CHAPTER 8
SALES AND OPERATIONS PLANNING

Discussion Questions

1. What are the basic controllable variables of a production planning problem? What are the four major costs?

   Basic controllable variables: production rate, work force levels, and inventories.

   Major costs: production costs (fixed and variable), production rate change costs, inventory holding costs, and backlog costs.

2. Distinguish between pure and mixed strategies in production planning.

   Pure strategies use only one variable to absorb demand fluctuations. Mixed strategies combine variables from two or more pure strategies.

3. What are the major differences between aggregate planning in manufacturing and aggregate planning in services?

   There are two main differences. One is that services typically need to be provided when demanded – there are not many opportunities for backorders in a service firm. When demand cannot be met, the typical result is lost sales. The second difference compounds that problem: services cannot be inventoried during slow periods to satisfy demand during peak periods. Capacity in excess of demand in any period is almost always wasted capacity, unlike in manufacturing.

4. How does forecast accuracy relate, in general, to the practical application of the aggregate planning models discussed in the chapter?

   A highly accurate forecast encourages the use of deterministic techniques such as linear programming which in turn permits the development of near optimal plans. Clearly, though, any reduction in uncertainty enhances the likely accuracy of any production planning method.

5. In what way does the time horizon chosen for an aggregate plan determine whether it is the best plan for the firm?

   Many factors affect the selection of an appropriate time horizon. Perhaps, the most important is what the firm intends to plan during that time period. An aggregate plan implies a period of up to 18 months wherein the firm takes its forecast and plans production using inventory, work force size, overtime and under time, subcontracting, and backlogging orders to achieve a reasonable schedule at reasonable costs. A very stable firm in a very stable environment with a very stable demand really doesn't need to go out very far with its aggregate plan. However, when there is variation, especially when this variation is considerable, then a longer aggregate plan will show the need to find subcontractors, new workforce availability, etc. Planning for these can start early.

6. Define yield management. How does it differ from the pure strategies in production planning?

   Yield management is the process of allocating capacity in a fixed-capacity system to customers at the right price and time to maximize revenue. In practice it is a variable pricing model that reduces prices for time periods when demand is low and excess capacity exists, and increases prices for time periods when demand is high and there is limited capacity remaining. It works best for systems where capacity is essentially fixed due to the high cost of the system structure, variable costs are low, inventory is perishable, and the product can be sold in advance. There are several examples in the travel industry: airlines, hotels, and car rentals among others.

   This approach is different from the pure strategies in a number of ways. Product cannot be inventoried, so a level approach is infeasible. There is a strict capacity limit in the system (number of seats, number of rooms, number of cars, etc.) that cannot be temporarily increased by adding workers, working overtime, or subcontracting, so a pure chase strategy would not work. Also, yield management includes active efforts to manage demand and revenue in a dynamic manner, where the pure strategies are designed to simply react to forecasted demand.

7. How would you apply yield management concepts to a barbershop? A soft drink vending machine?

   The first step would be to determine when peak and off-peak times existed. For the barbershop, lower prices could be given during off-peak times. For example, price discounts could be given during days of the week, or times of the day when demand is low. Another approach would be to offer a discount and an appointment to people that walk-in during peak times, thus transferring them to an off-peak time.

   Hopefully, lack of capacity would not be a problem for a vending machine, so reallocating peak demand should not be an issue. But, trying to increase usage during non-peak times is difficult because most vending machine can charge only one price. However, new technology could allow the prices to be changed based on time of day, or even the day of the week. Therefore, during off-peak times, a lower price could be charged to stimulate sales.

Objective Questions

1. Major operations and supply planning activities can be grouped into categories based on the relevant time range of the activity. What time range category does sales and operations planning fit into?

    Medium range

2. What category of planning covers a period from a day to six months, with daily or weekly time increments?

    Short range planning

3. In the agriculture industry, migrant workers are commonly employed to pick crops ready for harvest. They are hired as needed and are laid off once the crops are picked. This approach is made necessary by the realities of the industry. Which production planning strategy would this best be an example of?

    Chase strategy

4. What is the term for a more complex production strategy that combines approaches from more than one basis strategy?

    Mixed strategy

5. List at least three of the four costs relevant to the aggregate production plan.

    Basic production costs, costs associated with changes in the production rate, inventory holding costs, backordering costs

6. Which of the four costs relevant to aggregate production planning is the most difficult to accurately measure?

    Backordering costs

7. Develop a production plan and calculate the annual cost for a firm whose demand forecast is fall, 10,000; winter, 8,000; spring, 7,000; summer, 12,000. Inventory at the beginning of fall is 500 units. At the beginning of fall you currently have 30 workers, but you plan to hire temporary workers at the beginning of summer and lay them off at the end of summer. In addition, you have negotiated with the union an option to use the regular workforce on overtime during winter or spring if overtime is necessary to prevent stockouts at the end of those quarters. Overtime is not available during the fall. Relevant costs are hiring, $100 for each temp; layoff, $200 for each worker laid off; inventory holding, $5 per unit-quarter; backorder, $10 per unit; straight time, $5 per hour; overtime, $8 per hour. Assume that the productivity is 0.5 unit per worker hour, with eight hours per day and 60 days per season.

	Fall	Winter	Spring	Summer
Forecast	10000	8000	7000	12000
Beginning inventory	500	-2300	0	200
Production required	9500	10300	7000	11800
Production hours required	19000	20600	14000	23600
Production hours available[1]	14400	14400	14400	14400
Overtime hours		6200		
Temp workers[2]				20
Temp worker hours available				9600
Total hours available	14400	20600	14400	24000
Actual production	7200	10300	7200	12000
Ending inventory	-2300	0	200	200
Workers hired				20
Workers laid off				20
Straight time	$72,000	$72,000	$72,000	$120,000
Overtime	0	49600	0	0
Inventory			$1,000	$1,000
Backorder	$23,000			
Hiring				$2,000
Layoff				$4,000
Total	$95,000	$121,600	$73,000	$127,000
				$416,600

[1]30 workers*8 hours*60 days

[2]Temp workers to be hired = (23,600-14400)/(8*60) = 19.17 ≈ 20 workers

8. Plan production for a four-month period: February through May. For February and March, you should produce to exact demand forecast. For April and May, you should use overtime and inventory with a stable workforce; stable means that the number of workers needed for March will be held constant through May. However, government constraints put a maximum of 5,000 hours of overtime labor per month in April and May (zero overtime in February and March). If demand exceeds supply, then backorders occur. There are 100 workers on January 31. You are given the following demand forecast: February, 80,000; March, 64,000; April, 100,000; May, 40,000. Productivity is four units per worker hour, eight hours per day, 20 days per month. Assume zero inventory on February 1. Costs are hiring, $50 per new worker; layoff, $70 per worker laid off; inventory holding, $10 per unit-month; straight-time labor, $10 per hour; overtime, $15 per hour; backorder, $20 per unit. Find the total cost of this plan.

	February	March	April	May
Forecast	80,000	64,000	100,000	40,000
Beginning inventory	-	-	-	(16,000)
Production required	80,000	64,000	100,000	56,000
Production hours required	20,000	16,000	25,000	14,000
Regular workforce	125	100	100	100
Regular production	80,000	64,000	64,000	64,000
Overtime hours	-	-	5,000	
Overtime production	-	-	20,000	-
Total production	80,000	64,000	84,000	64,000
Ending inventory	-	-	-	8,000
Ending backorders	-	-	16,000	-
Workers hired	25			
Workers laid off	-	25		
Straight time	$200,000	$160,000	$160,000	$160,000
Overtime	-	-	$ 75,000	-
Inventory	-	-	-	80,000
Backorder	$0	$0	$320,000	$0
Hiring	1,250	-	-	-
Layoff	-	1,750	-	-
Total	$201,250	$161,750	$555,000	$240,000
				$1,158,000

9. Plan production for the next year. The demand forecast is spring, 20,000; summer, 10,000; fall, 15,000; winter, 18,000. At the beginning of spring you have 70 workers and 1,000 units in inventory. The union contract specifies that you may lay off workers only once a year, at the beginning of summer. Also, you may hire new workers only at the end of summer to begin regular work in the fall. The number of workers laid off at the beginning of summer and the number hired at the end of summer should result in planned production levels for summer and fall that equal the demand forecasts for summer and fall, respectively. If demand exceeds supply, use overtime in spring only, which means that backorders could occur in winter. You are given these costs: hiring, $100 per new worker; layoff, $200 per worker laid off; holding, $20 per unit-quarter; backorder cost, $8 per unit; straight-time labor, $10 per hour; overtime, $15 per hour. Productivity is 0.5 unit per worker hour, eight hours per day, 50 days per quarter. Find the total cost.

	Spring	Summer	Fall	Winter
Forecast	20,000	10,000	15,000	18,000
Beginning inventory	1,000	-	-	-
Production required	19,000	10,000	15,000	18,000
Production hours required	38,000	20,000	30,000	36,000
Regular workforce	70	50	75	75
Regular production	14,000	10,000	15,000	15,000
Overtime hours	10,000	-	-	
Overtime production	5,000	-	-	-
Total production	19,000	10,000	15,000	15,000
Ending inventory	-	-	-	-
Ending backorders	-	-	-	3,000
Workers hired	-		25	
Workers laid off	-	20		
Straight time	$280,000	$200,000	$300,000	$300,000
Overtime	150,000	-	-	-
Inventory	-	-	-	-
Backorder	$0	$0	$0	$24,000
Hiring	-	-	2,500	-
Layoff	-	4,000	-	-
Total	$430,000	$204,000	$302,500	$324,000
				$1,260,500

10. DAT, Inc., needs to develop an aggregate plan for its product line. Relevant data are:

Production time	1 hour per unit	Beginning inventory	500 units
Average labor cost	$10 per hour	Safety stock	One-half month
Workweek	5 days, 8 hours each day	Shortage cost	$20 per unit per month
Days per month	Assume 20 workdays per month	Carrying cost	$5 per unit per month

The forecast for next year is

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2,500	3,000	4,000	3,500	3,500	3,000	3,000	4,000	4,000	4,000	3,000	3,000

Management prefers to keep a constant workforce and production level, absorbing variations in demand through inventory excesses and shortages. Demand not met is carried over to the following month. Develop an aggregate plan that will meet the demand and other conditions of the problem. Do not try to find the optimum; just find a good solution and state the procedure you might use to test for a better solution. Make any necessary assumptions.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
Forecast	2500	3000	4000	3500	3500	3000	3000	4000	4000	4000	3000	3000	
Beginning inventory	500	1250	1500	2000	1750	1750	1500	1500	2000	2000	2000	1500	
Production requirements	3250	3250	4500	3250	3500	2750	3000	4500	4000	4000	2500	3000	3458.3
Ending inventory	1250	1500	2000	1750	1750	1500	1500	2000	2000	2000	1500	1500	

													Total	Cost
Forecast	2500	3000	4000	3500	3500	3000	3000	4000	4000	4000	3000	3000	40500	
Beginning inventory	500	1360	1720	1080	940	800	1160	1520	880	240	-400	-40		
Production plan	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	40320	$403,200
Ending inventory	1360	1720	1080	940	800	1160	1520	880	240	-400	-40	320		
Safety stock	1250	1500	2000	1750	1750	1500	1500	2000	2000	2000	1500	1500		
Excess inventory	110	220					20						350	$1,750
Back order										400	40		440	$8,800
													Total	$413,750

This plan uses a workforce of 21 workers. Assumptions include no carrying cost for inventory used to satisfy safety stock, nor any cost for not having enough safety stock to satisfy company policy. Costs would vary under different assumptions.

Next, try increasing or decreasing the number of workers by one, and recalculate the total cost. A better solution may be found.

11. Old Pueblo Engineering Contractors creates six-month “rolling” schedules, which are recomputed monthly. For competitive reasons (it would need to divulge proprietary design criteria, methods, and so on), Old Pueblo does not subcontract. Therefore, its only options to meet customer requirements are (1) work on regular time; (2) work on overtime, which is limited to 30 percent of regular time; (3) do customers’ work early, which would cost an additional $5 per hour per month; and (4) perform customers’ work late, which would cost an additional $10 per hour per month penalty, as provided by their contract.
Old Pueblo has 25 engineers on its staff at an hourly rate of $30. The overtime rate is $45. Customers’ hourly requirements for the six months from January to June are:

January	February	March	April	May	June
5,000	4,000	6,000	6,000	5,000	4,000

Develop an aggregate plan using a spreadsheet. Assume 20 working days in each month.

There is more than one solution. The following solution assumes no backordered work at the end of the plan.

	January	February	March	April	May	June
Forecast work hours	5,000	4,000	6,000	6,000	5000	4,000
Beginning inventory (work done earlier)		200	1,400	600	(200)	-
Work hours required	5,000	3,800	4,600	5,400	5,200	4,000
Regular work hours available	4,000	4,000	4,000	4,000	4,000	4,000
Overtime hours	1,200	1,200	1,200	1,200	1200	-
Total planned hours	5,200	5,200	5,200	5,200	5,200	4,000
Ending inventory (early work completed)	200	1,400	600	-		
Ending backorders (work to be done later)	-	-	-	200	-	-
Straight time	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000
Overtime	54,000	54,000	54,000	54,000	54,000	-
Inventory	1,000	7,000	3,000	-	-	-
Backorder	$0	$0	$0	$2,000	$0	$0
Total	$175,000	$181,000	$177,000	$176,000	$174,000	$120,000
						$1,003,000

Allowing backordered work at the end of the plan can reduce the cost but will leave work to be done in the second half of the year. Following allows up to 500 hours backordered work.

	January	February	March	April	May	June
Forecast work hours	5,000	4,000	6,000	6,000	5000	4,000
Beginning inventory (work done earlier)		(0)	1,200	400	(400)	(500)
Work hours required	5,000	4,000	4,800	5,600	5,400	4,500
Regular work hours available	4,000	4,000	4,000	4,000	4,000	4,000
Overtime hours	1,000	1,200	1,200	1,200	900	-
Total planned hours	5,000	5,200	5,200	5,200	4,900	4,000
Ending inventory (early work completed)	-	1,200	400	-		
Ending backorders (work to be done later)	0	-	-	400	500	500
Straight time	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000
Overtime	45,000	54,000	54,000	54,000	40,500	-
Inventory	-	6,000	2,000	-	-	-
Backorder	$0	$0	$0	$4,000	$5,000	$5,000
Total	$165,000	$180,000	$176,000	$178,000	$165,500	$125,000
						$989,500

12. Alan Industries is expanding its product line to include three new products: A, B, and C. These are to be produced on the same production equipment, and the objective is to meet the demands for the three products using overtime where necessary. The demand forecast for the next four months, in hours required to make each product, is:

Product	April	May	June	July
A	800	600	800	1,200
B	600	700	900	1,100
C	700	500	700	850

Because the products deteriorate rapidly, there is a high loss in quality and, consequently, a high carrying cost when a product is made and carried in inventory to meet future demand. Each hour's production carried into future months costs $3 per production hour for A, $4 for Model B, and $5 for Model C.

Production can take place either during regular working hours or during overtime. Regular time is paid at $4 when working on A, $5 for B, and $6 for C. The overtime premium is 50 percent of the regular time cost per hour.

The number of production hours available for regular time and overtime is

	April	May	June	July
Regular time	1,500	1,300	1,800	2,000
Overtime	700	650	900	1,000

Set up the problem in a spreadsheet and an optimal solution using the Excel Solver. Appendix A describes how to use the Excel Solver.

The decision variables are how many regular and OT hours to assign to production of each product each month. The constraints are the limits of total regular and OT hours each month, and no backorders. The costs are a combination of production and inventory carrying costs. Solution is shown on the following page.

	APRIL	MAY	JUNE	JULY	
Demand A	800	600	800	1,200	
Demand B	600	700	900	1,100	
Demand C	700	500	700	850	
Total Demand	2,100	1,800	2,400	3,150	
Regular hours Available	1,500	1,300	1,800	2,000	
Overtime Available	700	650	900	1,000	Costs
Regular Hours A	200	100	200	50	4
Regular Hours B	600	700	900	1,100	5
Regular Hours C	700	500	700	850	6
Total Regular Hours	1,500	1,300	1,800	2,000	
OT Hours A	600	500	750	1,000	6
OT Hours B	0	0	0	0	7.5
OT Hours C	0	0	0	0	9
Total OT Hours	600	500	750	1,000	
Total Hours A	800	600	950	1,050	
Total Hours B	600	700	900	1,100	
Total Hours C	700	500	700	850	
Excess Hours A	0	0	150	0	3
Excess Hours B	0	0	0	0	4
Excess Hours C	0	0	0	0	5

Production Costs	11,600	9,900	14,000	16,800	
Inventory Costs	0	0	450	0	
				TOTAL COST:	52,750

Objective value = $52,750. There may be alternative optimal solutions.

13. Shoney Video Concepts produces a line of video streaming servers that are linked to personal computers for storing movies. These devices have very fast access and large storage capacity. Shoney is trying to determine a production plan for the next 12 months. The main criterion for this plan is that the employment level is to be held constant over the period. Shoney is continuing in its R&D efforts to develop new applications and prefers not to cause any adverse feelings with the local workforce. For the same reason, all employees should put in full workweeks, even if that is not the lowest-cost alternative. The forecast for the next 12 months is:

Month	Forecast Demand	Month	Forecast Demand
January	600	July	200
February	800	August	200
March	900	September	300
April	600	October	700
May	400	November	800
June	300	December	900

Manufacturing cost is $200 per server, equally divided between materials and labor. Inventory storage cost is $5 per month. A shortage of servers results in lost sales and is estimated to cost an overall $20 per unit short.

The inventory on hand at the beginning of the planning period is 200 units. Ten labor hours are required per server. The workday is eight hours.

Develop an aggregate production schedule for the year using a constant workforce. For simplicity, assume 22 working days each month except July, when the plant closes down for three weeks' vacation (leaving seven working days). Assume that total production capacity is greater than or equal to total demand.

*Number of workers = (6700-200)10/(249*8) = 32.6 or 33 workers*

Monthly production (except July) = 22(8)33/10 = 580 units/month

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total
Forecast	600	800	900	600	400	300	200	200	300	700	800	900	6700
Beginning inventory	200	180	0	0	0	180	460	444	824	1104	984	764	
Available Production	580	580	580	580	580	580	184	580	580	580	580	580	6564
Ending inventory	180	-40	-320	-20	180	460	444	824	1104	984	764	444	
Costs													Total
Lost Sales	0	800	6400	400	0	0	0	0	0	0	0	0	7600
Inventory	900	0	0	0	900	2300	2220	4120	5520	4920	3820	2220	26920
Total	900	800	6400	400	900	2300	2220	4120	5520	4920	3820	2220	34520

14. Develop a production schedule to produce the exact production requirements by varying the workforce size for the following problem. Use the example in the chapter as a guide (Plan 1).
The monthly forecasts for Product X for January, February, and March are 1,000, 1,500, and 1,200, respectively. Safety stock policy recommends that half of the forecast for that month be defined as safety stock. There are 22 working days in January, 19 in February, and 21 in March. Beginning inventory is 500 units.
Manufacturing cost is $200 per unit, storage cost is $3 per unit per month, standard pay rate is $6 per hour, overtime rate is $9 per hour, cost of stockout is $10 per unit per month, marginal cost of subcontracting is $10 per unit, hiring and training cost is $200 per worker, layoff cost is $300 per worker, and worker productivity is 0.1 unit per hour.
Assume that you start off with 50 workers and that they work 8 hours per day.

The following solution assumes no backorders, and includes safety stock in inventory cost calculations.

	January	February	March
Forecast	1,000	1,500	1,200
Safety stock	500	750	600
Beginning inventory	500	503	751
Net production required	1,000	1,747	1,049
Workers required	57	115	63
Hired	7	58	
Laid off			52
Actual production	1,003	1,748	1,058
Ending inventory	503	751	609
Labor	$60,192	$104,880	$63,504
Inventory	$ 1,509	$ 2,253	$ 1,827
Hiring	$ 1,400	$ 11,600	$ -
Layoff	$0	$0	$15,600
Total	$63,101	$118,733	$80,931
		Total:	**$262,765**

15. Helter Industries, a company that produces a line of women's bathing suits, hires temporaries to help produce its summer product demand. For the current four-month rolling schedule, there are three temps on staff and 12 full-time employees. The temps can be hired when needed and can be used as needed, whereas the full-time employees must be paid whether they are needed or not. Each full-time employee can produce 205 suits, while each part-time employee can produce 165 suits per month.

    Demand for bathing suits for the next four months is as follows:

MAY	JUNE	JULY	AUGUST
3,200	2,800	3,100	3,000

    Beginning inventory in May is 403 complete (a complete two-piece includes both top and bottom) bathing suits. Bathing suits cost $40 to produce and carrying cost is 24 percent per year.

    Develop an aggregate plan that uses the 12 full-time employees each month and a minimum number of temporary employees. Assume that all employees will produce at their full potential each month. Calculate the inventory carrying cost associated with your plan using planned end of month levels.

The following plan assumes no backorders. The only cost data provided is for inventory carrying costs. The 24% per year works out to 2% per month based on the $40 cost per unit, or $0.80 per unit per month.

	May	June	July	August
Forecast	3200	2,800	3,100	3,000
Beginning inventory	403	158	148	3
Production required	2,797	2,642	2,952	2,997
Regular workforce	12	12	12	12
Regular production	2,460	2,460	2,460	2,460
Temp workforce	3	2	3	4
Temp production	495	330	495	660
Total production	2,955	2,790	2,955	3,120
Ending inventory	158	148	3	123
Inventory Cost	$126.40	$118.40	$2.40	$98.40
				$345.60

16. The widespread scientific application of yield management began within what industry?

    Airline

17. Under what type of demand is yield management most effective?

    Highly variable

18. In a yield management system, pricing differences must appear logical and justified to the customer. The basis for this justification is commonly called what?

    Rate fences

19. The essence of yield management is the ability to manage what?

    Demand

ANALYTICS EXERCISE: Bradford Manufacturing

This exercise can be left as a homework exercise or used as a teaching case. A solution to the problem is shown in the plan below. Afterwards, teaching notes for use as a case are presented.

Aggregate Plan	**Quarter (Week Numbers)**			
	1st (1-13)	**2nd (14-26)**	**3rd (27-39)**	**4th (40-52)**
Lines run	10	10	12	11
Overtime hours per day	0	0	0	0
Beginning Inventory	200.0	393.8	387.5	520.0
Production	2,193.8	2,193.8	2,632.5	2,413.1
Expected Demand	2,000.0	2,200.0	2,500.0	2,650.0
Ending Inventory	393.8	387.5	520.0	283.1
Ending Inventory Target (Rounded)	338	385	408	338
Deviation from Inventory Target	55.8	2.5	112.0	-54.9
Employees	60	60	72	66
Cost of Plan				
Labor Regular Time	$624,000	$624,000	$748,800	$686,400
Labor Overtime				
Hiring and Training	$0	$0	$60,000	$0
Layoff	$0	$0	$0	$18,000
Inventory Carry Cost	$13,950	$650	$28,025	$0
Stockout Cost	$0	$0	$0	$32,880
Quarter Budget	$637,950	$624,650	$836,825	$737,280
			Total Cost of Plan	$2,836,705

The plan above is from the Excel spreadsheet at the book website, and is just one possible solution. It is based on the following assumptions:

- Inventory carrying costs are based on ending quarterly inventory in excess of safety stock. Quarterly carrying cost is $0.25 per case, or $250 per 1,000 cases.
- Backorder costs are incurred on negative deviation from planned safety stock, even though total inventory may be positive.
- Overtime is planned in hours per day across an entire quarter. A more reasonable approach might be to plan on overtime-weeks in a quarter (integer constraint, <= 26).

A discussion of the students' approach to the problem, including any assumptions made would be a worthwhile exercise.

Teaching Note

This is a case that is designed to give the student experience with developing an aggregate plan. A follow up in-class simulation exercise can also be done with the students. The simulation involves the operation of the plant over the first 13 to 20 weeks of the year. The simulation allows students to experience the problems associated with implementing an aggregate plan.

Assign the case as a homework assignment. The student should be instructed to develop an aggregate plan. Remind them to use the spreadsheet named "Bradford Manufacturing" from the CD. You might want to take 10 minutes in the class prior to the day when you plan to do the simulation exercise to quickly familiarize students with the spreadsheet.

Remind students to bring a printout of their aggregate plan to class and to bring their notebook computer, if they have one.

Start the class by asking about their aggregate plans. Generate a range of costs that students obtained on the board.

Next, ask students to describe how they obtained their solution to the problem. Try to characterize the different approaches. Some likely categories would be "Trial and Error", "A simple heuristic", and "Excel Solver".

Following this, the spreadsheet can be brought up and some of the better solutions displayed. You can also run the Solver if you like at this time. You may need to "unprotect" the spreadsheet to run the Solver (Tools > Protection > Unprotect). Finish this section by putting a solution in the Aggregate Plan portion of the spreadsheet that seems to be a good one.

Now move to the Simulation Worksheet part of the spreadsheet. Here the plan has been reorganized into a weekly master schedule with the data from the Aggregate Plan initially seeding the schedule. The idea is to now work through the weekly schedule by putting in what actually happened in terms of sales and production rates. After seeing the data each week, students should be given the opportunity to change next week's schedule. You should do this for at least the first 13 weeks. Then you can click on the Actual Costs worksheet and compare the budgeted cost to the actual cost of running the plant.

To make the simulation interesting use actual demand that demonstrates the old "hockey stick" phenomenon. Sales should be real slow at the beginning of the quarter and then surge at the end. Remember there is a sale at the end of the 1st quarter. Try to be real straight when you go from week to week and don't hint at the fact that demand will take off at the end. This can be a good lesson for the student.

The following are a set of production rates and demand that work well:

Week	Production Rate	Demand	Week	Production Rate	Demand
1	423	140	11	465	112
2	455	120	12	450	200
3	430	100	13	455	450
4	435	125	14	450	160
5	435	125	15	430	165
6	460	105	16	450	160
7	465	115	17	455	145
8	470	120	18	470	150
9	455	105	19	460	155
10	460	110	20	455	160

You can complete the exercise by discussing the following items:

- Why did demand vary the way it did during the first quarter?
- Why is it important for manufacturing and marketing to coordinate plans?
- What types of things can marketing do to make it easier on manufacturing? (Separate the deals from the deliveries. Everyday low pricing, etc.)
- Do you think that management should change their inventory target?

Teaching Plan for a Class using Bradford Manufacturing

Explain how Aggregate Planning fits into the overall process of Planning and Control – show chart.

What is Aggregate Planning?
- Setting workforce levels
- Aggregate inventory levels
- Production rate
- 6-18 month horizon
- Product groups – rather than individual products

A strategy for how demand will be met, given current resource constraints.

Why is Aggregate Planning important?
- Key interface to the capital budgeting process

10 minutes into the class
Bradford Manufacturing
- What are the key drivers of this plan?

Forecast -> Marketing/Market Research
Ending Inventory Target -> Management
Technical Parameters – define current resource constraints and costs.
- Evaluate the costs associated with the current plan.

Develop a solver plan. Rationalize the plan. – Integerize

30 minutes into class
- Two basic strategies – chase demand or level demand (use inventory)
- Put a high hiring and firing cost into the solution and generate a level plan. Use hiring and training cost of $15,000 and layoff cost of $5,000.

35 Minutes into class
- Explain the relationship between the Aggregate Plan and the Master Schedule

Run the simulation (takes about 40 minutes)
Conditions

Inventory target – 1 week
Hiring/training = $5,000
Layoff cost = $3,000

Initial inventory = 200(000) units

Offer prize!

First, each student (or pair of students) needs to finalize an Aggregate Plan, and then move to the simulation worksheet. Make sure initial inventory is set correctly. Show actual cost worksheet. Run simulation per the previous instructions.