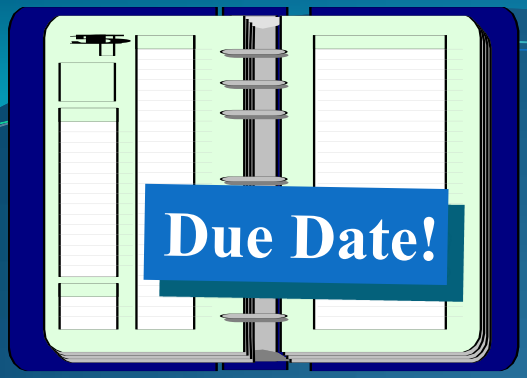
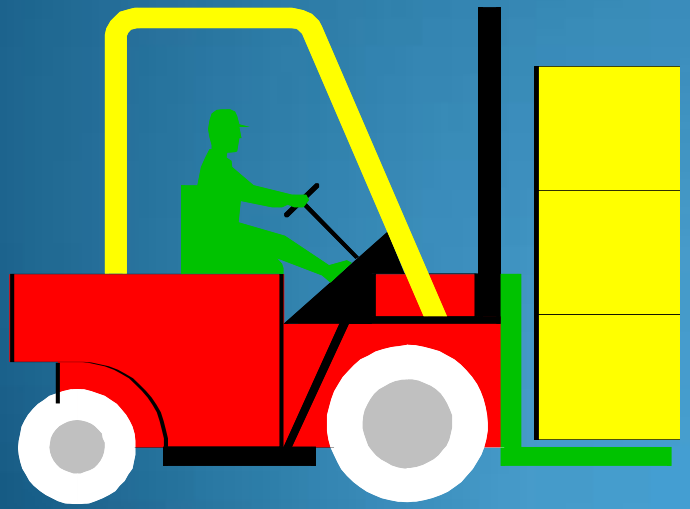
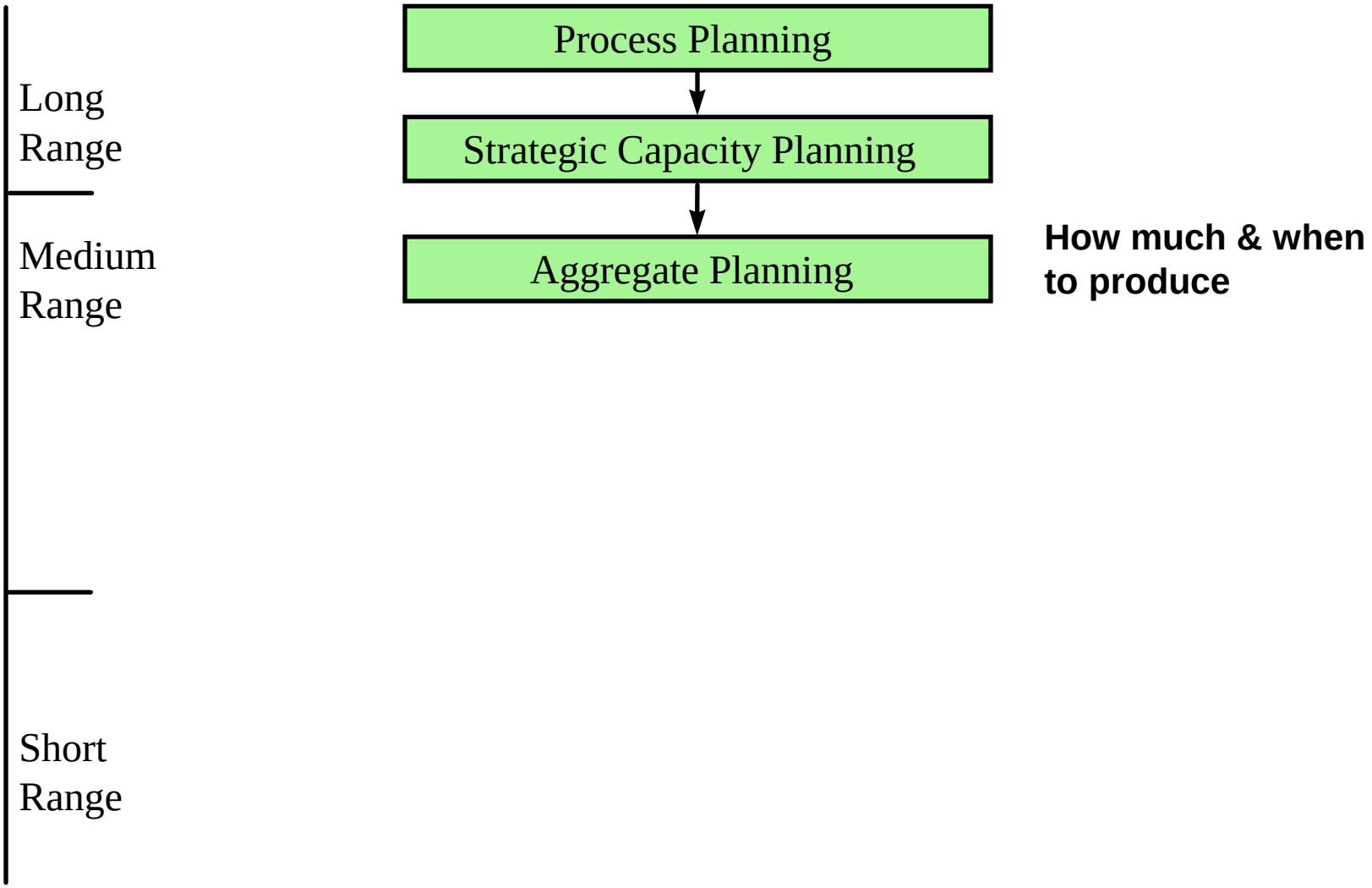


Aggregate Planning (Sales & Operations Planning)



Module 10
July 22, 2014

Production Planning Process



Aggregate Production Planning/ Sales and Operations Planning (S&OP)

- A managerial statement of time-phased
  - –production rates,
  - –work-force levels, and
  - –inventory investment,

  which takes into account customer requirements and capacity limitations

Aggregate Production Planning
Sales and Operations Planning (S&OP)

- **Objective:**

Generally to determine the quantity and timing of production for the intermediate future (generally 6 - 18 months); called the "planning horizon."

Aggregate Production Planning (Sales and Operations Planning (S&OP))

Sales and Operations Planning is:

- prepared for product families (i.e. products with similar labor, material or processing requirements);

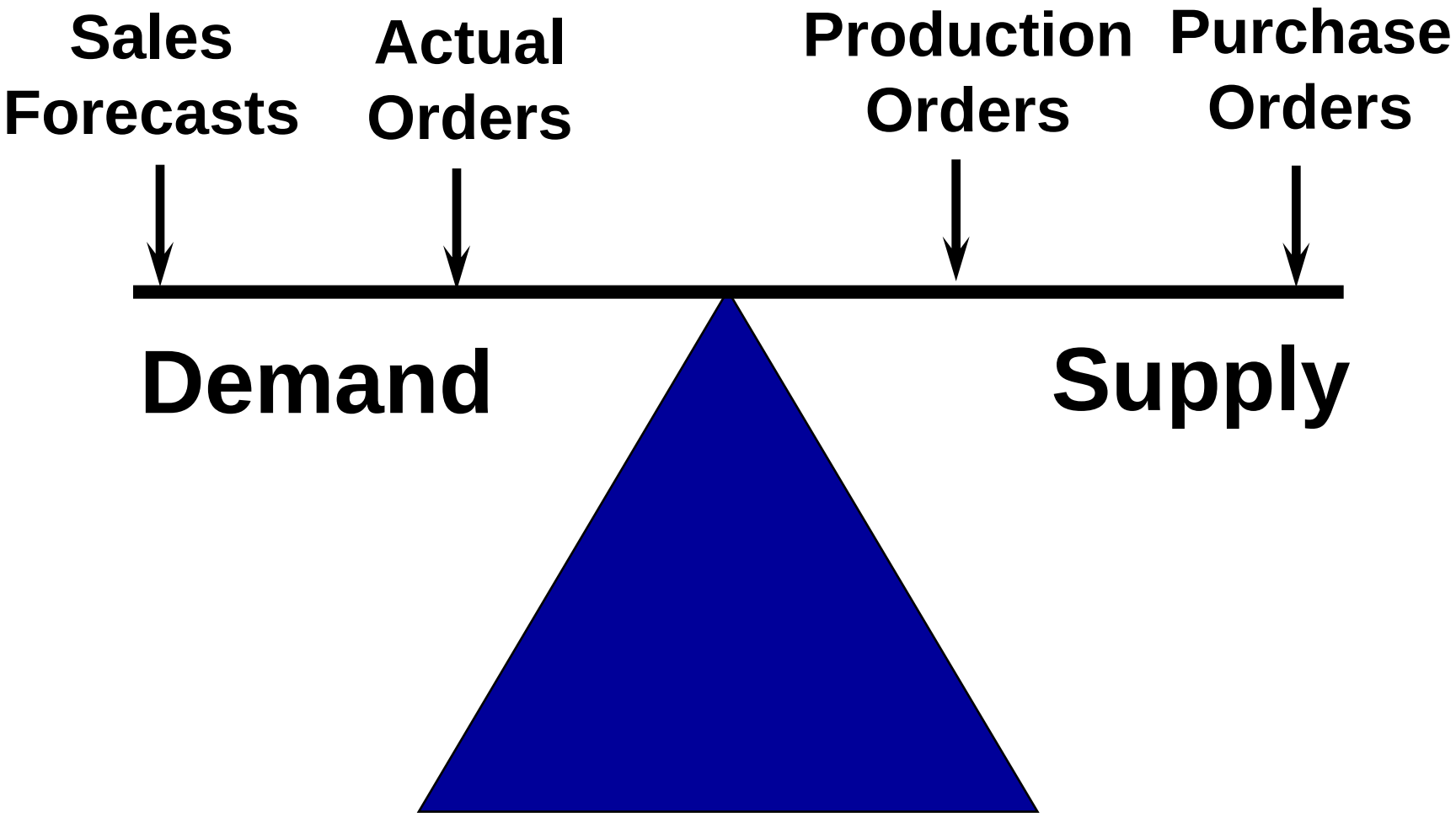
  e.g., passenger tires.

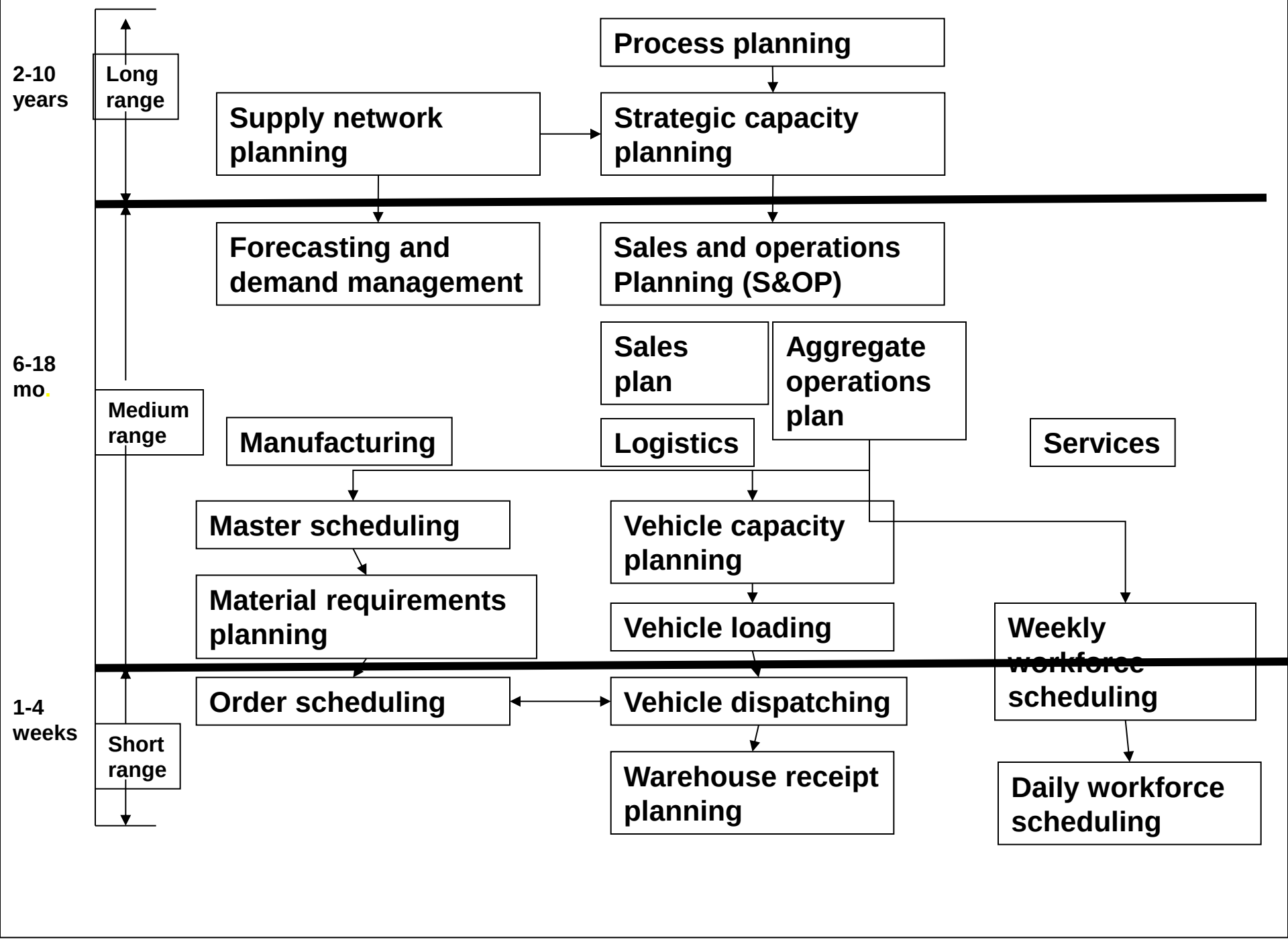
- in aggregate terms such as total units (e.g. Camry's), standard labor hours or dollars.

Sales and Operations Planning Characteristics

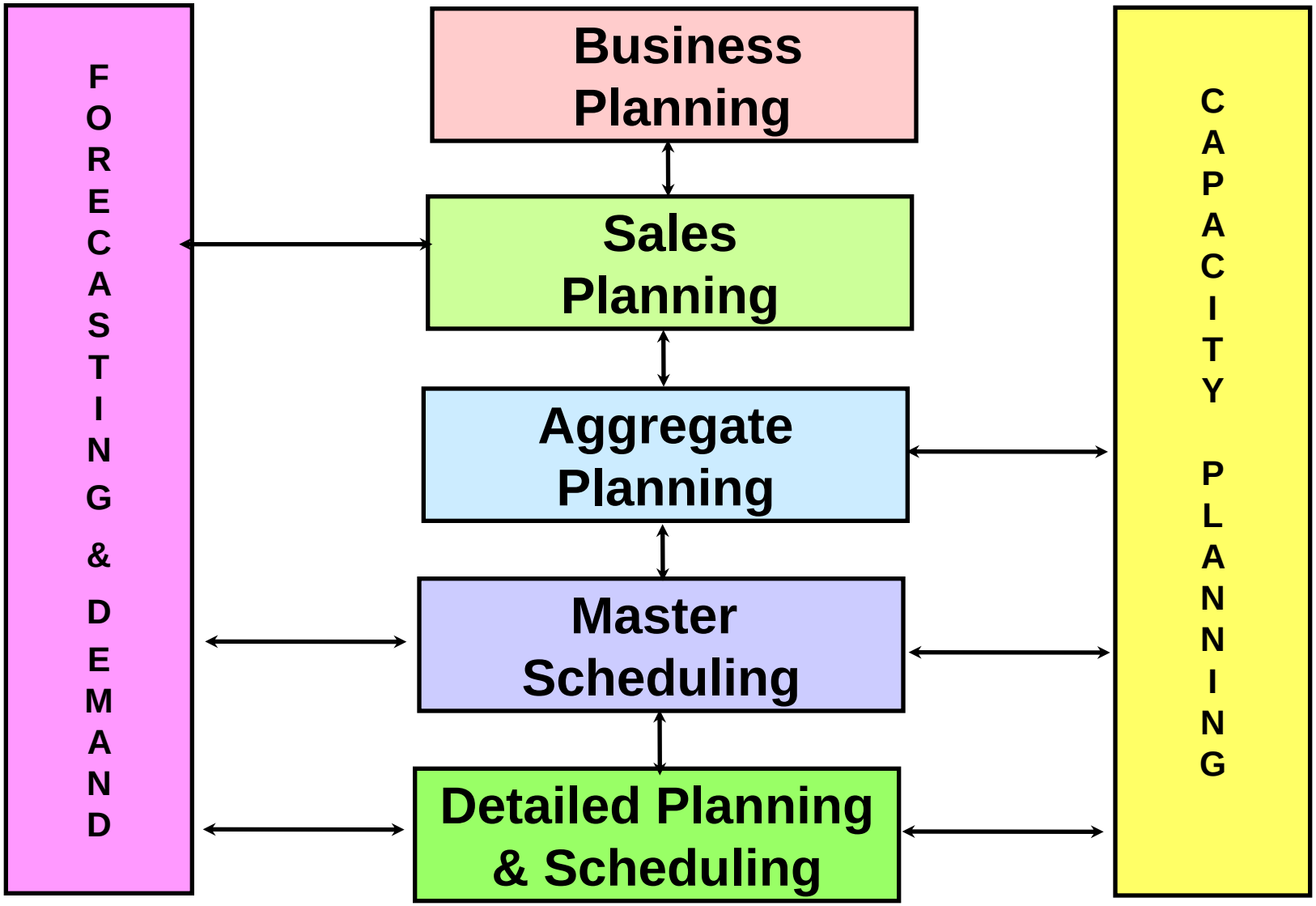
- A time horizon of about 12 months
- An *aggregated* level of demand for one or few categories of product
- The possibility of changing both supply and demand
- A variety of management objectives
- Facilities that are considered fixed (cannot be expanded or reduced)
- The underlying purpose of Sales and Operations Planning (S&OP) is to *balance demand and supply*.
- Uses cross-functional teams
- Input into the master schedule

The Balancing Act



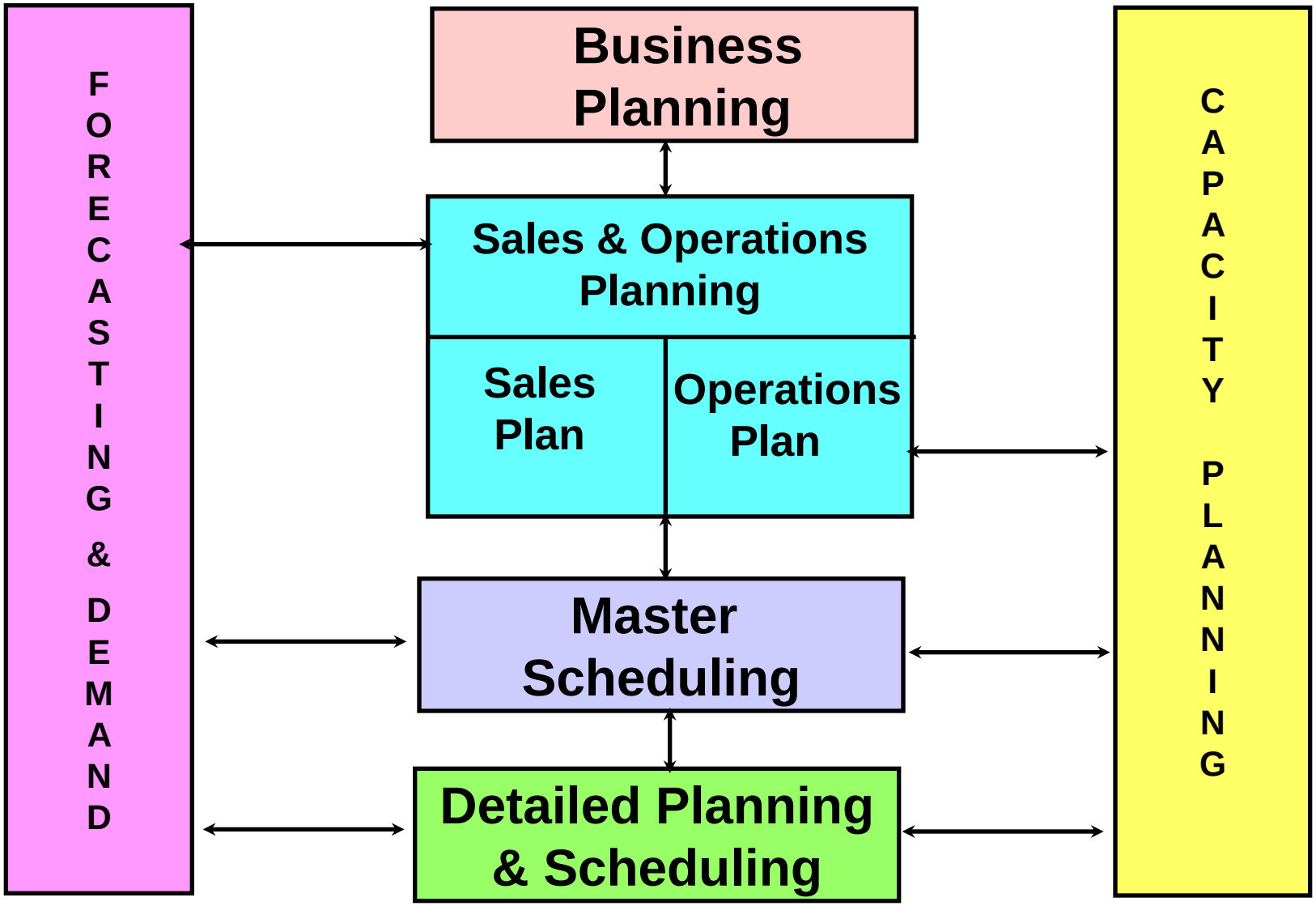

2-10 years
Long range
Process planning
Supply network planning
Strategic capacity planning
Forecasting and demand management
Sales and operations Planning (S&OP)
6-18 mo.
Medium range
Sales plan
Aggregate operations plan
Manufacturing
Logistics
Services
Master scheduling
Vehicle capacity planning
Material requirements planning
Vehicle loading
Weekly workforce scheduling
1-4 weeks
Short range
Order scheduling
Vehicle dispatching
Warehouse receipt planning
Daily workforce scheduling

Planning for Production (Old)



Source: Wallace, Tom F. *Sales and Operations Planning, A How-To Guide,* T.F. Wallace & Co. 1999.

Planning for Production (New)



Source: Wallace, Tom F. *Sales and Operations Planning, A How-To Guide*, T.F. Wallace & Co. 1999.

Planning Options

- Options for managing demand.
  - influencing demand from customers
  - delivering orders as promised
- Options for managing supply
  - delivering what is promised
  - managing capacity & other resources

Options for Influencing (Managing) Demand

- Pricing
- Advertising and promotion
- Backlog or reservations (shifting demand)
- Development of complementary products

Demand Management

Influencing What the Customer will Buy

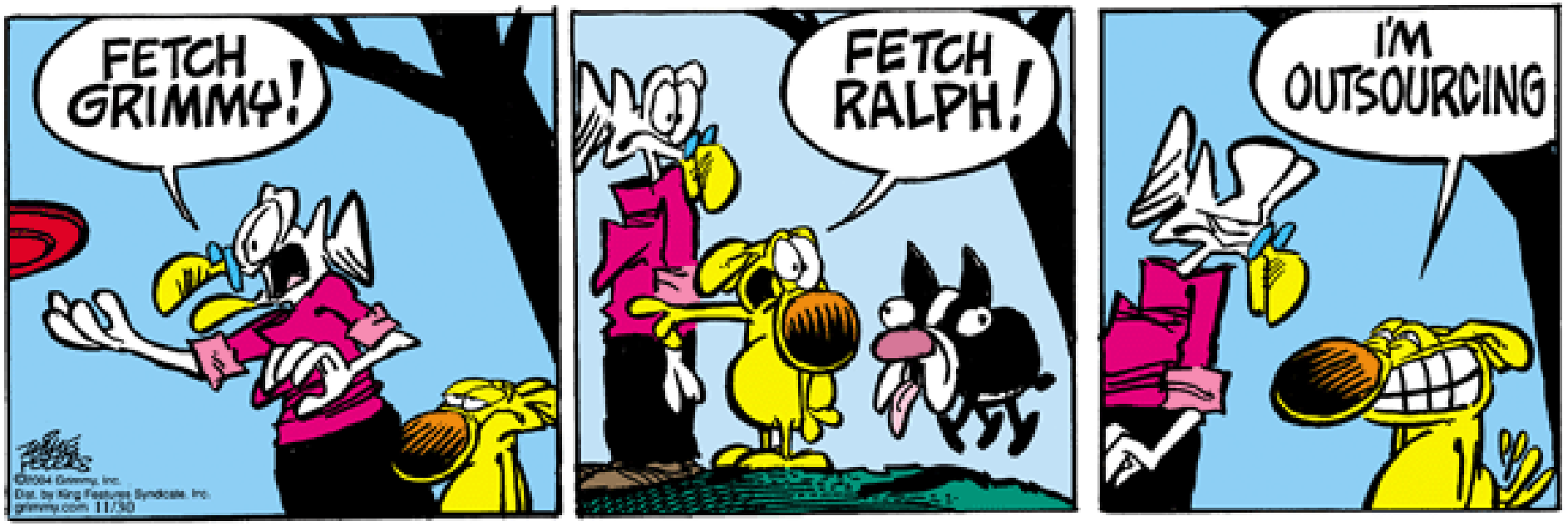
Demand Management

Influencing What the Customer will Buy

Options for Influencing (managing) Supply

- Hiring and layoff of employees
- Using overtime and under-time
- Using part-time or temporary labor
- Carrying inventory
- Outsourcing or Subcontracting
- Making cooperative arrangements

Outsourcing or Subcontracting



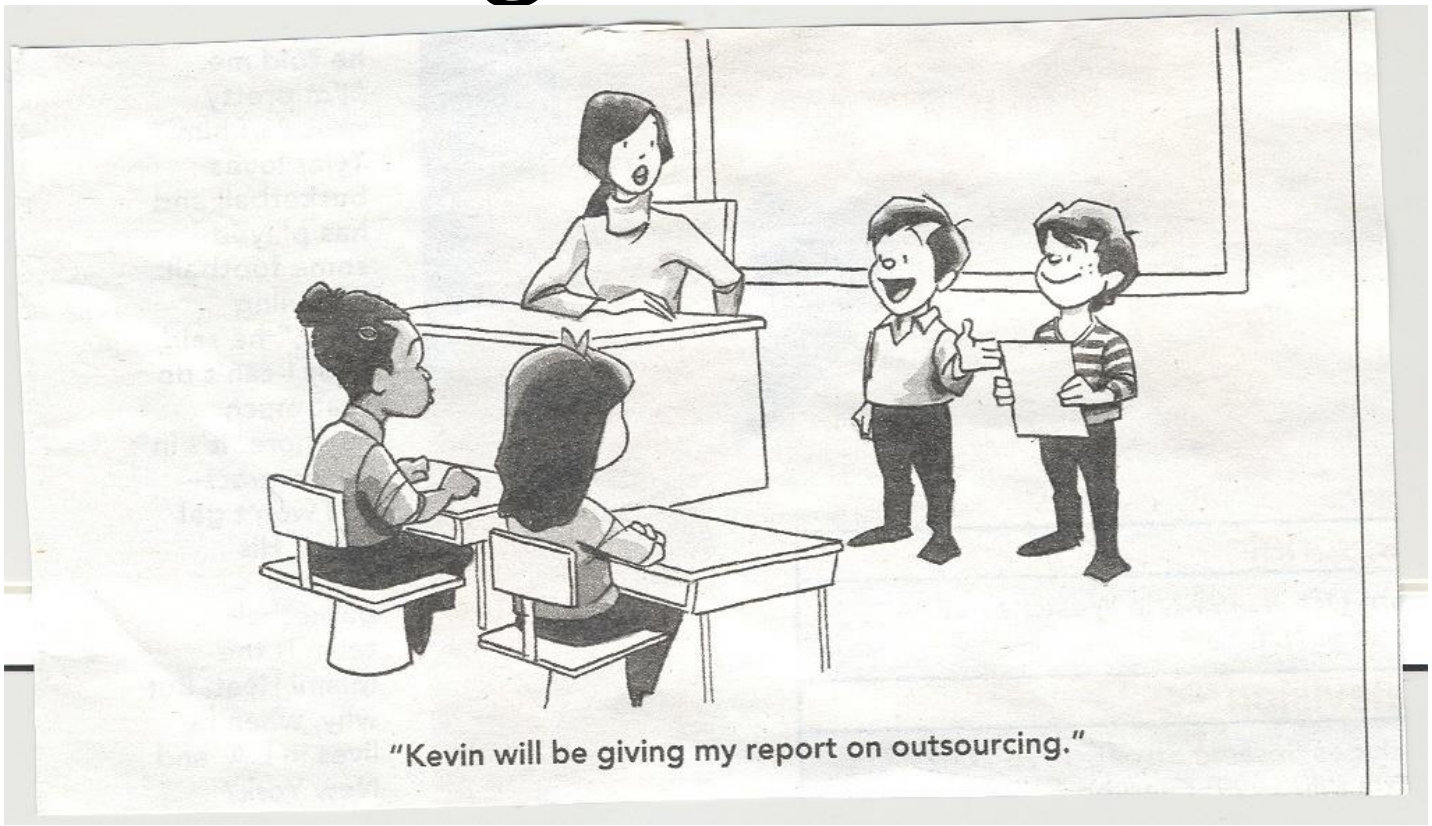
Using someone else's capacity to help manage supply

Outsourcing or Subcontracting

"Marm outsourced his barking to the dog across the street."

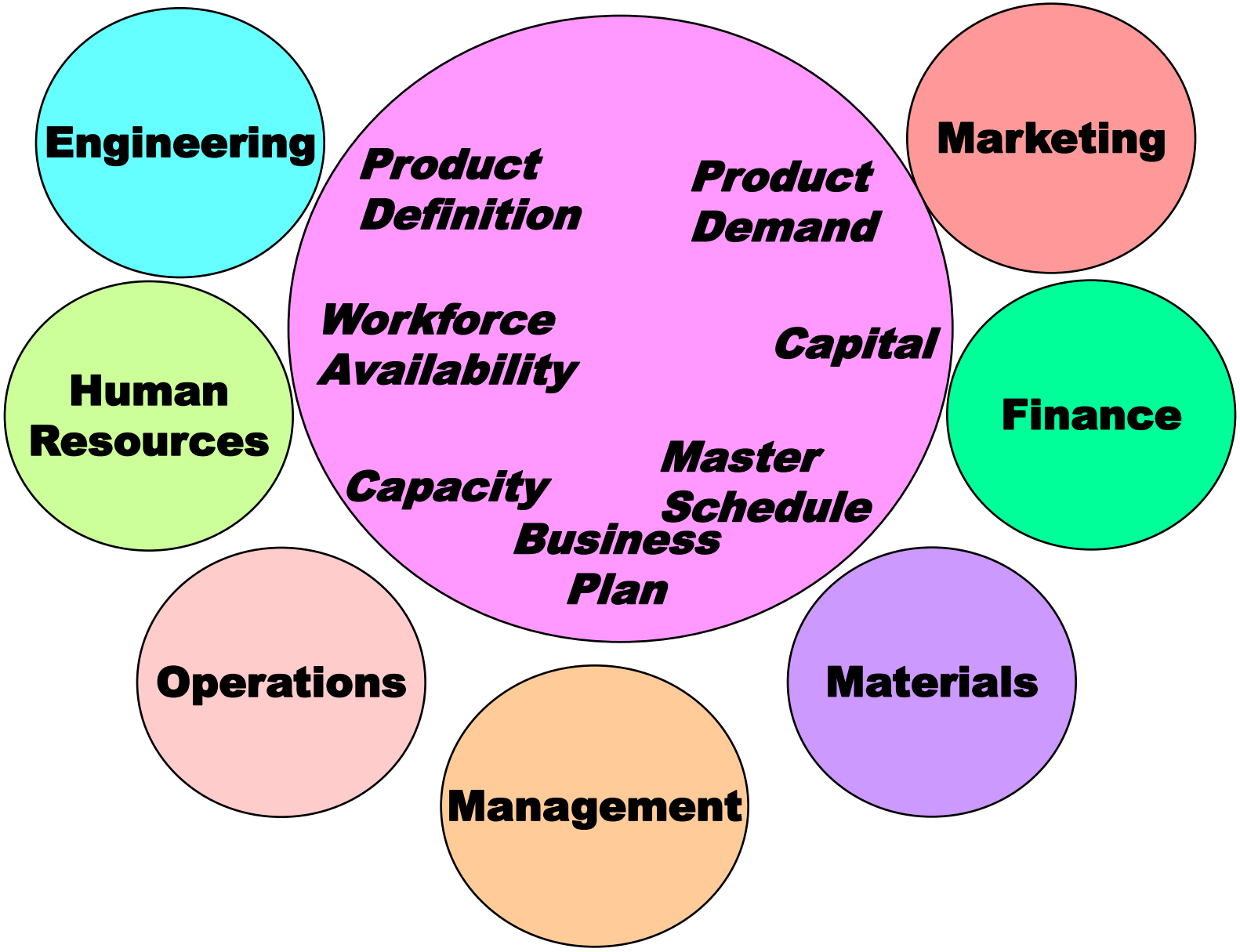
Using someone else's capacity to help manage supply

Outsourcing or Subcontracting



Using someone else's capacity to help manage supply

S&OP: Who Brings What to the Table?



Source: Launchbury, Keith J. Principles of Planning Omeric, 1999.

Inputs to S&OP

Input	Responsibility
Demand Forecast	Marketing
Market intelligence	Marketing
Actual sales	Sales
Capacity information	Manufacturing
Management targets	Management
Financial requirements	Finance
New product information	R&D
New process information	Process engineering
Workforce availability	Human resources

Sales and Operations Planning

Specific Inputs needed are:

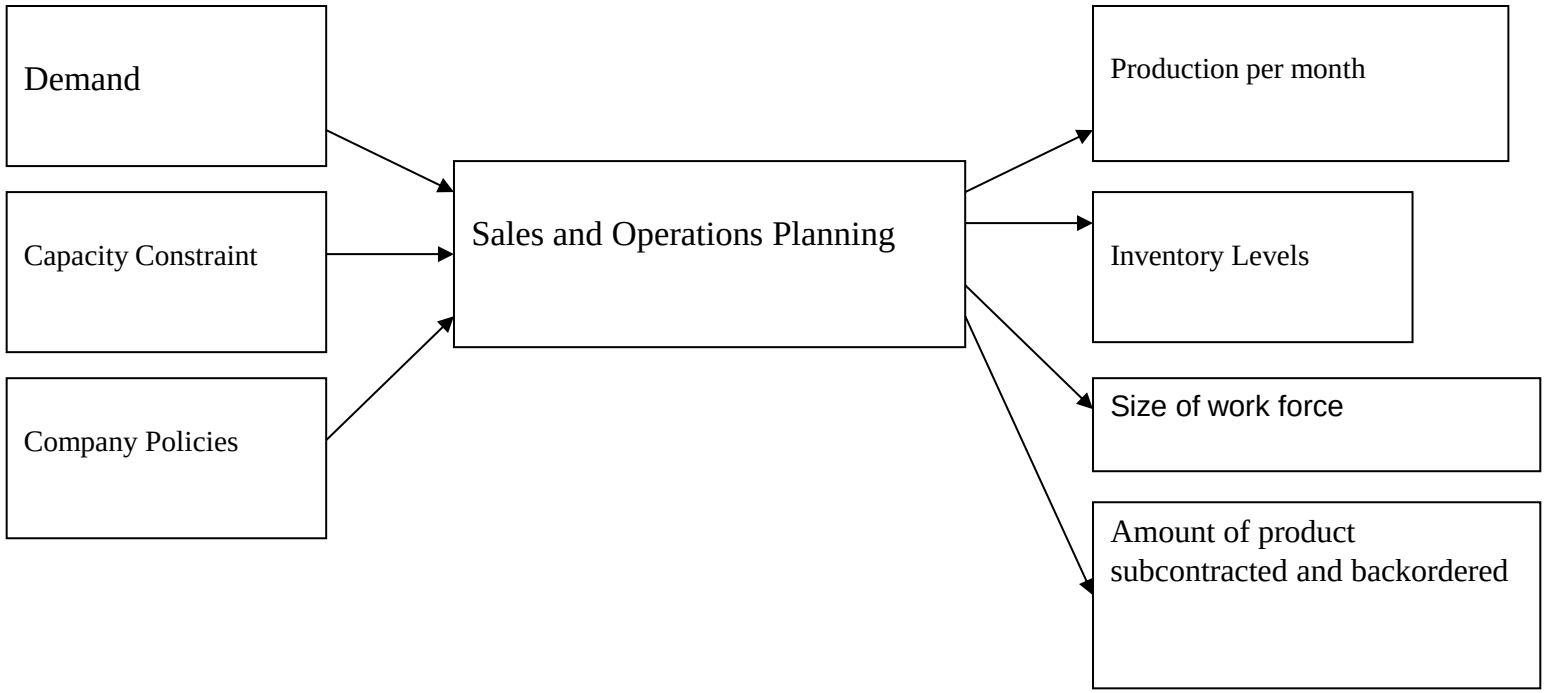
- updated sales forecast for the planning horizon
- company policies on acceptable inventory levels, personnel

  (e.g., no backordering, no layoffs, overtime up to 20% of
- regular time, etc.), subcontracting and others

S&OP Outputs

Output	Responsibility
Sales plan	Marketing and sales
Production plan	Manufacturing
Inventory plan (MTS)	Management
Backlog plan (MTO)	Management
Purchasing plan	Purchasing
Financial plan	Finance
Engineering plan	Engineering
Workforce plan	Human resources

Inputs and Outputs of S & OP



Iterative Nature of S&OP

1. Develop *production* plan.
2. Check implications for *inventory/backlog* plan.
3. If necessary, adjust *production* plan.
4. Check against *resource* plan and availability.
5. If necessary, adjust *production* plan.
6. Recheck against *inventory/backlog* and *resources*.
7. *Continue* (go to 5) until you meet all constraints.

Sales and Operations Planning

Criteria generally used include:

- Minimizing cost
- Maximizing customer service level
- Minimizing inventory
- Maintaining a stable work force level
- Combination of the above

Methods for Sales and Operations Planning

- Intuitive approach
- Analytical approaches –
  - Transportation method of linear programming
  - Linear Decision Rule (LDR),
  - Management Coefficients Model (MCM),
  - Parametric Production Planning (PPP),
  - Search Decision Rule (SDR), etc.

For services, space often dictates capacity-number of beds in a hotel, number of airline seats…

- Another capacity limitation can be “time” for services
- Other characteristics of APP in services are:
  - Most services cannot be inventoried,
  - Demand for services is difficult to forecast ,
  - Service capacity must be provided at the appropriate place and time,
  - Labor can be the most constraining resource for services,

The following are common Sales and Operations Planning choices within different strategies

- Inventories are used to absorb demand.
- Over time and under time can be used to increase or decrease production.
- Subcontracting can be used.
- Part-time workers can be used.

Important cost factors

- Regular production cost
- Over time cost.
- Subcontracting cost.

Important cost factors

- Inventory holding cost
- Backordering cost
- Hiring cost
- Layoff cost

Alternative approaches - or how to reduce the need for Sales and Operations planning

- Use substitute or alternative products
- Promotional campaigns
- Creative pricing

Sales an Operations Planning in Service Environments

- Strategies for managing service ***Demand***:
  - Segmenting customers
  - Differential pricing
  - Counter-seasonal products and services
  - Substitute or alternative products and services
  - Reservation systems

Sales and Operations Planning in Service Environments

- **Strategies for managing service *Supply*:**
  - Schedule employees
  - Customer participation
  - Contingent employees
  - Adjustable capacity
  - Shared capacity

Sales and Operations Planning?

- Let's us determine how much and when to produce in the intermediate future

  - Examples
    - labor hours of production
    - total number of units (in aggregate)
      - # of cars to make

NOT
# of red cars,
# of green cars,
# of 2-doors,…

Sales and Operations Planning?

- Let's us determine how much and when to produce in the intermediate future

  – which periods (months, quarters, etc.)?

Sales and Operations Planning?

- Let's us determine how much and when to produce in the intermediate future
  - 6-18 months
  - "planning horizon"

Sales and Operations Planning?

- Let's us determine how much and when to produce in the intermediate future

- Goal
  - Minimize the cost of resources required to meet demand over the planning horizon

Sales and Operations Planning?

- Let's us determine how much and when to produce in the intermediate future

- These are capacity decisions
- How can we change our capacity in the intermediate future?
  - Change inventory levels
  - Vary workforce size *hiring, layoffs, subcontracting, part-time*
  - Vary capacity with overtime or idle time

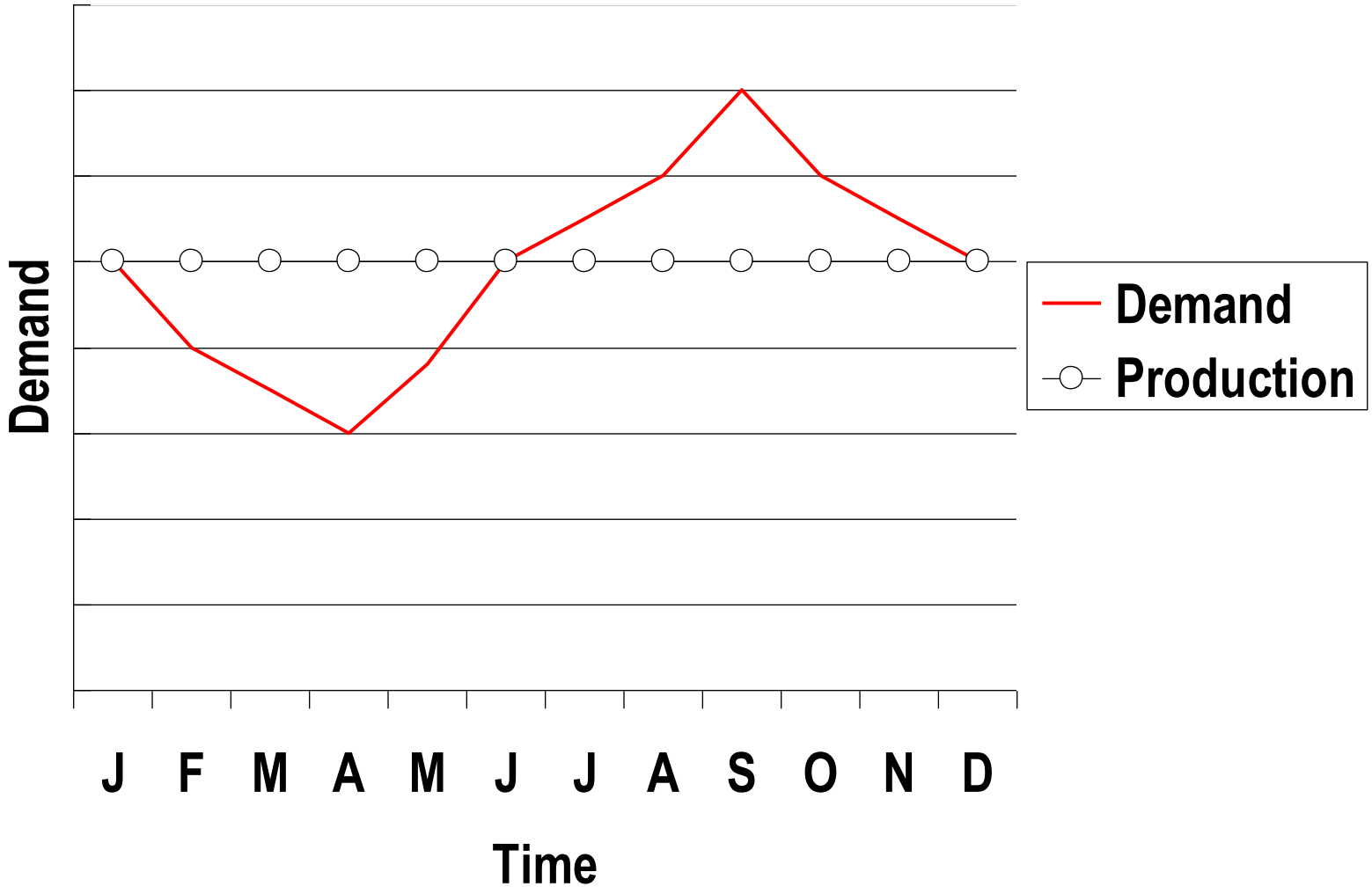
Basic Production Strategies

- “Level” strategy (constant work force, use inventory as buffer)
- “Chase” strategy (produce to demand, vary workforce)

Level Strategy

- Deliver products and services at a constant rate
- Avoid making changes to operations

Level Production Strategy



Reprinted with permission, J.R. Tony Arnold, *Introduction to Materials Management,* third edition, Prentice-Hall, 1998

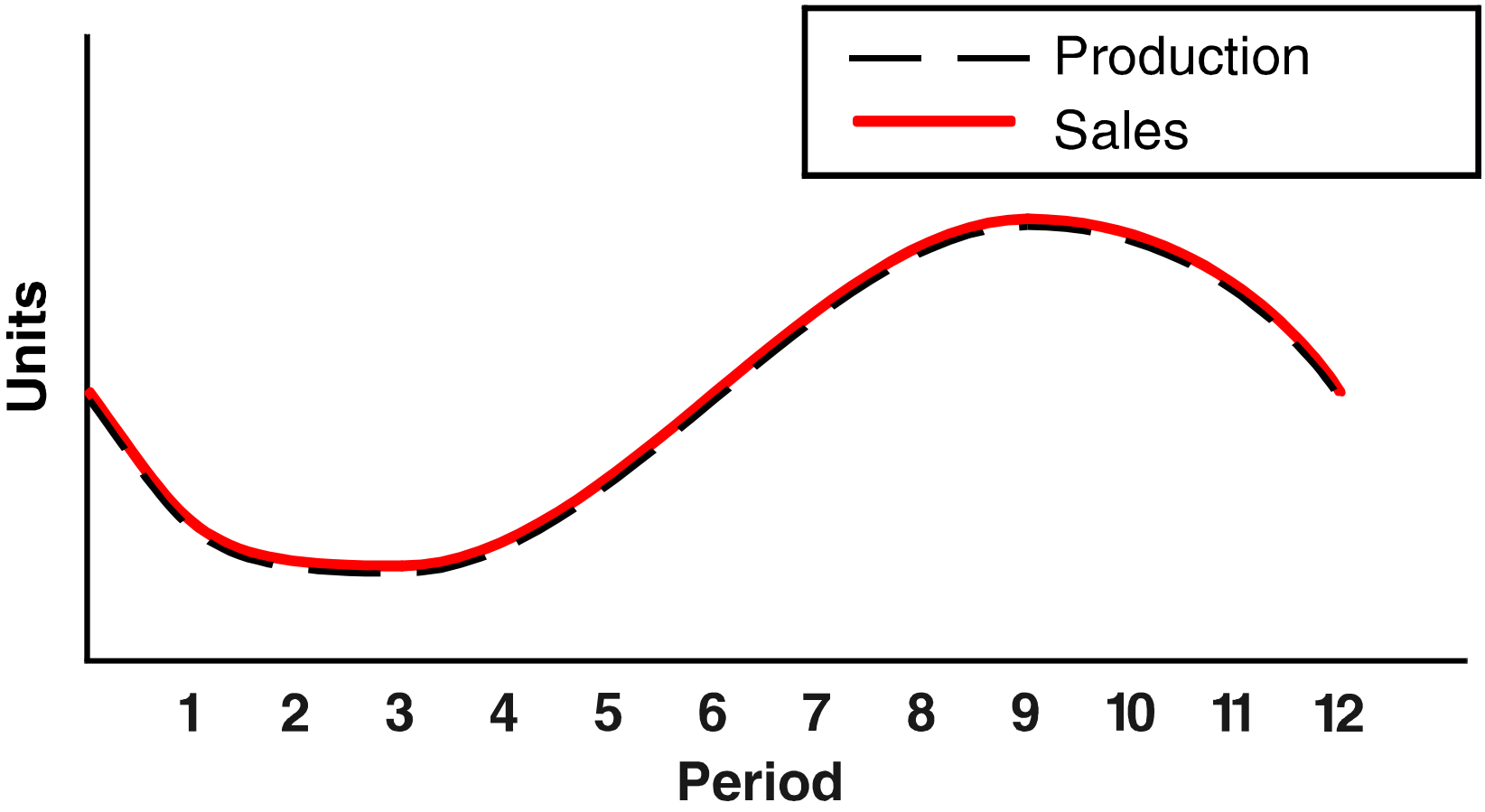
Level Production Strategy (cont.)

- Advantage:
  - Smooth, level production avoids labor costs of demand matching
- Disadvantage:
  - Buildup of inventory
  - Requires accurate forecast

Chase Strategy

- Produce only what you sell
- Produce products or services just-in-time
- If there are no sales—do not produce
- Typical for services

Chase Strategy



Chase Strategy

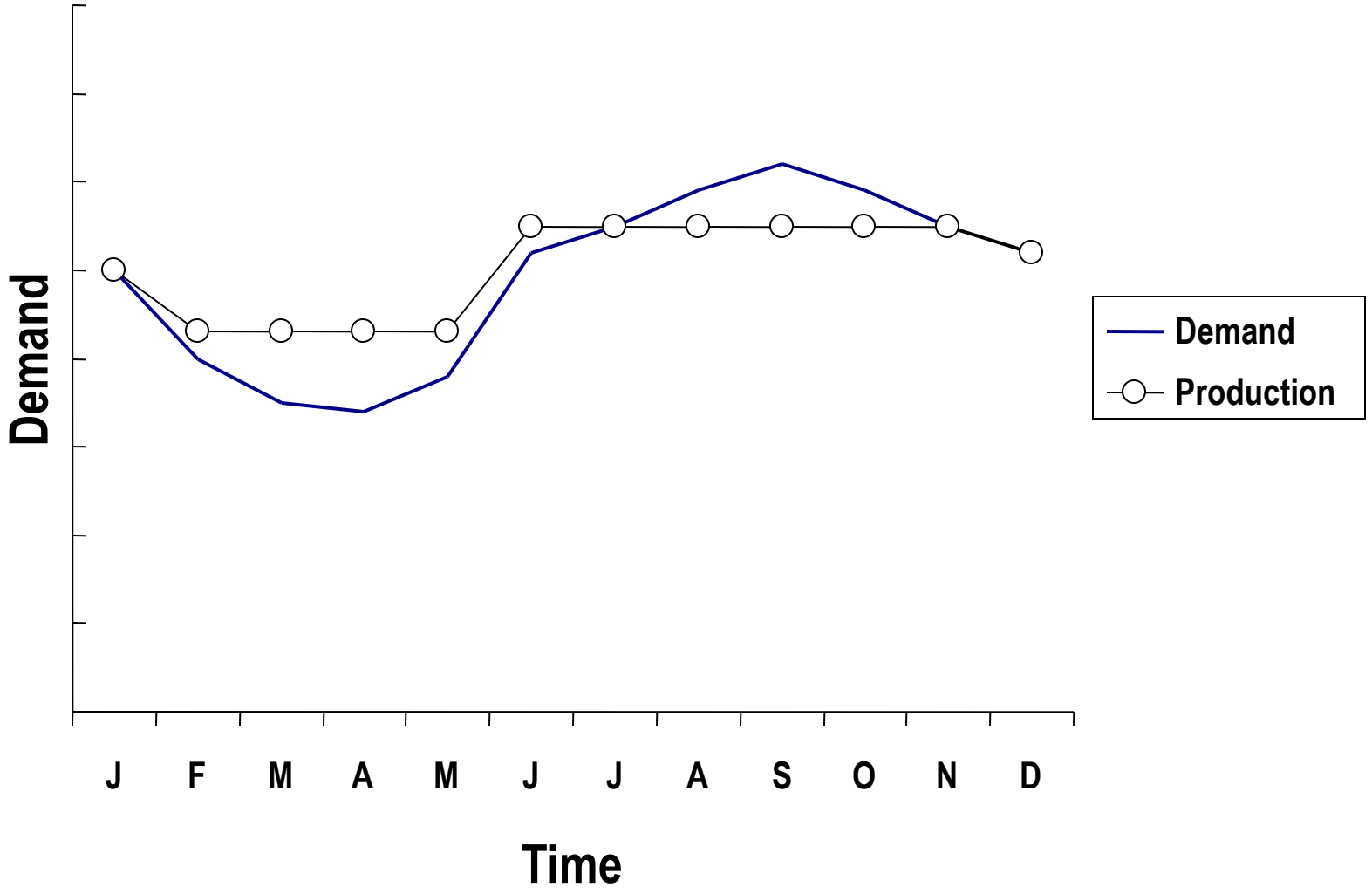
- Advantages:
  - Stable inventory
  - Varied production to meet sales requirements

- Disadvantages:
  - Costs of hiring, training, overtime, and extra shifts
  - Costs of layoffs and impact on employee morale
  - Possible unavailability of needed work skills
  - Maximum capacity needed

Sales and Operations Planning Costs

- Hiring and firing costs (chase)
- Overtime and under-time costs (chase)
- Subcontracting costs (chase)
- Part-time labor costs (chase)
- Inventory-carrying costs (level)
- Cost of stockout or back order (level)

Combination Strategy

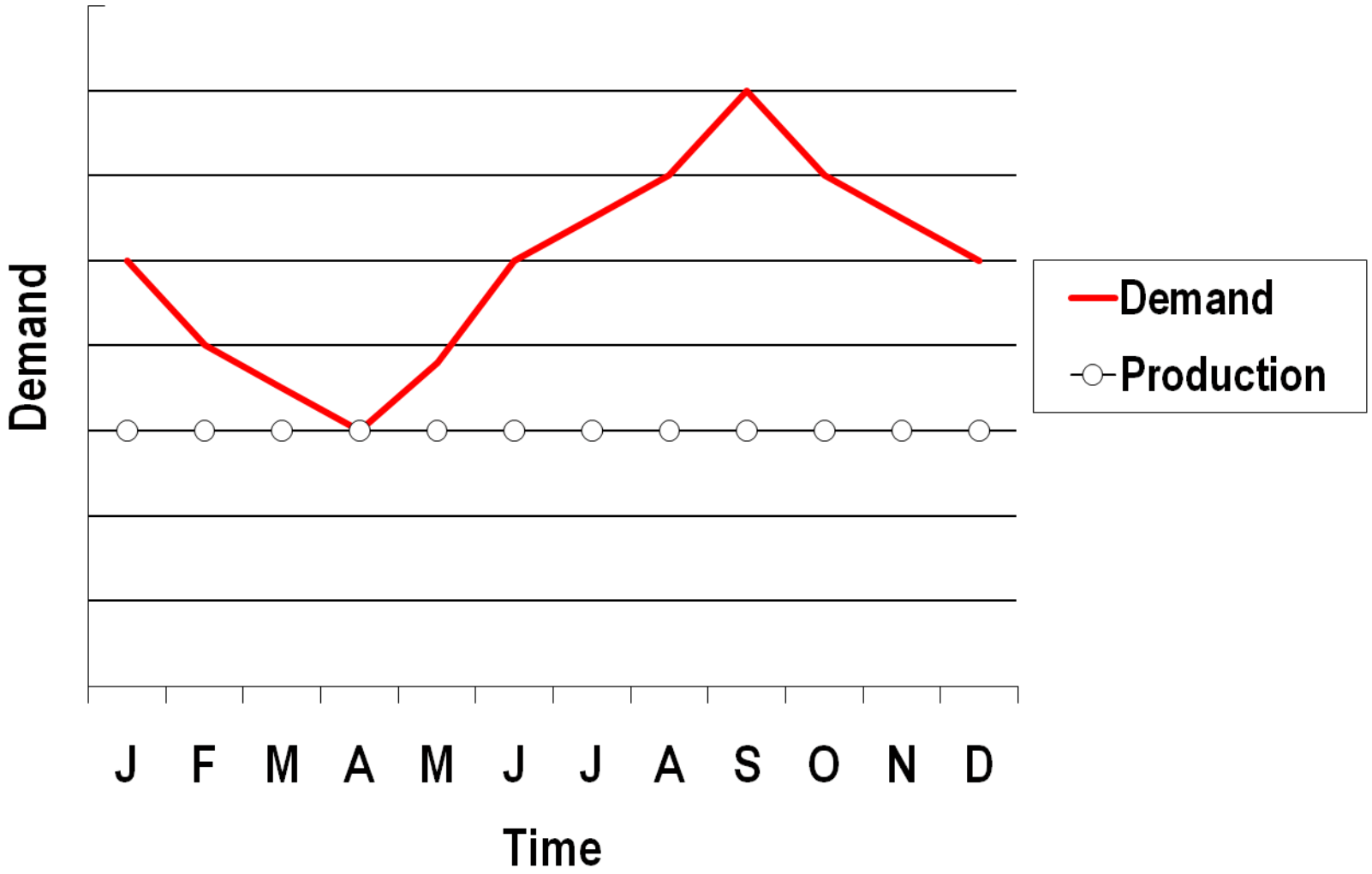


Reprinted with permission, J.R. Tony Arnold, *Introduction to Materials Management,* third edition, Prentice-Hall, 1998

Combination Strategy (cont.)

- Produces at or close to full capacity for some part of the cycle
- Produces at a lower rate (or does not produce) during the rest of the cycle
- Makes use of available capacity, yet limits inventory buildup and inventory carrying costs

Minimum Production Strategy



Minimum Strategy (cont.)

- Produces at or close to full capacity for all of the cycle
- Subcontracts for demand above the minimum
- Makes full use of available capacity, and eliminates inventory buildup and inventory carrying costs

Comparison of Chase versus Level Strategy

	Chase Demand	*Level Capacity*
Level of labor skill required	Low	High
Job discretion	Low	High
Compensation rate	Low	High
Training required per employee	Low	High
Labor turnover	High	Low
Hire-fire cost	High	Low
Error rate	High	Low
Amount of supervision required	High	Low
Type of budgeting and forecasting required	Short-run	Long-run

Four General Strategic Plans

How to meet changes in demand

1. Level
   - constant workforce/production level
   - fluctuating inventory levels
2. Chase
   - production and manpower fluctuate
3. Combination

4. Minimum

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets						
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500					
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000				
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500			
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000		
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900					

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Simple Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440				

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Simple Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800			

Simple Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100		

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200
Total						

Skilled, flexible labor

10 labor-hours per widget

6 labor-hours per wadget

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200
Total	2,400					
Cumul						

Example Problem

Forecast - Units

Month	1	2	3	4	5	6
Widgets	150	300	450	500	240	150
Wadgets	150	240	300	350	270	200

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200
Total	2,400	4,440	6,300	7,100	4,020	2,700
Cumul	2,400					

Simple Problem

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200
Total	2,400	4,440	6,300	7,100	4,020	2,700
Cumul	2,400	6,840	13,140	20,240	24,260	26,960

Simple Problem

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200
Total	2,400	4,440	6,300	7,100	4,020	2,700
Cumul	2,400	6,840	13,140	20,240	24,260	26,960

- Basic equation
  - Ending Inventory = **Beginning Inventory** + **Production** - **Demand**

What is left over = **what you begin with** + **what came in** - **what went out**

Skilled, flexible labor
10 labor-hours per widget
6 labor-hours per wadget

Example Problem

Forecast - Aggregate

Month	1	2	3	4	5	6
Widgets	1,500	3,000	4,500	5,000	2,400	1,500
Wadgets	900	1,440	1,800	2,100	1,620	1,200
Total	2,400	4,440	6,300	7,100	4,020	2,700
Cumul	2,400	6,840	13,140	20,240	24,260	26,960

Suppose, current inventory = 56 widgets and 40 wadgets
→ Current labor hours of inventory = 56x10 + 40x6 = 800

What if we want 600 labor hours worth of inventory at the end of month 6?

- E **600** **800** + **Production** - **26,960**
- Production = 26,760 labor hours over 6 months
- Production = 4,460 labor hours/month

Level Plan With Backorders

DEMANDS FROM THE PREVIOUS SLIDE

Month	1	2	3	4	5	6
BI						
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.						
EI						

→ Current labor hours of inventory = 56x10 + 40x6 = 800

What if we want 600 labor hours worth of inventory at the end of month 6?

– Production = 4,460 labor hours/month

Level Plan With Backorders

Month	1	2	3	4	5	6
BI	800	2,860	2,880	1,040	(1,600)	(1,160)
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,460	4,460	4,460	4,460	4,460	4,460
EI	2,860	2,880	1,040	(1,600)	(1,160)	600

Values in parenthesis are negative, representing backorders

– Ending Inventory = **Beginning + Production - Demand Inventory**

∴ what if we don't want to permit backorders?

– Production = 4,460 labor hours/month

Level Plan Without Backorders

- Level plan with minimum inventory and no backorders
- Key point: in one of six months ending inventory will be zero
  - If it never falls to zero, we are keeping more inventory than needed
- Solution: solve 6 level plans
  - Each plan has zero ending inventory in one of the six months
  - Highest production level is solution

Solved problem

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000

Solved problem

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000

Solved problem

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000

Solved problem

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000

Let's extend this example
to look at the other strategies…

Starting employment:	
Work hours per month:	
Hiring cost:	
Firing cost:	
Hourly wage:	
Holding cost (/labor-hr/mo):	

Our assumptions

- Widget 'N Wadgets Inc. currently has 28 employees
- Hiring costs $500
- Firing costs $800

- Each employee is paid $12 per hour
- Each labor-hour product costs us $4 to store in inventory for one month

- Assume 4 weeks per month & 40 hours per week
- Work hours per month
    - (40 * 4) = 160

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

From the previous example…

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000
Hire						
Fire						
Empl.						

 # workers needed in month 1 = $\dfrac{\text{4860 hr/mo}}{\dfrac{\text{160 hr/mo}}{\text{1 worker}}}$ **=30.375 ~31 workers**

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000

Hire

Fire

Empl. 31

but we only have 28

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000
Hire	3					
Fire						
Empl.	31	31	31	31	31	31
Hiring$						
Firing$						
Wage$						

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000
Hire	3					
Fire						
Empl.	31	31	31	31	31	31
Hiring$						
Firing$						
Wage$						

= 31 workers

= $59,520

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000
Hire	3					
Fire						
Empl.	31	31	31	31	31	31
Hiring$	1,500					
Firing$						
Wage$	59,520					
Inv$						
Total$						
Cum$						

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000
Hire	3					
Fire						
Empl.	31	31	31	31	31	31
Hiring$	1,500					
Firing$						
Wage$	59,520					
Inv$	13,040					
Total$	74,060					
Cum$	74,060					

This process continues for each period…

Level Production – No Backorders

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	3,260	3,680	2,240	0	840
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	4,860	4,860	4,860	4,860	4,860	4,860
EI	3,260	3,680	2,240	0	840	3,000
Hire	3					
Fire						
Empl.	31	31	31	31	31	31
Hiring$	1,500					
Firing$						
Wage$	59,520	59,520	59,520	59,520	59,520	59,520
Inv$	13,040	14,720	8,960	0	3,360	12,000
Total$	74,060	74,240	68,480	59,520	62,880	71,520
Cum$	74,060	148,300	216,780	276,300	339,180	410,700

Three General Strategic Plans

How to meet changes in demand

1. Level
   - constant workforce/production level
   - fluctuating inventory levels
2. Chase
   - production and manpower fluctuate
3. Stable Workforce
   - size of workforce is constant
   - number of hours worked fluctuates

Chase Approach (with hiring & firing, no overtime)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Hire
Fire
Empl.

 # workers needed in month 1 = $\dfrac{1600 \text{ hr/mo}}{\dfrac{160 \text{ hr/mo}}{1 \text{ worker}}}$ = **10 workers**

Hiring$
Firing$
Wage$

Under chase production how much will we produce in each period??

Inv$
Total$
Cum$

Chase Approach (with hiring & firing, no overtime)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	1,600	4,440	6,300	7,100	4,020	2,700
EI	0	0	0	0	0	0
Hire						
Fire						
Empl.	10					
Hiring$						
Firing$						
Wage$						
Inv$						
Total$						
Cum$						

but we have 28

= 10 workers

= $19,200

Chase Approach (with hiring & firing, no overtime)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	1,600	4,440	6,300	7,100	4,020	2,700
EI	0	0	0	0	0	0
Hire						
Fire	18					
Empl.	10					
Hiring$						
Firing$	14,400					
Wage$	19,200					
Inv$	0					
Total$	33,600					
Cum$	33,600					

 # workers needed in month 2 = $\dfrac{\text{4440 hr/mo}}{\dfrac{\text{160 hr/mo}}{\text{1 worker}}}$ **~ 28 workers**

Chase Approach (with hiring & firing, no overtime)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	1,600	4,440	6,300	7,100	4,020	2,700
EI	0	0	0	0	0	0
Hire						
Fire	18					
Empl.	10	28				
Hiring$						
Firing$	14,400					
Wage$	19,200					
Inv$	0					
Total$	33,600					
Cum$	33,600					

but we only have 10

= 28 workers

= $53,760

Chase Approach (with hiring & firing, no overtime)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	1,600	4,440	6,300	7,100	4,020	2,700
EI	0	0	0	0	0	0
Hire		18				
Fire	18					
Empl.	10	28				
Hiring$		9,000				
Firing$	14,400					
Wage$	19,200	53,760				
Inv$	0	0				
Total$	33,600	62,760				
Cum$	33,600	96,360				

but we only have 28

 # workers needed in month 3 = $\frac{\text{6300 hr/mo}}{\frac{\text{160 hr/mo}}{\text{1 worker}}}$ **~ 40 workers**

= 40 workers

= $76,800

Again, this process continues for each period…

Chase Approach (with hiring & firing, no overtime)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
Prod.	1,600	4,440	6,300	7,100	4,020	2,700
EI	0	0	0	0	0	0
Hire		18	12	5		
Fire	18					
Empl.	10	28	40	45		
Hiring$		9,000	6,000	2,500		
Firing$						
Wage$	19,200	53,760	76,800	86,400		
Inv$	0	0	0	0		
Total$	33,600	62,760	82,800	88,900		
Cum$	33,600	96,360	179,160	268,060		

Three General Strategic Plans

How to meet changes in demand

1. Level
   - constant workforce/production level
   - fluctuating inventory levels
2. Chase
   - production and manpower fluctuate
3. Stable Workforce
   - size of workforce is constant
   - number of hours worked fluctuates

Stable Workforce – Variable Hours

OT wage = 1.5 x regular wage

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Now, instead of just regular production we can have…

Stable Workforce – Variable Hours

OT wage = 1.5 x regular wage

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2.400	4.440	6.300	7.100	4.020	2.700
RT Prod.						
OT Prod.						
EI	0	0	0	0	0	0

Stable workforce = 28 employees
Regular work hours per month per employee = 160 hr

Maximum regular time production per month = 28 x 160 = 4480

Stable Workforce – Variable Hours

OT wage = 1.5 x regular wage

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
RT Prod.	1,600	4,440	4,480	4,480	4,020	2,700
OT Prod.			1,820	2,620		
EI	0	0	0	0	0	0
Empl.	28	28	28	28	28	28
Hiring$						
Firing$						
RTWage$	19,200	53,280				
OTWage$						
Inv$						
Total$						
Cum$						

Again, this process continues for each period…

= 1600 labor-hr x $12/hr

= 1820 labor-hr x ($12/hr x 1.5)

Stable Workforce – Variable Hours

OT wage = 1.5 x regular wage

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
RT Prod.	1,600	4,440	4,480	4,480	4,020	2,700
OT Prod.			1,820	2,620		
EI	0	0	0	0	0	0
Empl.	28	28	28	28	28	28
Hiring$						
Firing$						
RTWage$	19,200	53,280	53,760	53,760		
OTWage$			32,760	47,160		
Inv$	0	0	0	0		
Total$	19,200	53,280	86,520	100,920		
Cum$	19,200	72,480	159,000	259,920		

Stable Workforce – Variable Hours (mandatory 40 hours)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Stable Workforce – Variable Hours (mandatory 40 hours)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
RT Prod.	1,600	4,440	4,480	4,480	4,020	2,700
OT Prod.			1,820	2,620		
EI	0	0	0	0	0	0
Empl.	28	28	28	28	28	28
Hiring$						
Firing$						
RTWage$	$53,760					
OTWage$						
Inv$						
Total$						

Regular Time pay = **28 workers**

Now we need to pay each worker for a 40 hour work week (regardless of time worked) plus any overtime

Stable Workforce – Variable Hours (mandatory 40 hours)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
RT Prod.	1,600	4,440	4,480	4,480	4,020	2,700
OT Prod.			1,820	2,620		
EI	0	0	0	0	0	0
Empl.	28	28	28	28	28	28
Hiring$						
Firing$						
RTWage$	53,760	53,760	53,760	53,760	53,760	53,760
OTWage$			32,760	47,160		
Inv$	0	0	0	0	0	0
Total$	53,760	53,760			53,760	53,760
Cum$						

Stable Workforce – Variable Hours (mandatory 40 hours)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
RT Prod.	1,600	4,440	4,480	4,480	4,020	2,700
OT Prod.			1,820	2,620		
EI	0	0	0	0	0	0
Empl.	28	28	28	28	28	28
Hiring$						
Firing$						
RTWage$	53,760	53,760	53,760	53,760	53,760	53,760
OTWage$			32,760	47,160		
Inv$	0	0	0	0	0	0
Total$	53,760	53,760	86,520	100,920	53,760	53,760
Cum$	53,760	107,520	194,040	294,960	348,720	402,480

Stable Workforce – Variable Hours (mandatory 40 hours)

Starting employment:	28
Work hours per month:	160
Hiring cost:	$500
Firing cost:	$800
Hourly wage:	$12
Holding cost (/labor-hr/mo):	$4

Month	1	2	3	4	5	6
BI	800	0	0	0	0	0
Demand	2,400	4,440	6,300	7,100	4,020	2,700
RT Prod.	1,600	4,440	4,480	4,480	4,020	2,700
OT Prod.			1,820	2,620		
EI	0	0	0	0	0	0
Empl.	28	28	28	28	28	28
Hiring$						
Firing$						
RTWage$	53,760	53,760	53,760	53,760	53,760	53,760
OTWage$			32,760	47,160		
Inv$	0	0	0	0	0	0
Total$	53,760	53,760	86,520	100,920	53,760	53,760
Cum$	53,760	107,520	194,040	294,960	348,720	402,480

Summary

- Aggregate Planning Definition
- Options for Influencing Demand / Supply
- Iterative Nature of Planning
- Cost Factors
- Sales an Operations Planning in Service Environments
- Production Strategies