3

PLANNING AND CONTROL

Offering desirable customer service at a reasonable cost requires an efficient flow of materials and services while simultaneously managing the organization's resources that direct and transform these flows. Effective planning and coordination ensures that all resources required to deliver services or produce goods are available in the right quantity and quality at the right time. Such planning and coordination, however, is often very complex. For example, a typical manufacturer is required to track hundreds or thousands of raw materials, components, and subassemblies for effective production. In a similar way, a service provider must ensure the appropriate employees and range of necessary materials are available to fill the needs of multiple market segments, often on very short notice. Effective internal planning and control represents the fundamental "block and tackling" underlying an organization's efficient and effective operations.

Operations planning and control is the second of the foundational blocks that contribute to the management of broader operational systems (see Figure 3.1). Forecasting customer demand based on a wide range of business factors is one critical input. Planning for operations then must cover both the long-term planning horizon for overall capacity and process-related resources, such as facilities, equipment, and personnel, as well as detailed schedules to match these to customer needs. And once plans are in place, management must actively control the use of resources to meet customer demands and against budgets.

In practice, planning and control is a multistage process, often with iteration to refine the development or acquisition of particular resources (see Figure 3.2) (Vollmann, Berry, & Whybark, 1992). Although long-term forecasts and plans can stretch out over a number of years, a great deal of management attention is often focused on some form of annual plan. The medium-term, annual plan is then further broken down into detailed, short-term schedules for specific customer orders, equipment, and employees.

DEMAND MANAGEMENT

A critical input for much of the planning process is the challenge of forecasting customer demand. It is a difficult task because the demand for goods and services can vary greatly from year to year, month to month, and even hour to hour. For example, customer demand

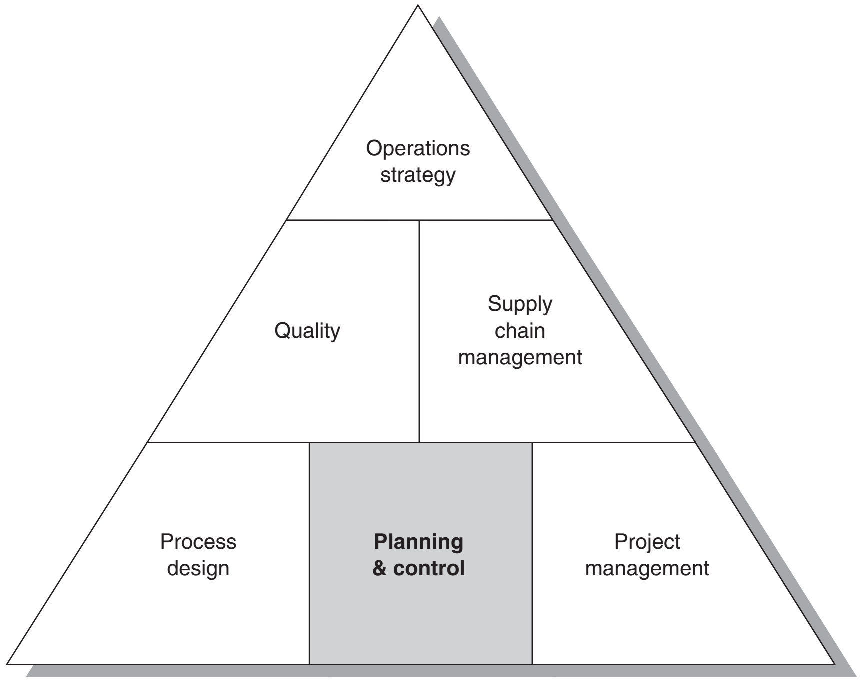

Figure 3.1 Operations Planning and Control

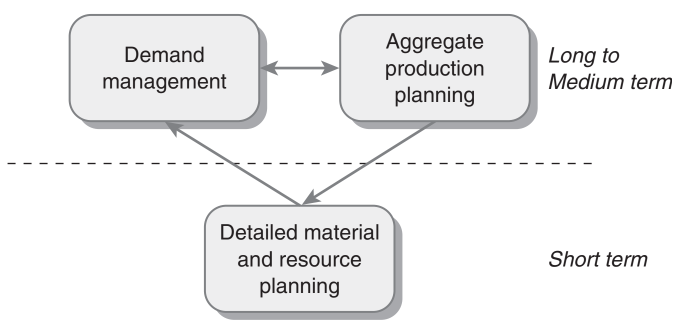

Figure 3.2 Basic Components of Planning and Control Systems

for snow skis predictably increases in the autumn and early winter months; however, the particular demand in any particular region of the country varies to some extent based on the snowfall experienced.

Sometimes, changes in demand are reasonably predictable. For example, in the fast-food industry, customer purchases are likely to be highest on days late in the week, such as Friday or Saturday. Moreover, demand at mealtime also routinely exceeds that during mid-afternoon. However, even here, it is much harder to predict how particular dietary factors, such as low-carbohydrate diets and food scares, affect overall demand for fast-food from year to year. These large-scale trends, combined with the actions of competitors, our own new product introductions, and other process changes, only add to the complexity of forecasting. A number of these issues are central to the Greaves Brewery case.

For short-term fluctuations in demand, managers might be tempted to simply respond to this variability by rescheduling resources. However, in many situations, proactive actions can be taken to either encourage or attenuate demand. Customer buying patterns can also be shifted through prices or waiting time information, thereby smoothing demand. Reservation systems, promotional marketing, and price increases all affect both timing and quantity of demand. For example, as we experience firsthand in the American Airlines case, adjusting price as time passes can help to better match demand with available capacity.

Aggregate Planning

Given the anticipated demand and overall capacity levels, management develops an aggregate plan for its resources, which is a formal document describing future production rates, workforce levels, and inventory holdings, if any. An aggregate plan is developed before detailed material and resource plans, as it provides the general direction of the organization over the longer term, and it is usually more accurate to develop a forecast for a group of product lines rather than for individual goods or services. Thus, the aggregated plan offers projections for several periods, often with a time horizon extending up to a year.

A manufacturing firm's aggregate plan, called a production plan, generally focuses on production rates and inventory holdings, whereas a service firm's aggregate plan, called a staffing plan, centers on staffing and other labor-related factors. Clearly, holding inventory may not be possible if the customer is the item being served within operations, and so a flexible workforce, material delivery, or facility configuration may be essential. For example, an auto repair center might carry a wide range of parts inventory and have quick distributor delivery and/or flexible employee skill sets to accommodate a diverse array of customer problems and vehicle models—all planned around offering same-day service. For both manufacturing and services, the plan must balance conflicting objectives involving customer service, workforce stability, cost, and profit (Ritzman, Krajewski, & Klassen, 2004).

The cases in this chapter address multiple challenges faced in developing and implementing an aggregate production plan. MacPherson Refrigeration must access the pros and cons of three different alternatives that collectively illustrate the three basic archetype plans available to many manufacturing firms: chase, level, and mixed plans. However, improvement is possible, and any plan must always address multiple objectives that transcend individual functional concerns. In contrast, Lamson Corp. requires you, as the operations manager, to develop, live with, and change a plan for the coming production season. Over the course of 12 decision periods, you are able to see the strengths and weaknesses of your evolving plan, as well as how well your corrective actions performed.

Material and Resource Planning

Materials requirements planning (MRP) and resource (i.e., capacity) planning collectively form the bridge between large-scale, aggregate plans and day-to-day scheduling and fulfillment of particular customer orders. Much of this planning is enabled by the concept of *dependent* demand, where the need for particular items and/or associated resources is exactly related to the production or delivery of a specific final service or end item.

For example, changing and balancing a new set of tires for an automobile at the previously described repair center might require the use of a service bay, 1.5 hours of a mechanic's time, four tires, and four valve stems. If a customer phones several days in advance to make a service appointment, the resources (i.e., mechanic and service bay) can be immediately booked for the needed time, and appropriate-sized tires can be ordered from a distributor. Scheduling the pickup of the used tires for recycling is also possible.

These concepts are developed further in the final two cases in this chapter. Martin Trailers considers both the complications surrounding the development of an aggregate production plan and its translation into materials and resources plans. However, the seasonal nature of the business, multiple product lines, and the necessity of hiring and laying off temporary workers compound the challenge. Illustrious Corp. moves down one level and focuses specifically on developing a detailed, though basic, MRP schedule for a product and a few of its component parts.

In summary, by considering the integration of demand management, aggregate planning, and material and resource planning, managers encounter operational elements that are foundational for the effective and efficient delivery of goods and services.

Greaves Brewery: Bottle Replenishment

Early in 2004, Alex Benson was trying to determine how many returnable beer bottles to purchase in the coming year. During 2003, the market had leveled off, and sales for 2004 were proving very challenging to predict. Moreover, there was a possibility that the bottle's design would change, in which case all bottle supplies would be scrapped. On one hand, Benson wished to be sure sufficient bottles were available to meet this year's sales, yet he also wanted to minimize year-end inventories. Benson needed to forecast beer sales, estimate bottle replenishment needs, and recommend how many bottles to purchase.

Key learning points: application of demand forecasting methodologies, such as moving averages and exponential smoothing, modeling dependent demand, order timing, and order quantities.

Yield Management at American Airlines

American Airlines is a widely cited leader in the development and implementation of yield (or revenue) management practices. This case is based on a training exercise used at American Airlines to introduce managers to their yield management system. You are given the responsibility for a single flight from Dallas–Fort Worth, Texas, to Miami, Florida, and are required to make a series of sequential booking decisions in real time in class. The objective of the exercise is to maximize total revenue for the flight, after taking into account no-shows and penalties.

Key learning points: background theory underpinning yield management, key inputs needed and expected benefits, and linkages between demand forecasting and capacity utilization.

MacPherson Refrigeration Limited

Linda Metzler, newly appointed production planning manager, is drafting an aggregate production plan for the company's refrigerators, freezers, and air conditioners for the next year. She has considered three plans, each of which must be evaluated from both a quantitative and qualitative perspective. In the end, Metzler is unsure of whether she might be missing a better alternative.

Key learning points: identify the key inputs to an aggregate production planning, explore the inputs from and uses by different functions within the organization, and have quantitative approaches for improving the planning process.

Lamson Corporation

This business game puts you in the position of Mr. Marino, who must develop and execute a plan for the coming production season. Your group of 3 to 5 participants must make 12 scheduling decisions under conditions of demand uncertainty, with an opportunity to revise future period plans as the season progresses.

Key learning points: aggregate production planning with uncertain demand, rescheduling, and managing trade-offs between capacity and inventory.

Martin Trailers Limited

Martin Trailers, which is experiencing rapid growth, produces a line of camping trailers, which have a pronounced seasonal sales pattern. Details for the previous year's planning process, staffing levels, production outputs, and costs are being reviewed by the owner, Kim Martin, with the objective of improving the management of materials in the year ahead. Based on this information, Martin is trying to assess how best to plan for the growth predicted for the coming year.

Key learning points: develop an aggregate production plan in a highly uncertain, seasonal industry; understand the impact of productivity; and have a conceptual introduction to materials requirements planning.

Illustrious Corporation

This exercise briefly describes the assembly of a fictional product, X500. You must construct a structured bill of materials and an MRP plan for 10 weeks for a single product, X500, and seven components in four levels. Based on the results of this analysis, you must develop an action plan to deal with any shortcomings.

Key learning points: define bill of materials, work through a basic materials requirements plan (MRP), and understand the managerial inputs for and implications of building and using an MRP system.

Management Questions Addressed in Production Planning and Control Chapter

1. What factors determine the customer demand? Do these factors interact?
2. How might demand forecasts be generated? What are the advantages and disadvantages of each approach?
3. What are the benefits of developing an aggregate plan, from the perspective of operations, marketing, finance, and human resources?
4. How are chase, level, and mixed production plans defined?
5. What are the cost and productivity implications of various approaches to production planning, including chase, level, and mixed production plans?
6. How are inventory and capacity related for production planning purposes?
7. What is a master production schedule (MPS)?
8. What is materials requirements planning (MRP)? How can MRP be used to help improve operations performance?
9. How are operations controlled? What could be done to make planning and control systems more responsive?

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Greaves Brewery: Bottle Replenishment

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Chris Piper

 Version: (A) 2004–10–01

The Bottle Replenishment Decision

Early in 2004, Alex Benson, purchasing manager for Greaves Brewery, Trinidad, was trying to determine how many bottles to purchase in the coming year. During 2003, the market had levelled off, and 2004 sales predictions were difficult. On the one hand, Benson wanted to be sure sufficient bottles were available to supply 2004 sales levels, yet also wanted to minimize year-end inventories. Covered storage space for empty bottles was tight, and a bottle design change seemed possible in 2005 or 2006.

Company Background

Greaves Brewery was located in the southern Caribbean Island of Trinidad. Founded by John Greaves in 1924, the company had established an excellent reputation. Greaves beer had become a favorite with tourists, and as a result, a modest export business to the United States had started in 2000. In February 2004, sales reached the highest level in the company's history. However, in 2003, the sales increase had been well below the trend average (see Exhibits 1 and 2).

Four sales peaks occurred during the year: Carnival,[1] Christmas, Easter and Independence.[2] Carnival was the highest sales period but each peak caused the company to operate on tight schedules and Greaves hired more labor and scheduled extra shifts.

Brewing Process

Beer brewing started with extraction of sugar from malt by an enzymic process. This sugar was then boiled with hops, producing a sterilized and concentrated solution. The resins extracted from the hops during boiling acted as a preservative and gave the beer its bitter flavor. The hops were then removed and the solution was cooled to optimum temperature (10C)[3] for bottom fermentation lasting seven days, during which time the yeast converted the sugar to alcohol and carbon dioxide. After fermentation, the beer was cooled to (−1C) and stored for 10 days (during which time the yeast dropped out) and was then roughly filtered through diatomaceous earth. After 24 hours' storage, the mixture was put through a polish-filtration process. By this time, the beer had been artificially carbonated, ready for bottling. After bottling and case packing, the beer was stored in the finished goods warehouse ready for delivery to retail outlets.

Sales Projections for 2004

Benson had difficulty forecasting sales for 2004, particularly because of the 2003 slump, government excise taxes and other factors such as the number of tourists and U.S. sales.

In November 1997, the government had placed an additional excise tax of $0.60[4] on each case of beer. The company passed this tax on to the consumer, raising the retail price from $9.90 to $10.50 per case, plus a bottle deposit of

Year / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	211	338	191	192	138	148	205	244	164	200	205	229	2,465
2000	244	403	213	244	153	195	231	327	337	247	234	438	3,266
2001	291	386	335	278	159	209	205	364	263	280	282	273	3,325
2002	323	478	327	327	211	342	288	374	304	337	304	357	3,972
2003	328	512	310	346	261	296	394	331	305	305	321	369	4,078
2004	342	535											

Exhibit 1 Monthly Sales January 1999 to February 2004 (in thousands of cases)

Source: Company files.

Year	Annual Sales	"Full Goods"	"Warehouse Empties"	"New Bottle Inventory"	"New Bottles Ordered in March"
1995	1,845	—	5.2	N/A	96.0
1996	2,088	11.7	10.4	N/A	70.0
1997	2,345	19.5	10.4	N/A	123.0
1998	2,876	18.2	18.2	N/A	71.0
1999	2,465	40.3	9.1	0.4	73.0
2000	3,266	23.4	7.8	0.7	66.0
2001	3,325	0.7	0.1	0.1	182.0
2002	3,972	23.4	29.9	16.9	195.0
2003	4,078	13.0	62.4	53.3	122.0
2004		28.6	33.8	38.0	To be decided

Exhibit 2 Sales and Inventory Position Ending February (in thousands of cases)

Source: Company files.

*New bottle inventory equals inventory at beginning of February, plus deliveries, minus breakage, minus transfers to warehouse.

$0.90. During 1999, sales slumped 13 per cent below the 1997 level. Again, in July 2001, a further tax of $0.90 per case was levied, and the company raised the retail price to $11.40. Sales growth slumped to a 2.0 per cent increase. In July 2003, another tax of $1.20 raised the retail price to $12.60 per case. Benson was reasonably certain that the government would not levy additional taxes during 2005, but wondered whether the full effect of the tax had been reflected in 2003 sales.

Beer Bottle Purchases

Benson had joined the company in 1999 as purchasing manager. Benson was responsible for all goods and materials used in the company's production processes, including the purchasing of new bottles and the scheduling of deliveries. Local bottle producers were equipped to manufacture only clear glass bottles. Greaves, therefore, had to import its standard 10 oz. dark amber, long-necked bottle. The company's brand name was etched in the glass, which eliminated replacing the label after each filling.

For many years, Greaves had imported bottles from a German manufacturer. Benson had continued buying from this supplier and had found the service excellent. The German company was one of the largest glass companies in Europe and Greaves' purchases represented less than two per cent of the supplier's 30 per cent export sales. The supplier allowed a minimum order quantity of 15,000 cases per year, with minimum deliveries of 5,000 cases per month. Prices were always quoted cost, insurance and freight (CIF). The CIF price included transportation and insurance, but excluded import duties and local handling. The CIF price gave the supplier the option of shipping the deliveries by any number of freighters in any one month. Ownership passed to Greaves as soon as the shipment left the factory. Quantity discounts were not given on orders below 300,000 cases. Benson had always found the German company's price to be competitive compared to quotes received from South American companies.

Benson was responsible for setting the delivery schedule, and the supplier was quite reliable in this regard. "If new bottle stocks are too low," Benson said, "it's my fault for not ordering in sufficient quantities or not scheduling properly." When the freighters arrived at the docks in Port-of-Spain, Greaves was responsible for wharfage charges plus transportation costs of the four-mile trip to the company premises. Wharfage charges varied based on space used and time held on the dock. Under normal circumstances, stock remained at the dock for three to four days while the company's broker cleared the goods through customs. When the shipment needed to be expedited, the broker could clear the papers in less than a day if they arrived ahead of the shipment. For transportation from the port to Greaves, Benson used a local delivery service that charged $15 per truckload of 400 cases.

To prepare for shipment, the supplier stacked the cartons on pallets and wrapped them with a plastic cover. The cover gave added protection in transit and during outside storage at Greaves. New bottle breakage prior to filling was less than one per cent per year.

Empty Bottle Flow

Empty bottles were either returns from the trade or new bottles. The warehouse superintendent was responsible for control and storage of all returned bottles. Every day, truckloads of empty cases returned from retailers. The printed, corrugated and reusable cardboard cases used by Greaves were imported from the United States. Each case contained 24 bottles. The warehouse crew ensured that each case was in reusable condition and contained 24 unbroken bottles. They then loaded 40 cases of empties on each pallet and delivered the loaded pallets to the covered warehouse. The printed cartons could deteriorate when exposed to the weather, so empty returns received priority over new bottles for covered space. Normally, space in the warehouse was barely sufficient to store the returned empties.

Benson found it very difficult to determine the turnaround time for bottles (i.e. the elapsed time from being removed from storage through processing, finished goods, retailer, consumer, retailer again, and back to storage). The warehouse superintendent estimated turnaround time as being between two and three months. Empty bottle stocks were lowest just after Carnival, and did not build up to normal levels until late April or early May. One executive estimated that, every eight years, the total stock of in-service bottles was completely replaced with new bottles, but another thought that at least 80 per cent of the bottles were replaced in two to three years.

The warehouse superintendent sent empty bottles into the bottling shop as production demanded. When the empty stocks were low and returns not sufficient to meet production requirements, the warehouse superintendent requested new bottles from Benson. When Benson received the warehouse order, a five-person crew "picked" the new bottles. Picking consisted of removing the plastic cover from the pallets, unpacking the new bottles from their plain cardboard shipping containers, and repacking the bottles in the printed company cases. The men placed the cases on pallets again, and a forklift truck transported the pallets to the warehouse.

Order Procedure

Each year at the end of February, Benson reviewed the stock control sheets showing empty bottle stocks, finished goods stocks, new bottle purchases and delivery records (see Exhibits 2, 3 and 4). Benson then compared these stocks with the sales trends and projected the new bottle order quantities for the next year. Benson had to order four months ahead to allow for supplier and transportation lead times. Cancellation charges were high, thus it was not practical to try to reduce the order once it had been placed. Increases were possible, however, provided minimum order quantities and lead time were met. It had been standard practice to order 75 per cent of yearly requirements in March followed by another order in August.

The situation would be different when Greaves requested a change in the bottle design.

Year / Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
2001	N/A	N/A	—	—	—	—	18	18	13	61	36	18	164
2002	17	—	—	—	—	—	8	20	15	26	58	18	162
2003	48	—	—	—	—	—	21	—	17	12	9	35	142
2004	—	28											

Exhibit 3 Monthly Deliveries of New Bottle Purchases (in thousands of cases)

Source: Company files.

*Deliveries over 20,000 cases occurred in two to four shipments.

Year / Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
2002	N/A	N/A	5	—	—	—	10	8	19	32	18	9	101
2003	32	16	—	—	—	—	27	16	18	—	—	18	127
2004	35	22											

Exhibit 4 Monthly New Bottle Warehouse Transfers (in thousands of cases)

Source: Company files.

In this case mold design costs increased, and the supplier would require a minimum of six months' notice. Benson was aware that there was a 50 per cent possibility the company would change the bottle design at the end of 2005, and if not, it certainly would change in 2006. At change-over time, all remaining old-type bottles, new or used, would be scrapped.

Past Bottle Purchases

Prior to 1999, because of a tight working capital situation, the plant manager controlled expenditures for new bottles closely so that just enough were available to meet demand. In 2000, extra funds became available and this policy was relaxed. Because of an unexpectedly large increase in sales during 2001, however, Benson's new bottle order of 66,000 cases in 2000 was barely large enough. By mid-February of 2001, the company ran out of finished goods and empty bottles in the warehouse. Bottling operations were cut back in the plant, and capacity depended on the speed at which daily empty returns were washed. Delivery salesmen waited for the finished goods to load their trucks. February sales suffered with this bottle shortage crisis and were 17,000 cases less than in February of 2000. In 2001, Benson made sure sufficient bottles would be available and ordered 182,000 cases; in 2002, 195,000 cases were ordered. Empty bottle stocks at the end of February 2003 were the highest in the company's history, and Benson reduced the 2003 order to 122,000 cases.

Benson always met with the plant manager and the sales manager before placing the bottle order. The forecast problem had already been informally discussed with both, and neither was confident in Benson's predictions. Benson wanted to suggest a buying strategy that made sense to both production and sales, but could not delay ordering past March 4, 2004. Benson had, therefore, requested a meeting with both executives for March 2, 2004. Regardless of the uncertainties, the proposals would have to be ready by then.

Notes

1. Carnival took place two days before Ash Wednesday, which normally occurred during February or occasionally in early March.
2. Trinidad gained its Independence from Britain on August 31, 1962.
3. The temperatures in Fahrenheit corresponding to Celsius temperatures of 10C and −1C are 40F and 10F, respectively.
4. All monies in US$ unless otherwise specified.

Yield Management at American Airlines

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American Airlines

One of the largest passenger airlines in the world, with sales of $15 billion in 1998, American Airlines provided scheduled service to destinations throughout North America, the Caribbean, Latin America, Europe and the Pacific. Each day the company's employees processed more than 340,000 reservation calls, and operated over 2,200 flights carrying approximately 200,000 passengers.

Faced with an expanding service network, a costly fleet of aircraft and an increasingly diverse group of customers, American Airlines began research in the 1960s on how to improve its reservation system to ensure greater capacity utilization. Natural seasonal fluctuations in demand could be partially offset by altering ticket prices. Moreover, some customer groups could plan trips well in advance, while others often booked days, or even hours, before a flight. Combined, management recognized that both supply and demand could be actively changed to alter dynamic competitive markets and to improve business performance.

American Airlines' yield management system, sometimes termed revenue management, attempted simultaneously to combine demand management, by changing fares, and supply management, by controlling availability. It took into account aircraft capacity, historical customer bookings, pricing, cancellations and no-show rates, costs of oversales and costs of spoilage. Its purpose was to fill seats on each flight with the highest paying passengers by determining the optimal mix of fares to sell on each flight to obtain the highest possible revenue. By the late 1990s, the company, through its Sabre division, used its expertise in a variety of service industries, such as hotels and car rental agencies.

The following exercise is based on the training program used at American Airlines to introduce managers to their yield management system.

How to Play the Exercise

In the Yield Management Exercise, your team will take on the role of a yield management analyst responsible for a single flight from Dallas-Fort Worth, Texas (DFW) to Miami, Florida (MIA). Over the course of the exercise, you will be making the actual booking decisions for the flight as customers make travel inquiries and decisions. Your objective is to maximize the flight's total revenue, taking into account penalties. Under normal circumstances, these decisions are made using American Airlines' yield management system.

The objective of the exercise is to maximize revenue on your flight (prorated fares paid, less spoilage or oversales penalties). You are scheduled to use a Super 80 jet for your flight, with a capacity of 125 seats.

Over the course of the exercise, you will be given 20 to 25 booking opportunities. To simplify this exercise, all tickets are fully refundable. Before each booking opportunity, you will have a chance to set a new *bid price.* After all groups have set their bids for the next booking, the instructor will announce the actual passenger booking price and the number of passengers (pax) for the booking.

Your bid price is used only to trigger accepting or rejecting the booking. If the passenger-requested booking price (*prorated fare*) for the DFW to MIA flight is *equal to or greater than your bid price,* you must accept the entire number of passengers at the prorated fare requested by the customer.

For example, if your bid price is $100 and you receive a request for booking for 10 passengers with a prorated fare of $110, then you must take all 10 passengers at a price of $110. If the prorated fare is less than $100, then you cannot accept the booking. Consequently, final revenue is calculated based on the prorated fare, not on your bid price.

You are responsible for setting the bid price before each bidding opportunity through whatever means you wish. Historically, fares for this flight have ranged from $170 to $750 per seat. As you might expect, there is far more demand at the lower end of the price range than the top end. As the flight starts to fill up, you normally increase your bid price to hold for more lucrative bookings. If the flight is lightly booked, you can lower your bid price to allow for more bookings. **Exhibit 1** shows average historical data for the Dallas to Miami flight.

The final part of the exercise is the day of departure (*DOD*). Not every passenger that books a flight will show up on the day of departure.

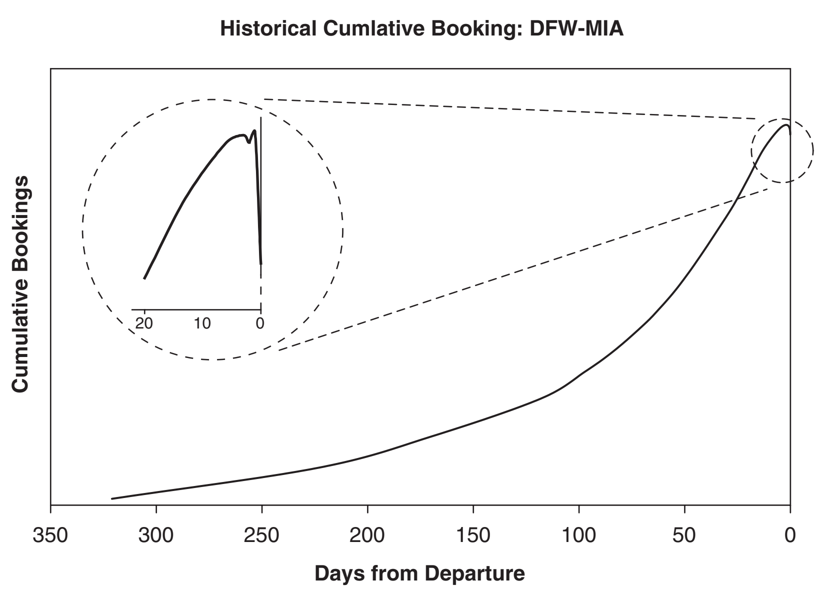

Exhibit 1 Historical Cumulative Bookings: Dallas-Fort Worth (DFW) To Miami (MIA)

Historically, the no-show rate for local passengers has been 15 per cent. This figure has been 20 per cent for flow passengers (those with connecting flights). At the conclusion of the exercise, the instructor will identify the passengers that arrive for the flight, after which you will be asked to calculate your total revenues and penalties for this Dallas to Miami flight. If passengers fail to show up for the flight, no revenue is obtained for their booking.

Costs Involved

Two additional costs are normally incurred: spoilage and oversales. The penalty for unsold seats (spoilage) is $150 each, which is an estimate of the opportunity cost of the lost contribution on this flight as well as on connecting flights from flow passengers.

Penalties for oversales escalate as the number of disappointed passengers increases. If five or fewer passengers are oversold, the cost is $100 per passenger. Costs increase to $250 per passenger for six to 10 oversales, and to $500 per passenger for 11 or more oversales. All oversales penalty costs are calculated on a per seat basis (e.g., for seven oversales the penalty would be $1,750). These amounts are to cover out-of-pocket costs for passengers and subsequent rebooking, as well as the inevitable "badwill" incurred when a passenger is disappointed.

A glossary of terms that you might find useful is provided in **Exhibit 2** and a list of airport codes is provided in **Exhibit 3**. A Yield Management Exercise Score Sheet to be used by you to keep track of your progress during the exercise is provided in **Exhibit 4**.

Bid Price: The minimum acceptable fare for a reservation to be accommodated on a flight. The prorated fare value must equal or exceed the bid price in order for the passenger-requested booking to be accepted.

Cancellation: A passenger who makes a booking for a flight and later cancels the reservation (before departure).

Capacity: The physical number of seats on the aircraft. Coach capacity is often referred to as Y capacity (as Y is the code for the coach cabin).

DOD: Day of departure.

Fare: The price the customer pays for the flight. Typically, the fare refers to the ticket price only, and does not include taxes, departure fees or passenger facility charges (PFCs).

Flow Passenger: A passenger travelling behind or beyond the city pair. In this example, boarding in DEN, connecting in DFW and then deplaning in MIA. Or, boarding in DFW, connecting in MIA and then travelling to GRU.

Itinerary: The complete trip taken by a passenger, including all flights.

Local Passenger: A passenger travelling only between the city pair. In this example, a passenger boarding in DFW and deplaning in MIA.

Market: Any given pair of cities between which a flight operates.

No Show: A passenger who does not show up for the flight in which he or she was holding a reservation.

No Show Factor: The percentage of passengers who do not show up for their flight as a percentage of total reservations at departure.

Oversales: Occurs when the airline has to deny boarding to a revenue passenger because too many seats have been sold for the flight. This does not include revenue passengers booked on earlier/later flights but standing by for a different flight.

Pax: passenger(s).

Prorated Fare: The portion of the fare for a complete itinerary that is attributed to a particular flight within the itinerary.

Spoilage: Occurs when a flight departs with empty seats and **at any point prior to departure**, the flight was closed for sale or a booking was turned away. This would indicate sub-optimal yield management of the flight.

Voucher: Also known as denied boarding compensation. This is a future travel credit is some amount that is compensation for having been an oversale on a previous flight.

Exhibit 2 Glossary of Terms

START OF EXERCISE

The only decision that you will be asked to make during the class is setting the bid price for each booking opportunity. In preparation for the class, you should develop a bid-price strategy for the exercise and decide on your opening bid price.

ABQ	—	Albuquerque, New Mexico
ANU	—	Antigua, West Indies
AUS	—	Austin, Texas
DEN	—	Denver, Colorado
DFW	—	Dallas/Fort Worth, Texas
EYW	—	Key West, Florida
GIG	—	Rio de Janeiro, Brazil
GRU	—	Sao Paulo, Brazil
HNL	—	Honolulu, Hawaii
LAS	—	Las Vegas, Nevada
LAX	—	Los Angeles, California
LIM	—	Lima, Peru
MAD	—	Madrid, Spain
MCO	—	Orlando, Florida
MIA	—	Miami, Florida
MSP	—	Minneapolis/St. Paul, Minnesota
NAS	—	Nassau, Bahamas
NRT	—	Tokyo, Japan (Narita Airport)
PDX	—	Portland, Oregon
SCL	—	Santiago, Chile
SFO	—	San Francisco, California
SJO	—	San Jose, Costa Rica
SJU	—	San Juan, Puerto Rico
TUS	—	Tucson, Arizona
YYC	—	Calgary, Alberta
YYZ	—	Toronto

Exhibit 3 Airport Codes Used in Exercise

Bid Price?	Booking Code	Prorated Fare	Pax	Running Total Pax

Total Booked Passengers: ______

DOD Show-up	Revenue Value
Enter total in "Total DOD Pax" at lower left	*Enter total in "Total Revenue"below*

Total DOD Pax: ______

Final Capacity: ______

Oversales? __________ × penalty __________

or

Spoilage? __________ × $150/pax __________

Total Revenue: __________

→ __________

Total Flight

Exhibit 4 Yield Management Exercise Score Sheet

MacPherson Refrigeration Limited

Bill Rankin

John Haywood-Farmer

 Version: (A) 2002–12–16

In October, Linda Metzler, newly appointed production planning manager of MacPherson Refrigeration Limited (MRL) of Stratford, Ontario, was formulating the production plan for the year beginning on January 1. She had to submit the plan to the plant's general manager by the end of the month.

Background

MRL had sales of about $28.5 million. The company began in Stratford almost 30 years ago, specializing in commercial refrigeration. Ten years ago the company opened a new 300,000 square foot plant in Stratford and diversified into consumer refrigeration. Subsequently, MRL added air conditioners to its freezer and refrigerator lines. The company sold its Hercules brand appliances through independent furniture and appliance stores in southern Ontario.

The Stratford Plant

In the past 20 years, manufacturing efficiency at the plant had increased dramatically through changes in both process design and assembly technology. During this time, annual output per worker had increased from about 240 to 450 appliances; it was expected to be about 480 appliances next year. Although the Canadian market was too small to allow the productivity levels of American appliance manufacturers, MRL was considered to be relatively efficient by Canadian standards.

The Planning Process

Each year in September the marketing and sales department produced a forecast of appliances by month for the next year. The production planning department used these forecasts to plan production for the next year. The first step in the planning process was to construct an aggregate production plan. This plan consisted of planned gross production by month for the year and did not indicate numbers of specific appliance types, sizes, or models to be made each month but, as the name indicates, was an aggregate. Linda Metzler's task in October was to construct this aggregate plan. As the production periods approached later in the year, master production plans would be formulated which would be specific regarding appliance type, model number, etc.

Exhibits 1–4 present the September forecast showing the expected seasonal fluctuations and the aggregate number of appliances to be shipped each month. Linda knew that, although there would be significant variation of specific appliance types within each month, each type of appliance required roughly similar materials and labour resources. Thus, for aggregate planning purposes, the number of appliances to be shipped would be sufficient.

The Aggregate Plan

In preparation for her decision, Linda gathered the following information:

1. The Stratford plant had the physical capacity to make only 13,000 appliances per month.

Month	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Totals*
Production Plan														
Shipment Forecast		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Production Plan		8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	101,280
Shipments		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Inventory[1]	240	4,280	8,320	10,760	11,200	13,040	9,680	5,120	2,360	0	840	3,280	6,120	75,000
Extraordinary Labour Costs														
Number of Workers[2]	160	211	211	211	211	211	211	211	211	211	211	211	211	2,532
Hirings		51	0	0	0	0	0	0	0	0	0	0	0	51
Layoffs		0	0	0	0	0	0	0	0	0	0	0	0	0
Worker Months Overtime		0	0	0	0	0	0	0	0	0	0	0	0	0
Cost of Alternative 1														
Hiring Costs	51 × 1,800	=	91,800											
Layoff Costs	0	=	0											
Inventory Holding Costs	75,000 × 8	=	600,000											
Labour Costs														
Regular	2,532 × 2,400	=	6,076,800											
Overtime	0	=	0											
Total Costs			**$6,768,600**											

Exhibit 1 Level Production to Meet Peak Demand

1. On December 31, finished goods inventory was predicted to be 240 units.

2. On December 31, the workforce was predicted to be 160 workers.

Month	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Totals*
Production Plan														
Shipment Forecast		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Production Plan		4,160	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,160
Shipments		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Inventory[1]	240	0	0	0	0	0	0	0	0	0	0	0	0	0
Extraordinary Labour Costs														
Number of Workers[2]	160	199	199	199	199	199	199	199	199	199	199	199	199	2,388
Hirings		39	0	0	0	0	0	0	0	0	0	0	0	39
Layoffs		0	0	0	0	0	0	0	0	0	0	0	0	0
Worker Months Overtime		0	0	0	1	0	96	126	81	71	0	0	0	375
Cost of Alternative 2														
Hiring Costs	$39 \times 1,800$ =		70,200											
Layoff Costs	0 =		0											
Inventory Holding Costs	0 =		0											
Labour Costs														
Regular	$2,388 \times 2,400$ =		5,731,200											
Overtime	$375 \times 3,300$ =		1,237,500											
Total Costs			**$7,038,900**											

Exhibit 2 Chase Production Plan With Constant Workforce and Overtime

1. On December 31, finished goods inventory was predicted to be 240 units.

2. On December 31, the workforce was predicted to be 160 workers.

Month	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Totals*
Production Plan														
Shipment Forecast		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Production Plan		4,160	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,160
Shipments		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Inventory[1]	240	0	0	0	0	0	0	0	0	0	0	0	0	0
Extraordinary Labour Costs														
Number of Workers[2]	160	199	110	150	200	165	295	325	280	270	190	150	140	2,379
Hirings		0	6	40	50	0	130	30	0	0	o	0	0	256
Layoffs		56	0	0	0	35	0	0	45	10	80	40	10	276
Worker Months Overtime		0	0	0	0	0	0	0	0	0	0	0	0	0
Cost of Alternative 3														
Hiring Costs	256 × 1,800 =		460,800											
Layoff Costs	276 × 1,200 =		331,200											
Inventory Holding Costs	0 =		0											
Labour Costs														
Regular	2,379 × 2,400 =		5,709,600											
Overtime	0 =		0											
Total Costs			**$6,501,600**											

Exhibit 3 Chase Production Plan With Varying Workforce

1. On December 31, finished goods inventory was predicted to be 240 units.

2. On December 31, the workforce was predicted to be 160 workers.

Month	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Totals*
Production Plan														
Shipment Forecast		4,400	4,400	6,000	8,000	6,600	11,800	13,000	11,200	10,800	7,600	6,000	5,600	95,400
Production Plan		____	____	____	____	____	____	____	____	____	____	____	____	____
Shipments		____	____	____	____	____	____	____	____	____	____	____	____	____
Inventory[1]	240	____	____	____	____	____	____	____	____	____	____	____	____	____
Extraordinary Labour Costs														
Number of Workers[2]	160	____	____	____	____	____	____	____	____	____	____	____	____	____
Hirings		____	____	____	____	____	____	____	____	____	____	____	____	____
Layoffs		____	____	____	____	____	____	____	____	____	____	____	____	____
Worker Months Overtime		____	____	____	____	____	____	____	____	____	____	____	____	____

Cost of Alternative 4		
Hiring Costs	____ × 1,800 =	________
Layoff Costs	____ × 1,200 =	________
Inventory Holding Costs	____ × 8 =	________
Labour Costs		
Regular	____ × 2,400 =	________
Overtime	____ × 3,300 =	________
Total Costs	$	________

Exhibit 4 Aggregate Plan for Macpherson Refrigeration Limited

1. On December 31, finished goods inventory was predicted to be 240 units.

2. On December 31, the workforce was predicted to be 160 workers.

2. On October 1, MRL employed 160 hourly paid unionized production workers. Their two year contract, signed in February of last year, called for an increase of $0.75 per hour effective next January 1, bringing the average hourly rate to $10.50. With fringe benefits, the monthly cost to MRL would be about $2,400 per worker. Under the agreement, overtime was 1.5 times the regular hourly rate but, because not all fringes were affected, a worker-month of overtime cost about $3,300. The standard work week was 40 hours. The aggregate plan in effect until December 31 called for a total production workforce of 160 at that time.

3. The personnel department estimated that hiring, training, and related expenses would amount to $1,800 per worker. It also estimated that severance and other layoff expenses would cost a total of $1,200 per worker.

4. The accounting department predicted that it would cost about $8 to hold an appliance in inventory for a month during the next year. Raw materials were readily available from regional sources on short notice. The current aggregate plan, supported by marketing's most recent revised forecasts and the master production schedule, predicted an inventory of 240 finished units on December 31.

5. Although MRL manufactured some parts and subassemblies, the plant was primarily a final assembly operation with a throughput time of about three days. The company used an MRP-based planning system. For aggregate planning purposes, management had found that it was adequate to assume that all worker hours scheduled in a particular month would contribute directly to output in the same month. Similarly, they had learned from experience that they would not have to consider any special allowances for learning.

6. There appeared to be three basic tools available to meet demand fluctuations, each of which involved both quantitative and qualitative tradeoffs:
   - building inventory to meet peaks
   - using overtime
   - hiring and laying off workers

THE ALTERNATIVES

Linda identified three alternatives the company could follow to meet forecasted demand:

1. The production level and the workforce could be held constant throughout the year at a level sufficient to meet the peak demand period. In periods of low demand inventory would be accumulated and would be drawn down during peak demand periods. Linda was attracted by the protection this plan offered against unforeseen demand changes. This plan is one example of a level strategy and is shown in Exhibit 1.
2. The production level could vary to meet demand with a constant workforce by the use of overtime in peak months and restricted output in slow months; it is an example of a chase strategy and is shown in Exhibit 2. The workforce would be held at just the number to meet average monthly requirements. MRL would incur no inventory carrying costs with such a scheme. However, Linda wondered if excessive overtime might lead to lower efficiency, or if restricted production might promote poor work habits and low morale.
3. Some of these potential problems could be overcome by a strategy that met demand by varying workforce levels. Linda's calculations showed this to be the cheapest of the three alternatives (see Exhibit 3). However, she was well aware that union relations and employee morale could be adversely affected by frequent layoffs. As well, hiring and training new employees brought their own headaches, especially in a limited labour market such as existed in Stratford.

THE DECISION

Linda knew that these three very different plans were by no means the only feasible ones available. She realized that her decision on an aggregate plan would involve both quantitative and qualitative trade-offs. One thought nagged in the back of her mind: no matter which plan she chose, how would she know if a better one existed? She decided to start by filling out her blank form (Exhibit 4) one more time.

LAMSON CORPORATION (R)

M.R. Leenders

 Version: (A) 2001–07–20

In this game you will have the chance to try your skill at inventory and operations planning using the information similar in type to that available to Mr. Marino, the operations manager of Lamson Corporation, a large multi-plant manufacturer of sewer pipes. Every two weeks in the summer sales period, Mr. Marino had to decide how many tiles of each type and size should be produced during the coming two weeks. In doing this planning, he took into account sales trends, the time of the year, the capacity of Lamson's tile making machinery, the stock of the various sizes of tiles on hand, the cost of overtime production and the cost of missed deliveries. In this game you will be able to make similar decisions, although the game will be a simplified version of the actual situation. The most important feature of this simplification is that you will be dealing with only two sizes of sewer tile—the 18" diameter size and the 36" diameter size. Mr. Marino, in contrast, had to decide on production levels for 13 different sizes of tile and which plants would produce what mix.

SALES PATTERNS

Company sales, and industry sales in general, were very much influenced by general economic and seasonal factors. Since weather affected tile laying conditions and the number of construction starts, sales of sewer tiles exhibited a yearly sales trend of the following general shape (Figure 1). Sales were low for six months, from October to April 1, and rose rapidly in the spring to a summer peak and then tapered off again. About one-third of all annual sales were made in the two middle months of the year, while about three-quarters were made in the summer sales season. However, there was not necessarily a smooth rise and fall in sales in any particular year. The curve shown is only the average of the experiences of many years. In any given year, biweekly sales might vary ± 25 per cent from levels they would assume if a smooth sales curve existed. Last year, the maximum number of 18" tiles sold in any two week period between April and October was 4,500.

The similar figure for 36" tiles was 2,000. Major fluctuations in annual sales and mix levels were caused by economic conditions.

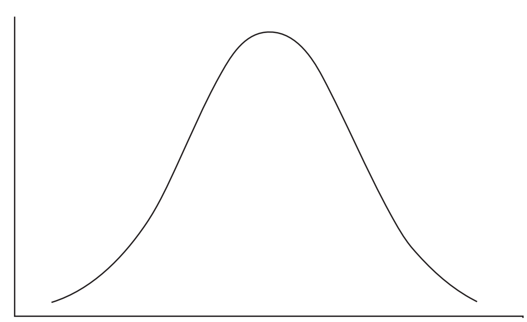

Figure 1

In the game you are about to play, Period 1 refers to the first two weeks in April. Thus, company sales are just leaving the low part of the annual swing. The game culminates in Period 12, the last two weeks in September, when sales are reentering the low winter period. Between Periods 1 and 12, sales follow the general shape of the curve shown in Figure 1.

All sales made by Lamson are booked for delivery within the period being considered.

That is, there is no advance ordering. Mr. Marino has no idea what the sales for any coming period will be other than from judgement of the sales level of prior periods and from consideration of the general shape of the sales trend curve.

Production Constraints

The most popular sizes of concrete tile sold by Lamson were the 18" diameter and the 36" diameter sizes. Mr. Marino had found that together, these tiles accounted for a large part of tile sales; in fact, roughly one half of each period's production was devoted to one or other of these sizes. The other half of each period's production was used to manufacture the other sizes of tile produced by Lamson. In order to simplify the game, it has been assumed that Mr. Marino will continue to schedule the production of the less popular 11 tile sizes and that he will use half the production time each period for these sizes. Each participating group will be asked to schedule the number of 18" and 36" tiles to be produced during each period. Thus, each group will, in fact, schedule the production of a summer season's supply of 18" and 36" diameter tiles.

There were nine possible volume combinations of 18" and 36" tiles. Four of these output values were based on the normal capacity output of the plants. The other five values represented the maximum output possible at Lamson, which required 50 per cent overtime.

The nine production levels possible for 18" and 36" tiles in each two week period are shown in Exhibit 1.

Cost Involved

Inventory Costs

In deciding on production alternatives, Mr. Marino bore in mind several costs which he knew were fairly accurate. For instance, storage costs of an 18" tile for one period were an average of $2. This amount took into account interest on tied-up capital, insurance against breakage, and direct handling expense. The inventory carrying costs of each 36" tile were higher and averaged $6 per tile per period. Mr. Marino had found that, over the period of a season, inventory carrying charges could be reasonably calculated on the basis of inventory on hand at the end of each period.

Normal Capacity			*50% Overtime*		
Option	*18" Tiles*	*36" Tiles*	*Option*	*18" Tiles*	*36" Tiles*
1	6,000	0	5	9,000	0
2	4,000	600	6	7,000	600
3	2,000	1,200	7	5,000	1,200
4	0	1,800	8	3,000	1,800
			9	1,000	2,400

Exhibit 1 The Nine Possible Production Choices Open to Mr. Marino Each Two Week Period

Please notice that trade-offs are involved in choosing a production level for a period. If the number of 18" tiles to be produced is increased, the number of 36" tiles that can be produced will necessarily decrease unless overtime is used.

Stock-Out Costs

Stock-out costs also had to be considered by Mr. Marino. A stock-out occurred whenever sales in a particular period could not be filled because there were insufficient tiles of the required diameter on hand or in production during that period. For instance, if 100 tiles were on hand at the beginning of a period, 2,000 tiles were produced during the period, and sales during the period totalled 2,200, then a stock-out of 100 tiles would occur. When such a stock-out occurred, there was a chance that a future customer of Lamson would be lost. Furthermore, Lamson lost the profit potential on the missed order. Mr. Marino had assessed the risks and costs involved and thought that a stock-out cost Lamson $20 for each 18" tile and $60 for each 36" tile. These figures took into account the fact that the larger the number of tiles that could not be delivered, the more apt the customer was to take future business elsewhere. Stock-outs could not be made up in subsequent periods. If a stock-out occurred, the sale was lost forever to the firm and the above costs were incurred.

Overtime Costs

If overtime was used in any period, a fixed charge of $20,000 was incurred, mainly to pay extra wages to the employees. The amount was fixed because the employees had been guaranteed a minimum amount each period overtime was used.

How to Play the Game

In the actual conduct of this game, teams will make the production decisions normally made by Mr. Marino regarding the 18" and 36" diameter tiles. Before each period, each team will be required to decide on the production level that will be used in the plant. This decision will be made by the team by whatever means it chooses. Thus, a prediction from a plot of past period sales might be used by some teams, a pure guess by others. In making the decision, teams should consider both the possibilities of future sales and the inventories of tiles now on hand.

After each team has decided on the production level it desires for the coming period, the instructor will announce the actual sales levels for the period. Given this information, teams will then be able to calculate inventory on hand, and inventory, stock-out, and overtime costs. These costs will be added to a total period cost which will then be added to a cumulative total of costs.

The objective of the game is to keep the total costs incurred over 12 periods to a minimum. This objective means that teams will have to decide whether it would be cheaper in the long run to incur overtime costs, inventory carrying costs, or stock-out costs. It is impossible to avoid all three. At the end of the Period 12 the game will be stopped and final costs calculated. Your team's results will be compared to those of other teams. During subsequent discussions the merits of various inventory and production policies can be evaluated. Teams will probably find it advantageous to split the work of making sales estimates, calculating costs and keeping records among the various members. To make the keeping of results easier for all teams, Exhibit 2 will be used.

The Early Season

Each team member should carefully trace the steps Mr. Marino followed already this year to understand fully all of the steps involved in playing and recording the game.

Mr. Marino has already used the form to record the operating results of the two periods prior to the first period for which you will be required to decide the production level (Period 1). Lamson started Period –1 with 400 – 18" tiles (Column B) and 100 – 36" tiles on hand (Column K). Because he knew that a special, large order for 18" tiles would be placed in Period –1, (a most unusual size of order at this time of year), Mr. Marino decided to go to overtime and to produce 7,000 – 18" tiles (Column A) and 600 – 36" tiles (Column J). Thus, 7,400 – 18" tiles (Column C) and 700 – 36" tiles (Column L) were available for sales during Period –1.

In actual fact, the special order was smaller than Mr. Marino had anticipated and total sales

		18" Tiles								*36" Tiles*								*Totals*				
Period	Month	Number Produced	Stock on Hand at Start of Period	Total Available for Sale C = A + B	Sales in Period	Inventory Remaining at end of Period E = C − D (Minimum = 0)	Inventory Carrying Cost $2 × E	Number of Stock-Outs G = D − C if Greater than 0	Stock-Out Cost H = $20 × G	Number Produced	Stock on Hand at Start of Period	Total Available for Sale L = J + K	Sales in Period	Inventory Remaining at end of Period N = L − M (Minimum 0)	Inventory Carrying Cost $6 × N	Number of Stock-Outs P = M − L if Greater than 0	Stock-Out Cost Q = $60 × P	Total Inventory Cost R = F + O	Total Stock-Out Cost S = H + Q	Overtime Cost $20,000 (if used)	Total Period Cost U = R + S + T	Cumulative Total to Date
		A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	V
−1	Mar	7,000	400	7,400	6,000	1,400	2,800	0	0	600	100	700	800	0	0	100	6,000	2,800	6,000	20,000	28,800	(28,800)
0	Mar	2,000	1,400	3,400	1,400	2,000	4,000	0	0	1,200	0	1,200	500	700	4,200	0	0	8,200	0	0	8,200	(37,000)
1	Apr																					
2	Apr																					
3	May																					
4	May																					
5	Jun																					
6	Jun																					
7	Jul																					
8	Jul																					
9	Aug																					
10	Aug																					
11	Sep																					
12	Sep																					
Total																						

Exhibit 2

turned out to be 6,000 for the 18" tiles (Column D) and 800 for the 36" tiles (Column M). Because 18" inventory available for sale exceeded sales, Mr. Marino entered 1,400 in Column E to show there was inventory remaining at the end of the period, and then entered zero in Column G to show that there had been no stock-out of 18" tiles on hand at the end of the period. He then calculated the carrying cost in Column F ($2 × 1,400 = $2,800) and the stock-out cost in Column H ($20 × 0 = $0). Column H shows that no stock-out cost was incurred. Because demand for the 36" tiles (800) exceeded the total available for sale (700), a stock-out of 100 occurred and no tiles were left in inventory at the end of Period –1. To show this occurrence, zero was entered in Column N and 100 was entered in Column P while a stock-out cost of $6,000 was entered in Column Q ($60 × 100 = $6,000).

The total inventory carrying cost was entered in Column R ($2,800 + 0 = $2,800) and the total stock-out cost in Column S (0 + $6,000 = $6,000). $20,000 was entered in Column T because overtime was used. The total period cost was calculated to be $2,800 + $6,000 + $20,000 = $28,800. This amount was then entered in Column U and also Column V.

Lamson began Period 0 with 1,400 – 18" tiles (Column B) and zero 36" tiles on hand (Column K). These totals had been brought down from Columns E and N respectively of Period –1. At the beginning of Period 0, Mr. Marino elected to produce 2,000 – 18" tiles (Column A) and 1,200 – 36" tiles (Column J). No overtime was called for. Thus there were 3,400 – 18" tiles (Column C) and 1,200 – 36" tiles (Column L) available for sale in Period 0.

In Period 0, sales totalled 1,400 – 18" tiles (Column D) and 500 – 36" tiles (Column M). Thus the inventory remaining at the end of the period was 2,000 – 18" tiles (Column E) and 700 – 36" tiles (Column N). There were zero stock-outs (Columns G and P). Inventory carrying costs were computed to be $2 × 2,000 = $4,000 (Column F) and $6 × 70 = $4,200 (Column 0). There were no stock-out costs (Column H and Q) because stock-outs equalled zero in this period.

The total inventory carrying cost for Period 0 was $8,200 ($4,000 + $4,200). This amount was entered in Column R, while zero was entered in Column S since there had been no stock-outs in the period. There was no overtime used, and consequently a zero was entered in Column T. The Column U entry shows that the total period costs incurred were $8,200. The Column V entry was $28,800 + $8,200 = $37,000. Since your team did not incur these costs, we will wipe them off the slate and have you start with a zero cost at the beginning of Period 1 in Column V.

A Few Operating Rules During the Game

1. The only production combinations your team may choose are those given in Exhibit 1.
2. If your team makes a calculation mistake, a penalty of $25,000 will be assessed and all figures will be corrected.
3. If your team is unable to reach a decision by the end called for by the instructor, it will automatically be decided that you produce 2,000—18" tiles and 1,200—36" tiles.
4. Normally, at the beginning of the game, each team will have approximately 10 minutes to make a decision. This time will decrease as the game progresses.

Start of Game

The game proper starts in Period 1. At the beginning of the game there are 2,000 – 18" tiles on hand (brought down from Column E of Period 0) and 700 – 36" tiles on hand (brought down from Column N of Period 0). It is now up to each team to pick the production level most appropriate for Period 1 and thus start the playing of the game.

MARTIN TRAILERS LIMITED

Chris Piper

 Version: (A) 2001–06–01

In early July, Kim Martin was reviewing Martin Trailer's production performance. Although sales this year had grown by 40 per cent, Martin wondered what could be done to improve the management of operations.

MARKETING

Trailers were sold under both the Martin label and under the private labels of major customers such as department stores. Private label trailers were ordered in November for delivery in January through June. Also, in November a one-year sales forecast was prepared by Martin. Last year's orders are shown in Exhibit 1, according to the month in which shipment was requested. The selling season for the Martin brand began with a trailer show in early February, at which each Martin dealer estimated how many of each model trailer could be sold. Martin then prepared a schedule of the expected number of each trailer model that would be required from the plant each month. This schedule was given to the production manager.

MATERIALS MANAGEMENT

The purchasing agent was told in early December of the forecast made by Martin, and purchased enough parts to produce the total number of trailers estimated. The purchasing agent usually established a schedule for each supplier, requesting at least half the total order immediately with one or two later deliveries.

Each trailer was made from about 100 different parts that ranged from pieces of precut plywood to nuts and bolts. Materials constituted about two-thirds of Martin's manufacturing cost, while labor (at $20 per hour) and overhead accounted for 13 per cent and 20 per cent respectively. The longest intervals between order placement and receipt of goods were for painted steel and springs, each of which required eight to 10 weeks for delivery.

Last November, Martin hired a clerk to maintain a perpetual inventory of raw materials. The clerk was informed when shipments arrived, and entered the amounts in a control ledger. Production figures for each model of trailer were received once a week and used to calculate the numbers of each part that must have been used. These were then subtracted from the previous balances. Since this was a new procedure, and had proven to be inaccurate on several occasions, the purchasing agent tended to rely on requests from the production manager. Workers usually told the production manager when they were just about out of a part.

MANUFACTURING

Camping trailers were produced from December until the end of June. (Last year's camping trailer manufacturing results are shown in Exhibit 1.) The company closed for vacation in July, then reopened to produce a line of snowmobile trailers (using the same production facilities) until the end of November. The production manager attempted to meet the monthly forecast requirements established by Martin. An attempt was made to schedule trailers in lots of at least 100. If the warehouse supply became very low (five or six), more would schedule into production.

In January and February, the production manager kept a mental schedule for the following three weeks. Typically, parts were manufactured for the trailers to be assembled the following week. At the same time, the production manager determined which trailers were most urgently required for the

Trailer	*Activity*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
T10	O	0	55	–29	34	61	122	14
	M	0	0	15	36	97	104	0
T12	O	0	28	–12	14	43	28	11
	M	0	0	87	0	42	25	1
T15	O	0	19	–5	13	15	41	12
	M	0	0	24	50	9	83	0
T15 MarkII & T20	O	0	40	–10	27	32	30	12
	M	0	0	27	50	0	94	0
T40	O	0	8	6	24	26	48	14
	M	0	0	0	0	0	56	39
T41	O	0	3	1	5	6	–1	2
	M	0	0	0	0	0	0	3
Martin Brand	O	0	153	–49	117	183	268	65
Totals	M	0	0	153	136	148	362	43
Mark IV	O	0	100	250	250	400	400	100
	M	5	127	131	132	171	481	203
Crown	O	0	25	25	50	100	100	0
	M	0	1	0	31	111	0	137
Regal	O	0	25	50	50	50	65	0
	M	5	0	44	17	100	50	23
Viceroy	O	0	25	0	25	10	0	0
	M	5	0	55	0	0	0	0
Quality	O	0	35	90	85	140	140	36
	M	0	0	12	232	97	87	0
Discount	O	0	40	100	105	165	200	0
	M	60	0	103	175	132	140	0
Private Brand	O	0	250	515	565	865	905	136
Totals	M	75	128	345	587	611	758	363
	O	0	403	466	682	1,048	1,173	201
Grand Totals	M	75	128	498	723	759	1,120	406
Workers		40	40	40	40	40	801	80
Hours/Week/Worker		20[2]	40	40	603	60	60	20[2]

Exhibit 1 Record of Trailers Ordered (O) and Manufactured (M)

1. Second shift was hired for the months of May and June.
2. Short work weeks were used at the beginning and end of the season.
3. Overtime was used during March, April and May

second week ahead. If parts were not available for this model, another model was chosen. Priorities were influenced largely by the importance of the customer, i.e., the demands of the largest buyers were filled first. In May and June, the tentative schedule was shortened to only one week ahead. This schedule was often upset by late demands from dealers. If a rush order were received, the trailers could be manufactured in three or four weeks, if no purchases were necessary.

Parts shortages presented persistent problems and upset the production manager's schedules several times a year. When this happened, the production manager quickly scheduled a different model into production, rather than allow the workforce to become idle.

It was clear to Martin that there were major problems in the operation of the plant, but wondered which were the most serious, and what should be done about them.

ILLUSTRIOUS CORPORATION

John Haywood-Farmer

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Nancy Barfield, production planner at Illustrious Corporation, a small assembly shop, was preparing the operating plan for the next 10 weeks as she did each Friday. One of the products she had to deal with almost every week was X500, a product assembled for a regular customer. Even though the customer gave Nancy a forecast of required shipments of X500 every two weeks, the forecasts frequently changed.

The manufacturing and assembly process for X500 began with part H590, which Illustrious bought from another local company. The H590s came with a number of holes. Illustrious first had to tap the holes on some of the H590s for mounting screws. Illustrious carried the tapped H590s as part P712. Just this last week Illustrious had returned a shipment of 900 H590s to its supplier because of poor quality. Nancy did not expect the shipment to be replaced until the following Monday, 10 days hence.

The P712 was then attached to a G418 to form part Q307. In a similar operation an untapped H590 was attached to a G418 to form L600, which Illustrious carried as a separate part number even though the only difference between it and Q307 was its untapped holes. Nancy knew inventory was tight on G418 because of a recently settled strike at the supplier's plant.

Illustrious workers next mounted an F416 on each Q307 to make the subassembly L477. Illustrious purchased the F416 in kit form; the kits included all the necessary mounting screws and accessories. X500s were formed by screwing two L600s onto one L477 in a final assembly operation.

Nancy reviewed the projected week-ending inventory levels for X500 and each of its components, the latest shipment forecast, and the standard lead times. The relevant figures were:

Part	*X500*	*H590*	*P712*	*G418*	*Q307*	*L600*	*F416*	*L477*
Inventory (units)	400	210	115	290	490	620	750	310
Lead time (weeks)	0	1	1	2	3	3	2	2

Week	*Demand*	*Week*	*Demand*	*Week*	*Demand*	*Week*	*Demand*
1	205	6	300	11	150	16	200
2	395	7	215	12	525	17	150
3	100	8	50	13	425	18	450
4	295	9	600	14	0	19	0
5	265	10	310	15	120	20	350