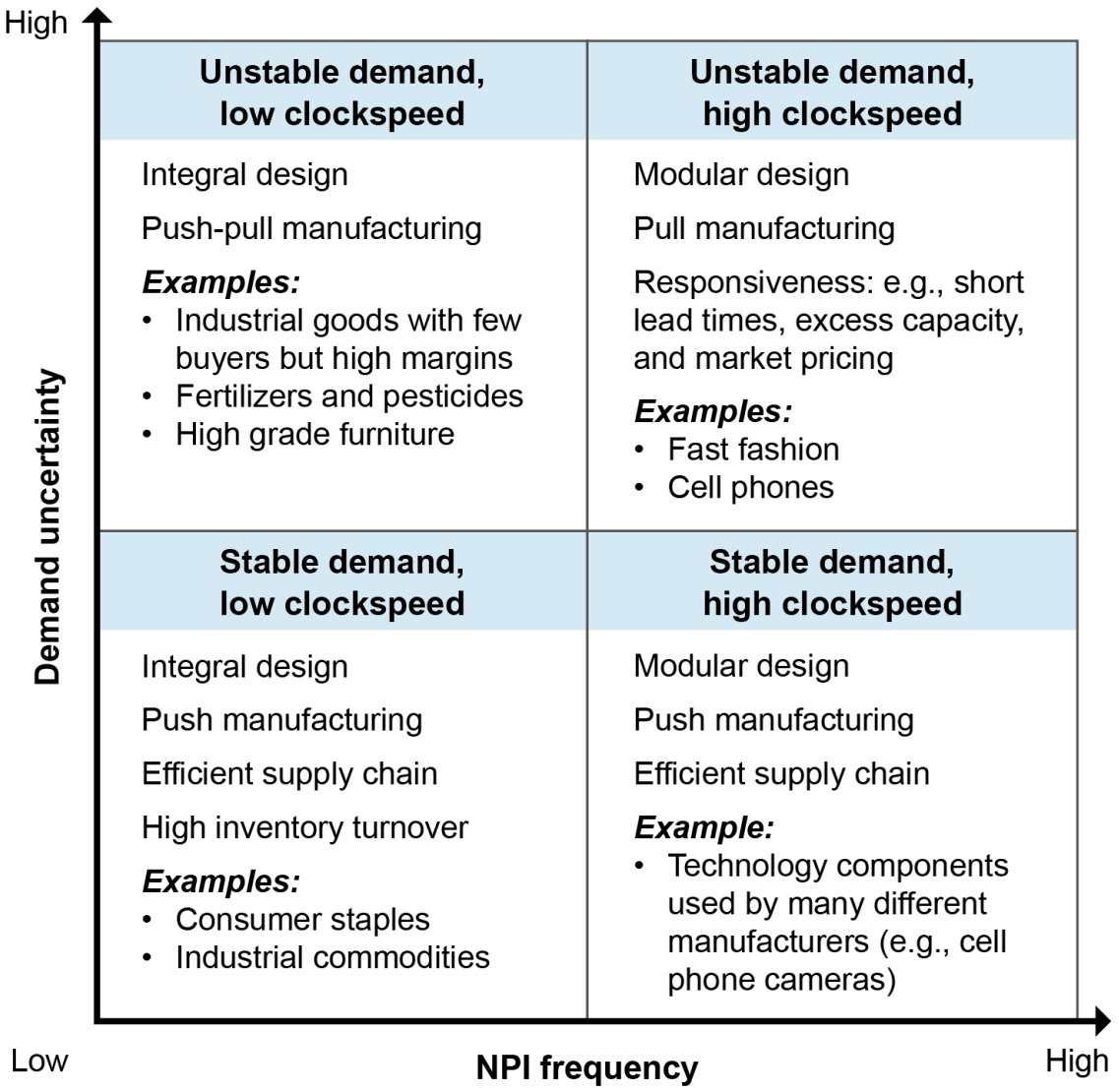
- Monitor for abnormalities.
- Time monitoring with throughput speed.
- Train and communicate with system users to avoid MRP system nervousness.

Product Life Cycle Management

PLM is also used to track life cycles of individual lots or units.



NPI Frequency versus Demand Uncertainty



End-of-Life Plan Elements