12 Principles of Airline Scheduling

Introduction The Mission of Scheduling Equipment Maintenance Flight Operations and Crew Scheduling Ground Operations and Facility Limitations Schedule Planning and Coordination Equipment Assignment and Types of Schedules Hub-and-Spoke Scheduling Data Limitations in Airline Scheduling

Chapter Checklist • You Should Be Able To:

- Describe the major internal and external factors that affect the scheduling process
- Define and explain *maintenance efficiency goals, flight-operations factors in schedule planning,* and *facility constraints*
- Understand the role of the scheduling department in developing and coordinating the schedule planning process
- Describe such unique problems facing schedulers as traffic flow, sensitivity to schedule salability, operational difficulties of adjusting schedules, and the financial leverage of load factors
- Explain the four basic schedule types
- Discuss the advantages and disadvantages of huband-spoke scheduling

INTRODUCTION

"Anyone without the mind of a computer, the patience of Job, or the ability to compromise need not apply." This sign should be on the door of every airline's scheduling department. Schedules represent one of the primary products of an airline and certainly the leading factor in a passenger's choice of a particular carrier. Scheduling may also be one of the most difficult jobs in any airline. Scheduling is one of the most vital functions in the business—as important as forecasting, pricing, fleet planning, or financing. As we shall see, a schedule can make or break an airline.

THE MISSION OF SCHEDULING

What is the mission of scheduling? It is as broad as the mission of the airline itself. An airline has the responsibility to provide adequate service to the cities it serves; an airline must also, of course, operate efficiently and economically. Therefore, in its scheduling practices, airline management must continually search for the balance between adequate service and economic strength for the company. Airline **scheduling** can be defined as the art of designing systemwide flight patterns that provide optimum public service, in both quantity and quality, consistent with the financial health of the carrier.

The public service and economic aspects of scheduling must be balanced with other factors, including these:

- 1. *Equipment maintenance.* A separate maintenance-routing plan must be drawn up for each type of aircraft in the fleet. All routing plans must be coordinated to provide the best overall service. Maintenance of airplanes requires that certain stations be provided with facilities and personnel for periodic mechanical checks. Concentration of maintenance at only a few stations is desirable, and it is likewise desirable to utilize fully the facilities provided by planning an even flow of maintenance work.
- 2. *Crews.* Assuming that all captains, first officers, flight engineers, and flight attendants have had adequate training on each type of airplane and over the routes to be flown, there are always considerations of utilization and working conditions. Certain crew routings must be followed to maintain efficient monthly utilization; crew routings that would require excessive flying without proper rest cannot be used.
- 3. *Facilities.* Gate space on airport ramps must be adequate. Terminal capacity, including ticket counters, baggage-handling areas, and waiting rooms, must be expanded to meet growing market requirements. Access roadways to and from airports must be adequate. Airport capacity, including runways, taxiways, and navigational aids, establishes an upper limit on operations.
- 4. *Marketing factors.* Marketing factors are numerous, including such characteristics as market size, trip length, time zones involved, and proximity of the airport to the market served.
- 5. *Other factors.* Seasonal variations in wind patterns require differences in summer and winter flying times on certain routes (usually east–west); however, some airlines

use constant year-round flying times on routes where variations in wind components are negligible (usually north–south routes). In addition, on many segments, variable times are used to allow, to some extent, for anticipated delays during periods of heavy air traffic.

External factors must be taken into consideration by the scheduling department. Air freight shippers and the U.S. Postal Service have schedule preferences. Airport authorities, seeking a smooth flow of traffic to optimize utilization of facilities, will discourage peaking; in recent years, certain large airports have assigned quotas (flight slots) to carriers during certain time periods. Local communities near an airport will voice strong opposition to flight departures before 7:00 A.M. and after 11:00 P.M. Hotel and motel operators generally prefer that all guests check in and check out between 11:00 A.M. and 1:00 P.M. Figure 12-1 is a conceptual framework for the scheduling process that shows all these elements.

Picture a city with a large metropolitan airport, another airport with short runways and a terminal handling only one flight at a time, and another airport bustling with multiple connections. Envision a maintenance base geared to accept aircraft at prescribed time intervals for various maintenance checks, from routine inspection to major overhaul.

As the picture begins to unfold, you see scheduling as a vital and complex function that cuts across every aspect of an airline operation. It is so vital, in fact, that scheduling



FIGURE 12-1 Conceptual framework for the schedule development process.

is performed by top management collectively. There is a chief architect, to be sure—the **scheduling department**, headed by a vice-president or director, depending on the size or organizational makeup of the company. With the exception of some of the major carriers, which include scheduling as part of the corporate economic planning administration, most scheduling departments are under the marketing administration because of the overriding importance of service to the public. In developing a system flight pattern or *schedule plot*, as it is sometimes referred to, the scheduling department works closely with all other departments and with all field stations.

In addition to its own continuing review, the department continually receives suggestions and proposals from local-station personnel and the public. With knowledge of traffic volumes and patterns, numbers and types of aircraft on hand and to be delivered, maintenance requirements, operational factors, and scores of other considerations, the scheduling department, after weeks and often months of planning, develops a proposed system schedule. This is then submitted to all appropriate departments for study.

Many airlines use the **committee system**, in which officials from all operating departments meet to analyze the proposed schedule, make suggestions, and resolve conflicts between departments. Whether the committee system or some other method of interdepartmental coordination is employed, the result is the same: a schedule that meets the combined goals of public service, sales and competitive effectiveness, profitability, and operational dependability and efficiency.

EQUIPMENT MAINTENANCE

The primary purpose of the maintenance organization of an airline is, of course, to provide a safe, salable aircraft for every schedule. This would be simple if the carrier had an unlimited number of airplanes, unlimited facilities, and unlimited personnel—all located at every point on the system. But it does not, and so it must strive for a number of **maintenance efficiency goals:** (1) minimize aircraft out-of-service time, (2) use up time allowable on aircraft and parts between overhauls, (3) seek optimum utilization of personnel and even workload, and (4) maximize utilization of facilities. These goals do not affect safety, of course—safety can never be sacrificed to meet a schedule. You can see, however, the implications these goals have for the schedule planner. Let's examine them closely.

- 1. *Out-of-service time.* Because the profitability of an aircraft depends to a large extent on its daily utilization or availability, the carrier must do everything it can to design a maintenance system that provides a high standard of maintenance yet minimizes out-of-service time. If this can be done only at the expense of safety and dependability considerations, the airline must either reduce planned aircraft utilization to allow adequate maintenance or improve the product until it meets the goals.
- 2. *Allowable time.* The carrier should utilize the maximum time allowable in the various inspection and overhaul programs. This item represents a very large cost variable in an airline's operation. Again, however, this must be done with the first objective in mind—minimum out-of-service time.

- 3. *Personnel and workload.* In performing any inspection, repair, or overhaul, the carrier requires either FAA-licensed personnel or highly trained specialists—engineers, planners, inspectors, and a host of others. Because the overhaul base payroll for a major air carrier runs into millions of dollars each year, it is important to keep costs down if the carrier is to achieve maximum utilization of its people. An airline also must maintain an even work flow, because these specialists and technicians require a high degree of training and experience and are not readily available in the open labor market.
- 4. *Use of facilities.* The carrier must utilize facilities to the maximum extent possible, because of its substantial investment in buildings, tooling, and specialized equipment.

Let's examine a hypothetical maintenance system and some of the problems of maintenance scheduling. Table 12-1 lists the various inspection and overhaul periods used today for a large jet aircraft, including the time between inspections, the hours required to accomplish the work, the elapsed or out-of-service time required, and the work performed. Here, we have assumed a normal amount of nonroutine, unscheduled work. In order to provide maximum flexibility for aircraft routing and to keep the maintenance system as simple as possible, the maintenance department attempts to schedule all new or revised maintenance needs into these maintenance inspection periods. The only exceptions are the engines and other expensive components, such as the turbo-compressor or auxiliary power unit. In these cases, the time is monitored on each unit and the unit is overhauled when it reaches the specified time. Note that these numbers are never static, because

Inspection	Time Between Inspections	Labor	Duration	Work Performed
En route service	Each stop	1 hour	1/2 hour	"Walk-around" — visual inspection to ensure no obvious problems, such as leaks, missing rivets, or cracks
Overnight	8 hours	Varies	Up to 8 hours	Ad hoc repairs – work varies
A-check	125 hours	60 hours	8 hours	Primary examination — fuselage exterior, power plant, and accessible subsystems inspected
B-check	750 hours	200 hours	Overnight	Intermediate inspection — panels, cowlings, oil filters, and airframe examined
C-check	3,000 hours	2,000–12,000 hours	5 days	Detailed inspection — engines and components repaired, flight controls calibrated, and major internal mechanisms tested
D-check	20,000 hours	15,000–35,000 hours	15–30 days	Major reconditioning — cabin interiors removed, flight controls examined, fuel system probed, and more

 TABLE 12-1
 Maintenance System for a Jet Aircraft (hypothetical example)

maintenance continually revises the work to be accomplished and the work is periodically evaluated, based on service experience as well as the experience of other operators.

Figure 12-2 shows the maintenance capability of the various stations on a major carrier's system. A similar setup exists on every major airline. On this map, the blocks indicate the type of work or inspection that can be performed at the various stations. There are two items to consider: (1) any station accomplishing service or maintenance checks requires not only hangars and tooling but also millions of dollars in spare parts (for a major carrier), and (2) each station also requires highly skilled mechanical and technical personnel. As Figure 12-2 shows, there are eight stations capable of accomplishing B-checks and three stations capable of doing C-checks. In addition, the overhaul base is located at San Francisco.

To further illuminate the problems involved in maintenance routing, Figure 12-3 shows the planned routing pattern for a 757 on a major carrier's system, including the various points at which the necessary inspections can and will be conducted. Because the inspection periods allowed are maximum times, the aircraft router must have the airplane at an inspection station before its time expires, or the carrier must obtain a ferry permit from the FAA to move the airplane to the correct station.

This pattern, which is ideal, shows the problem that exists if the airplane has a mechanical breakdown, for example, in Des Moines (DSM) or is affected by weather at that point. The router must then substitute another aircraft for the airplane in question. Moreover, a tied-up airplane is now off the track that was designed to allow the carrier to accomplish all required inspections and component replacements and to time engine changes with maximum utilization of the overhaul period.

Schedule planners must take into account the maintenance department's plans and systems for efficiency. Of course, this is a two-way street. When the maintenance organization makes certain changes in the way it does things, this, too, can affect the scheduling department. Therefore, the maintenance people and the scheduling planners in any airline maintain a close, day-to-day relationship.



FIGURE 12-2 Maintenance facilities (hypothetical case).



FIGURE 12-3 Boeing 757 routing pattern (hypothetical case).

FLIGHT OPERATIONS AND CREW SCHEDULING

Because airline schedules, once published, must be flown by the company's flight crews, the flight-operations department must ensure that flights are scheduled in a fashion that will permit them to be safely and efficiently operated. The following **operational factors** are important in schedule planning:

Airport runway lengths Aircraft fuel capacity Habitual adverse weather Air traffic control and routings Crew time limits Employee agreements

Obviously, airport runway lengths, aircraft fuel capacities, and so forth affect scheduling decisions. Other less obvious but equally important factors in drafting schedules include weather, aircraft routings, and flight crew scheduling.

In this sense, the term *weather* is used to describe the type of condition that occurs ordinarily at a specific locale during certain times of the day or seasons of the year. For example, in winter months, weather may make it inadvisable to overnight an aircraft in a particular northern city where hangar facilities are not available. Although overnighting might facilitate the operation of a desirable late-evening arrival and early-morning departure, the need to remove snow and ice from the aircraft after a storm might make such an operation impractical. Certain areas of the country, such as the Gulf Coast, do not lend themselves to dependable on-time or safe operations because of the likelihood of fog from shortly after midnight until sometime before noon. Often, flights scheduled during this period must be delayed or canceled or, if operated, restricted in load because of the excess fuel reserves required for safety.

A second operational factor concerns air traffic control (ATC). ATC routings often dictate longer flight times between two points than normal. In addition, certain flight segments are subjected to route closures and resultant time-consuming and costly diversion by military actions.

One of the most important and complex factors affecting flight operations is that of crew assignment to specific flights. The working limitations that govern flight crews are found in both the Federal Aviation Regulations (FAR) and employment agreements. The FAR limits are as follows:

- 1. There is a daily limitation of 16 hours maximum flight duty time for pilots on a twoperson crew, unless, prior to exceeding 16 hours, a rest period is provided of no less than 10 hours. Therefore, an increase of only a few minutes to a schedule, or the addition of one extra station, might force a crew break and layover not otherwise necessary. Duty time includes planned flight time, taxi time, known delays, and debrief time. After push back, the pilot must return to the gate if extended ground delays would cause duty to exceed 16 hours at the estimated release time.
- 2. Flight crew members must have had at least 8 hours of rest in any 24-hour period that includes a flight time.
- 3. Flight crews may not exceed a maximum of 40 flight hours during any seven consecutive days. Release from all duty for 24 hours must be granted to each flight crew member during any seven-consecutive-day period.

Employment contracts compound the difficulties. Most airline contracts provide that one hour of flight pay must be paid for every four hours a pilot spends away from the domicile. This time is frequently not flown; therefore, pilots are frequently paid for time not flown. These contracts also require that the airline bear the expense of training otherwise unneeded crews. And most airline agreements provide a maximum of 80 hours flight time during any month for their pilots.

An operations manager's dream is to be handed a schedule that permits all crews to operate flights on a direct turnaround basis with no layover problems or expense. This is manifestly not possible, but every attempt must be made in the interest of crew utilization and economy to minimize layovers. Average flight crew utilization for some of the major carriers with intricate route structures goes as low as 55 hours per crew member per month.

Seniority, labor's most valued asset, is management's biggest headache when it comes to training and assigning flight crews. The newer, faster planes generally are flown by the most senior crews, who earn the highest wages. Therefore, moving down through the ranks, the most junior captains and first and second officers fly the smaller, slower planes.

Were all crews based at a single location, the job of scheduling would be much easier. This is not, however, physically or economically practical, and so the majority of airlines assign crews to fly from one of several individual crew bases. A typical major carrier may base crews at only 7 of the 40 cities serviced. Which flights are to be flown by crews from which bases are determined by the company, but many factors influence such decisions. The equipment qualifications of the crews already assigned to each base, the crew expenses incurred if the flight is flown from that base, the seniority of the crews compared with those at other bases on the flight route, the likelihood of crews requesting reassignment if trips are not to their liking—all of these factors enter into a decision. An airline has to take a good hard look before implementing a schedule that will require additional crews to be trained when sufficient numbers already exist to meet the maximum utilization of the available equipment.

GROUND OPERATIONS AND FACILITY LIMITATIONS

Ground service can be arranged in any conceivable schedule pattern, provided that there is no limitation on the gate positions, ground equipment, passenger service facilities, and personnel. But, of course, there are limitations. First, it is physically impossible to obtain adequate facilities in many instances within a reasonable period of time. For example, additional gate positions at Fort Lauderdale/Hollywood International Airport are virtually impossible to obtain. Second, there is the matter of cost. The schedule planner must do the utmost to avoid excessive flight congestion, in view of such cost items as these:

\$400,000 for ground support equipment at an intermediate station, and approximately double this figure for two jet flights at the same time

\$2 million for construction of each added gate position, including the loading bridge, at a typical major airport

The objective of ground service, then, becomes to accommodate as many flights as possible and as efficiently as possible, consistent with physical limitations and prudent utilization of personnel and equipment. The schedule planner must consider all of the following at every station for every proposed schedule:

- 1. Are there enough gate positions for the number of planes on the ground simultaneously, including a cushion for early arrivals or delayed departures?
- 2. Is there adequate ticket-counter space to handle the passengers expeditiously?
- 3. Is sufficient time provided for on-line or interline transfer of passengers, baggage, mail, and cargo?
- 4. Can the planned flights be handled efficiently by the present level of ticket-counter, ramp, and food service personnel? If not, will additional revenue from the new flights or the new connection be sufficient to more than offset the cost of additional personnel?
- 5. Will the proposed schedules introduce a second or a third personnel shift? Conversely, will a minor flight adjustment permit the reduction of one shift?

6. Is there ground equipment of the right type: aircraft starter units, baggage vehicles, cargo conveyors, forklifts, tow tractors? If not, is there sufficient lead time to purchase them, and can they be economically justified? Should the carrier contract these services from another carrier because of the small number of flights into a particular station?

7. Does the proposed schedule overtax food service facilities?

These and many other questions must be answered for every station on the system for every schedule change. Any corrective action—and there is always a need for flight adjustments to meet ground service requirements—must be rechecked to determine its effect on the delicate balance worked out to accommodate sales, maintenance, and operational needs and to make sure that corrective adjustments at one station are not creating complications at another.

Normally, the scheduling department measures the physical and personnel requirements with a visual layout of the schedules at each station. All flights are plotted on a **station plotting chart** that documents sequence and schedule time of operation using certain standards and codes (see Figure 12-4). It shows precisely the amount of time an aircraft requires to maneuver into a gate position, the scheduled arrival time, the period of time it is at the gate, its scheduled departure time, and the length of time needed to clear the gate. The chart also shows whether it is an originating flight, a through trip, a terminating flight, or a turnaround. Figure 12-4, a section taken from a schedule pattern, illustrates peak and valley periods at the hypothetical All-American Airport (AAA). It illustrates clearly one of scheduling's biggest headaches—peaking, or multiple operation. Such peaks must be reduced wherever possible to achieve the goal of optimal utilization of personnel and equipment without sacrificing service or revenue.

After posting proposed flight times on this chart, the scheduling department must first determine that it has not exceeded the gate capability. Therefore, the first adjustments are those necessary to bring schedule times into line with available physical facilities. At AAA, for example, the carrier has four gate positions. At around 8:00 A.M., they are all



FIGURE 12-4 Station plotting for the hypothetical All-American Airport.

full. Obviously, any additional flight would have to be scheduled either before or after this peak period. On the other hand, if the additional flight is more important than the existing flights, then the carrier must consider moving an existing flight earlier or later.

Scheduling is sometimes restricted by ticket-counter space. For example, if a carrier had only four ticketing positions at a major location and one ticket agent could check in about 20 passengers an hour, the four ticket positions could handle one 757 flight. But if the carrier wanted to schedule three jet departures within a 45-minute period, it would have several alternatives. The carrier could, of course, go ahead and schedule these three flights, at considerable inconvenience to the passengers—forcing them to stand in line much too long—as well as at risk of jeopardizing on-time departures. The preferred solution would be not to schedule the two added trips until the carrier had expanded its ticket-counter facilities.

Station staffing is determined by application of time-study standards and formulas. These have been developed and are applied much the same as any manufacturer's production line time and workload standards. Schedulers use separate standards and formulas for ticket counters, ramp and load control, ramp cargo handling, food service, and freight facilities.

Like personnel staffing, flight peaking presents a major problem for the efficient utilization of ground equipment. Ground equipment costs to handle peak traffic can run into the millions of dollars at any one location. Understandably, carriers are anxious to reduce these requirements if they can do so without affecting other costs or revenues or service. Whenever a carrier changes schedules or adds flights, adequacy of ground equipment must be checked closely, not only because of expense but also from the standpoint of lead time.

In conclusion, the schedule planner contends with a variety of challenges in the ground operations area, many of them conflicting. Scheduling is literally hemmed in by space limitations. Yet planners must find gate positions for the essential flight complexes. They must keep personnel costs at a minimum but at the same time staff for flight connection opportunities to maximize service to the public. And they must avoid new capital outlays for expensive ground equipment yet do everything possible to enable flight peaking at times when passenger demand is greatest.

Every situation has to be studied separately at each of the carrier's stations, with every item of added cost weighed against the estimated added revenue. No decision can be made without carefully assessing its consequences.

SCHEDULE PLANNING AND COORDINATION

Thus far, we have discussed the particular problems faced by maintenance, flight operations, and ground operations. Each offers a multitude of requirements for the schedule planner to take into consideration. The responsibility for schedule development is the province of the scheduling department, which is generally within the marketing administration and which oversees the entire system. This department must pull together all of the factors discussed so far, plus many more. Just how a carrier goes about this task is the focus of this section.

Nothing is more basic to an airline than the schedule pattern it operates. All productive resources—planes, trained personnel, and ground facilities—have the one essential function of operating the schedule safely and dependably. All selling resources—the

carrier's ticket offices, reservations offices, sales representatives, marketers—have the one essential function of getting passengers and shippers to use the schedule. Let's take a look at some of the problems and complexities of developing a sound overall schedule pattern in these hectic postderegulation times.

At the outset, let us recognize the sheer impossibility of developing a schedule pattern that will simultaneously satisfy all desirable objectives. Many of these objectives are inherently in conflict. For example, a carrier must provide enough time on the ground for maintenance and servicing operations while at the same time keeping aircraft in the air as much as possible for economical utilization. It must build up complexes of connecting flights at major gateways while at the same time avoiding excessive peaking of station activity. It must maintain schedule stability for the convenience of passengers and the optimal utilization of employees while at the same time displaying the flexibility needed to adjust rapidly to new competitive threats or other developments. It must recognize that public service obligations will sometimes work against strictly economic considerations while at the same time remembering that it could not provide any service without a sound financial position.

Probably the schedule planner's most important function is to evaluate all of these varied and partially conflicting objectives and come out with the optimal balance between these several goals. Some of the problems faced by a schedule planning department are comparable to those that many other industries face in their own respective product planning:

- 1. Determining the size of a given market and projecting its future growth
- 2. Estimating the effect of planned product changes on the size of the total market and on the carrier's own share of the market
- 3. Attempting to forecast what the competition may do and developing a plan of action to meet such competitive thrusts
- 4. Estimating the costs and revenues of the alternative plans of action to determine which will be profitable

But the complexities of airline scheduling extend far beyond these problems. Many airline marketing problems are unique, stemming from the special nature of the business. Principal among these are (1) the problem of traffic flow, (2) the sensitivity of schedule salability to even minor differences in departure times or other factors, (3) the operational difficulty of accomplishing schedule adjustments as desired, because of problems of time zones, station personnel, equipment turnaround, and the chain reaction effect, and (4) the financial leverage of load factors.

Traffic Flow

The concept of **traffic flow**—or the number of originating and connecting passengers on a particular route—is widely recognized; the degree of its importance is not sufficiently understood. Smooth traffic flow helps to explain schedules that seem quite excessive in relation to origin-destination traffic. Let's take a hypothetical example of a 737 operating from Chicago to Detroit, Rochester, and Syracuse (see Figure 12-5). This flight averages





FIGURE 12-5 Traffic flow (hypothetical data).

about a 60 percent load factor on the leg from Detroit to Rochester, but this is possible only because of four separate, and almost equal, traffic flows. No single traffic flow, or combination of two traffic flows, would be adequate to support economical service. By the same token, this flight could not economically overfly Detroit or Rochester, as there would not be enough traffic flow remaining.

The schedule planner must take advantage of traffic flow opportunities but cannot wave a magic wand to create such opportunities. By its very nature, traffic flow varies from case to case, depending on geography, route structure, and alternative service available. Some cities, because of favorable geography, obtain maximum benefit from traffic flow; others do not. An airline cannot change this, and a carrier cannot generalize that City A can support a certain type of service simply because City B receives such service.

A few years ago, a route such as Chicago–Los Angeles received traffic flow support from the Los Angeles-bound passengers coming from major points in the northeast, including New York, Boston, Philadelphia, Cleveland, and Washington, D.C. Today, direct nonstop service from these other points to Los Angeles has drained away much of the traffic flow that formerly moved over the Chicago gateway. And this same development is taking place continuously throughout the air transport system.

This constitutes another reason for the impossibility of generalizing about traffic flow and about the type of service a community can economically support. Not only does traffic flow vary from city to city because of geography and route structure, but even for a single city the flow varies from year to year, depending on the type and volume of nonstop service that may be bypassing that city.

Schedule Salability

The second of the special complexities of airline scheduling is the fact that schedule salability is highly sensitive to even minor differences in departure time or other factors. Quite often, several key personnel will spend several days trying to work out a change of just 15 minutes or half an hour in the departure time of a transcontinental jet. This is not time misspent; experience has shown that even such minor adjustments can significantly affect the success of a flight.

The reason is that schedule convenience ranks high among the competitive elements affecting the traveler's choice of an airline. Loyalty to a particular airline will not normally cause a passenger to sit around an airport an extra hour or to miss a business appointment or to wake up earlier than usual if a competitor offers a viable alternative.

The speed of today's jet aircraft has intensified the importance of specific departure times. The difference between a 5:00 P.M. and a 6:00 P.M. departure was of minor consequence for a traveler confronted with a three-day transcontinental train trip. Nor did it make much difference when the industry was dealing with DC-3s that took 20 or so hours to fly coast to coast. But the same one-hour difference becomes vastly important with today's jets, when New York and Los Angeles are separated by less than five elapsed hours and by less than three hours on the clock.

The continual extension of nonstop service has also increased the importance of specific departure times. Thirty years ago, Boston–Los Angeles service involved one-stop schedules through Chicago. Those schedules were not entirely dependent on Boston–Los Angeles traffic, and if departure times were not ideal for such through traffic, they might nevertheless have been quite good for local Boston–Chicago or Chicago–Los Angeles passengers.

Let us consider some examples showing the sensitivity of schedules to differences in departure times. A 757 operates from Chicago to New York at 7:00 P.M., 8:00 P.M., and 9:00 P.M. But the 9:00 P.M. flight carries only about two-thirds the load of the flight that departed one hour earlier and only half the load of the flight that left two hours earlier (see Figure 12-6).

Let's take another example. An airline flying from Louisville to New York is forced to shift a flight 20 minutes later, from 5:15 P.M. to 5:35 P.M., due to equipment routing. The city manager in Louisville advises that this will cause the airline to lose an average of about 10 passengers per day to a competitor's 4:45 P.M. flight. However, the carrier has no practical option but to make the change (see Figure 12-7).

To make schedule planning even more complicated, schedule salability not only varies by time of day and by route but also has a different pattern of variation between the two directions on the same route. For example, between Hartford and New York, an airline might obtain a much higher volume of traffic on a late departure northbound out of New York than it does on a late trip southbound out of Hartford (see Figure 12-8). Nor does the sensitivity of schedules stop with the matter of departure time. Schedule salability also varies with airport. An airline might have a 4:40 P.M. flight from Newark to Boston, followed 15 minutes later by a departure from another New York-area airport, La Guardia, to Boston. The load factor on the Newark trip might be about 20 to 30 percentage points below that of the La Guardia trip (see Figure 12-9).



FIGURE 12-6 Schedules are sensitive to departure time (hypothetical data).



FIGURE 12-7 Schedules are sensitive to changes (hypothetical case).

By now, one important point should be emerging from this discussion. Although there is often a tendency to think broadly of airline capacity in terms of total seat-miles, a carrier actually deals with a highly varied product line. Every schedule an airline operates is a separate product, having its own special market and salability. And as competition gets ever more intense, the importance of even minor schedule changes becomes correspondingly greater, making the job of scheduling more complicated.

At this point, the question may arise as to why it should be particularly complicated to adjust schedules to achieve maximum salability. If a 15-minute or 30-minute change in departure time would significantly improve the salability of some schedule, why not simply make that minor change? This question is a logical one, and it leads to a discussion of the third of our general complexities of airline scheduling: the operational difficulty of accomplishing schedule adjustments as desired, even when the adjustments seem minor.





	Load Factor to Boston			
Flight A departing Ne	Flight A departing Newark	6	65 percent	
	at 4:40 P.M.			
	Flight B departing La Guardia			95 percent
аt 4:45 р.м.				

FIGURE 12-9 Schedule salability varies with the airport (hypothetical data).

Schedule Adjustments

An airline's total schedule pattern represents a tightly woven, highly interrelated structure. Many aspects are rigidly governed by specific regulatory or contractual requirements, such as those relating to maintenance of equipment, and working conditions of flight crews, as discussed earlier in the chapter. Moreover, almost every schedule is intertwined with other scheduled flights because of connections, equipment routing, or other factors. These other flights come from, or go to, such scattered points as Buffalo, Chicago, Hartford, Washington, Charleston, and Dallas, and more often than not, the ability to reschedule these other flights is limited and a change would create new problems elsewhere. Let's look at some hypothetical examples of the limiting factors at La Guardia Airport:

- 1. Flight A is our 5:00 P.M. departure to Chicago and is part of our hourly pattern of service on that route.
- 2. Flight B operates on the New York–Cincinnati–Indianapolis–Chicago route. If this flight were moved back, a gate-congestion problem would develop at Cincinnati.
- 3. Flight C is part of our hourly pattern of service from New York to Boston.
- 4. Flight D is a multistop coach from Dallas and Memphis. If it operated later, gate congestion would develop at Memphis.

Obviously, these limiting factors do not mean that it is impossible to move a hypothetical Flight E by 15 minutes. They do indicate, however, that even seemingly minor adjustments have a way of setting off chain reactions, which, in this case, might affect Flights A, B, C, and D.

Time Zones. An important factor affecting schedule actions is the **time zone effect**. The fact that we gain three hours on the clock going westbound and lose three hours coming eastbound has a major impact on scheduling a jet fleet. An eastbound nonstop jet from Los Angeles to New York takes eight hours "on the clock": five hours of flight time plus three hours lost crossing time zones. Most passengers do not like to arrive at their destination close to or after 11:00 P.M. They would usually prefer to fly overnight and arrive early in the morning.

With the eight-hour clock time, any Los Angeles departure at or after 4:00 P.M. means a New York arrival at or after midnight (see Figure 12-10). For all practical purposes, therefore, the period from 3:00 P.M. on is unusable for salable eastbound nonstop



FIGURE 12-10 Time zone effect on schedules.

departures. Then, beginning at about 11:00 P.M. Los Angeles time, the carrier can schedule the overnight flights. And after that, it will again have an unusable period, lasting until about 8:00 the next morning. Thus, the carrier's choices of salable eastbound departure times are effectively limited to the period from about 8:00 A.M. to about 3:00 P.M. and then at about 11:00 P.M.

But one other fact must be noted. Equipment starts arriving at Los Angeles from New York's morning schedules shortly after noon. Allowing time to service and turn the equipment, the planes become available for return trips at about 2:00 P.M. This, coupled with the other factors, determines the pattern of service that can economically be operated: early morning service with equipment that terminated in Los Angeles the night before; then service at around 2:00 P.M. with equipment that came from the east the same morning; finally, the 11:00 P.M. departures with equipment that came from the east in the afternoon.

Station Personnel. Still another factor that affects scheduling is the need to minimize the peaking of personnel and ground equipment. An extra ground crew for a jet operation requires 10 to 12 people and an annual payroll of \$400,000 or more. Wherever the carrier can feasibly avoid having two operations scheduled simultaneously, and thus can gain use of a single ground crew for two schedules, the carrier will naturally try to do so. This objective is, however, inherently in conflict with a marketing goal of maximizing connections. The carrier therefore has to find the balance between these two conflicting objectives.

The scheduling department staff cannot always tell at a glance from its own schedule plans whether it is creating an inefficiency of personnel utilization. Figure 12-11 shows the station activity chart used by local-station management to translate the impact of a given schedule pattern into staffing workload, by hour of day. This particular example shows the cabin service workload at a local station. Through split shifts and other arrangements, such as part-time personnel, local-station management can frequently handle what looks like a schedule peak without actually incurring a personnel peak. Unfortunately, the reverse situation also occurs: a schedule pattern looks like a smooth workload but in fact involves a peaking requirement of station personnel. In such cases, the station will ask to move Flight A by 15 minutes or Flight B by a half-hour in order to avoid inefficient use of



FIGURE 12-11 Local-station activity chart for airplane cleaners (hypothetical case).



FIGURE 12-12 Staggered arrivals and departures of afternoon jet service avoid costly duplication of ground crews and ground equipment (hypothetical case).

personnel. Then, of course, this adjustment of Flight A or B may create new problems for other stations, which may require still other flights to be adjusted, and so on.

This situation becomes especially problematic at stations where the carrier has only a limited volume of jet operations and where it would be especially inefficient to have this limited volume peak at one particular time. As an example, consider the departure and arrival times of an afternoon jet scheduled into St. Louis (see Figure 12-12). There presently is a gap of 27 minutes between the departure of Flight A and the arrival of Flight B. Now suppose that for some reason—possibly gate congestion at some other station—the carrier had to move Flight C up a half-hour. To do so would create simultaneous jet operations at St. Louis, making it no longer possible to handle the station with a single jet ground crew.

Equipment Turnaround Time. Let's now touch on one more factor affecting scheduling flexibility—equipment turnaround time requirements. At the end of every trip, certain

operations must be performed, such as cabin cleaning, refueling, and catering. Standards have been established for the *turn time* required for different planes on different-length hops. On top of these minimum requirements, the scheduling department must build in another factor as a cushion for the possibility of late arrival.

Quite often, an airline will find itself in the frustrating position of having equipment sitting idle on the ground at some station, with enough time available to fly the plane to some other point and back, but without enough time on the ground at the other point for adequate turn time. Lacking this extra hour or so, the carrier has no alternative but to leave the plane sitting on the ground, possibly for several hours.

Chain Reaction Effect. Thus far, we have discussed each of these operational marketing factors as separate and independent variables. Actually, however, several of them are usually present in a single schedule situation, thereby increasing the complexities in geometric proportion. Because of the interrelationship among gate congestion, maintenance routing, and other factors, a single schedule action frequently sets up a **chain reaction effect** requiring many other schedule changes. As an example, let's look at Flight A, a 757 operating from Dallas to New York via Little Rock, Memphis, and Nashville (see Figure 12-13).

At its Dallas origination, this flight receives connections from eight inbound flights in the Dallas gateway. When it gets to Memphis, it receives connections from four flights of other carriers and also delivers connections to seven other flights. In addition, its arrival and departure times at Memphis tie into gate occupancy with other flights going through that station at about the same time. When it gets to Nashville, the flight delivers connections to three other flights. Finally, when it gets to New York, it delivers passengers to seven flights, and the equipment then turns back out as scheduled Flight B to Chicago. If the carrier had to change this flight schedule at any point, it would potentially mean



FIGURE 12-13 Chain reaction effect (hypothetical case).

making many changes in other flights to preserve connections, avoid gate problems, and so forth.

Load-Factor Leverage

Now let's turn to the last of the special complexities of airline scheduling, the problem of load-factor leverage. One of the unfortunate facts of the airline business is that the carriers produce revenue passenger miles but sell available seat-miles—hence the importance of load factors. In other industries, a manufacturer can estimate the probable market for each individual product and then gear production accordingly. And, if overestimation has occurred, the manufacturer can add the surplus to inventory and dispose of it, perhaps at a reduced price.

An airline has no similar opportunity. It may be convinced that, say, a given nonstop jet to Los Angeles will average only 80 to 90 passengers per day. Nevertheless, if it operates the schedule, it must fly a seat-mile including 230 seats. And, of course, once it produces the empty seat-miles, they are irretrievably lost.

Costs of operating a schedule vary only slightly as load factor changes, whereas revenue varies in direct proportion to changes in load factor. Thus, a shift in load factor of only a few percentage points can make all the difference between a money loser and a profitable trip.

There is another way to dramatize this point. The sensitivity of schedules to even minor changes in departure times has been mentioned. Let's assume that we were unable to accomplish one of the desired changes in the departure of a Chicago–Los Angeles jet and as a result lost a daily average of 10 passengers per trip, most of whom would probably be lost in the opposite direction as well. These 10 daily passengers would represent an annual revenue of over \$1 million:

1 coach-class passenger	\$	300
10 coach-class passengers	\$	3,000
10 daily coach-class passengers for 30 days	\$	90,000
10 daily coach-class passengers for 365 days	\$1	,095,000

Because costs would not be materially changed, it can also be said that these 10 daily passengers would represent a reduction of over \$1 million in operating profits. This, then, may start putting into focus why airlines will go to such lengths to work out schedules to maximize their salability and why they do not take lightly requests from city managers for even a 10- or 15-minute change in a schedule.

We can look at the financial implications of our schedule action in still another way. Let's consider the total cost of operating a transcontinental jet schedule. In a year, a single daily round-trip between New York and Los Angeles costs over \$1.5 million. Assume that the carrier adds such a trip that is not really required and that is not likely to get any significant amount of new business to help pay its way. In that case, this cost becomes straight operating loss and a sheer economic waste. The economic waste involved in an unnecessary airline schedule is rarely appreciated, possibly because the waste in an airline schedule does not leave tangible physical evidence. At the end of the year, the unused seat-miles cannot be seen gathering dust in a warehouse.

Referring to the scheduling process, a planner was once overheard to say that "our job is like trying to put together a jigsaw puzzle, constructed in three dimensions, while the shape of key pieces is constantly changing." The fact that salability of an airline's product is sensitive to even minor changes would be no serious problem if the carrier had the flexibility to make these changes readily. Or carriers could live with the dual problems of sensitivity of schedules coupled with the difficulty of adjusting schedules without too much strain were it not for load-factor leverage. Then it would be possible to adjust capacity on any given schedule to the level of traffic the carrier thought it might get for that particular trip. But when all of these factors are taken together—the sensitivity of schedules to even minor changes, the difficulty of adjusting schedules, and the tremendous financial impact of losing even a few passengers—the full measure of the difficulty becomes apparent.

Putting Together the September Schedule

Normally, a carrier publishes a new schedule six or seven times a year, generally on a bimonthly basis. During an average year (the last several have been anything but average), the spring and fall schedules are the primary ones.

Schedule building never really starts from scratch. Data are continuously fed into the scheduling department from regional sales and services, as well as from the other major operating departments. These new data are added to the basic body of knowledge that the scheduling department has about the airline's scheduling patterns and the numerous factors involved. The schedule that emerges is the product of continual refinement.

Let's take a look at an example of a carrier attempting to put together a schedule for September 1, 20XX. The compilation and meshing of data begin around April 1. In our hypothetical case, a number of major marketing considerations have to be looked at by the scheduling department in preparing the September schedule:

- 1. The addition of two A320s
- 2. The need to return service to the point it had reached before the terrorist attacks of September 11, 2001, which had necessitated schedule cuts
- 3. Creation of a fourth connecting bank of flights in Buffalo
- 4. Addition of new hourly service between Pittsburgh and Chicago, based on more single-plane service through Pittsburgh
- 5. Restoration of Boston–Philadelphia and Pittsburgh–Philadelphia hourly frequencies

These are but a few of the objectives that top-level marketing management has set for scheduling in preparing the September schedule.

The scheduling department generally submits its proposed schedule to all operating departments 60 days before the effective date. About a week after the distribution, the interdepartmental meetings begin. The conference room adjoining the scheduling department, where the meetings are generally held, looks like the war room from a World War II movie. Station charts with the proposed schedule are taped on every spare inch of wall space. A typical meeting in the early stages of negotiation might include 10 to 20 management personnel representing all of the operating departments.

The scheduling department may make concessions when suggestions by other departments are backed up with the realities of operational requirements. But, in general, the scheduling department must remain firm. If it does not, the entire schedule—the results of months of planning—may suffer. Problems might involve such things as sufficient turnaround time or separation between flights. For one reason or another, including personnel, gate availability, or vehicles required, customer services or line maintenance might argue that they need more time between flights. Often, calls will be made to field personnel during the meetings to get their input: "Can you handle it? If not, what do you need?"

Another major factor in setting the September 1 schedule might be the goal of increasing the carrier's on-time performance. Economic planning might have performed a special study to determine what was causing delays. Late-arriving passengers, weather, cargo loading, maintenance, and other factors all play a role. The results would be integrated into the September 1 schedule.

At this stage, the scheduling department cannot afford to give away large chunks of time. It tries to take into account the peculiarities of each station's operational capacity and to trade in no larger than five-minute increments. Customer service gives a little, line maintenance backs off on its demands, and scheduling adds a couple of minutes along the aircraft's route. Flight operations agrees.

Another problem at one of the departmental meetings might involve a joint marketing program with one of the international carriers. Let's suppose the carrier has a flight to Kennedy Airport in the September 1 schedule that connects with a flight to London, whose time was to revert to standard after the schedule was published. Scheduling might have to change this flight at a later date.

Other problems might include the time required by maintenance for an aircraft en route check, an additional five minutes needed to accommodate a bus transporting commuter passengers at O'Hare Airport, or a 737 wingspan too wide to accommodate three planes simultaneously at La Guardia Airport's Gates 20 and 21, as the schedule calls for.

The meetings go on until a general consensus is reached. Even then, most schedulers admit that the final product is a compromise at best—the best possible under the marketing and operating criteria set forth.

As a carrier grows, the scheduling process becomes more complicated. Computer models are used quite extensively by the major carriers, but they have not eliminated the meetings that scheduling must have with the operating units to work out specific problems.

EQUIPMENT ASSIGNMENT AND TYPES OF SCHEDULES

The scheduling department will generally refer to aircraft throughout the system as being operated in either *in-service* or *out-of-service use*. In-service use refers to those aircraft being flown (1) on scheduled service, (2) as an extra section, or (3) as a charter flight. An *extra section* is an additional aircraft assigned to handle a particular flight because of an unusually large number of passengers. Out-of-service use refers to those aircraft temporarily assigned for major overhaul, maintenance checks, flight training, special projects, such as installing different seats, or line reserves. *Line reserves* are extra airplanes stationed at major terminals to be called on in the event of a problem with a scheduled flight.

Airlines use four basic schedule types in assigning their equipment: (1) skip-stop, (2) local service, (3) cross-connections (hub and spoke), and (4) nonstops. *Skip-stop* scheduling refers to the practice of providing service to points A, B, C, D, E, F, G, and so forth by scheduling flights in the following manner: A–C–E–G or A–D–G, or similar combinations in which one or more of the intermediate stations are "skipped," with service being provided by other flights. The principal advantage of skip stopping is to provide fast service to intermediate stations; the principal disadvantage is in not providing service between consecutive cities.

In *local-service* schedules, shorter-range aircraft make all stops on a segment and connect at larger intermediate stations with long-range aircraft. The principal advantage of local service is that it provides fast service between small intermediate stations and terminal points; the principal disadvantage is the change of planes involved.

Cross-connections (hub and spoke) are frequently used in schedule planning by all airlines. An example of a route over which this can be accomplished is the United Airlines route serving the principal cities shown in Figure 12-14. When a Washington–Chicago–San Francisco flight, a New York–Chicago–Seattle flight, and a Boston–Chicago–Los Angeles flight arrive at Chicago essentially at the same time, traffic can be transferred from one to another, thereby providing more daily service between points in the east and those in the west. This is the principal advantage, particularly if one of the flights is the only one to serve one or more of the stations; principal disadvantages are the change in planes and the congestion of traffic. (The next section discusses hub-and-spoke scheduling in more detail.)

Nonstops are being used more frequently than ever by the major and national carriers. The principal advantage is provision of fast service between terminal points; there is no real disadvantage, although, of course, no intermediate stations receive service on these flights.

Actually, all airlines have used and will continue to use all four major schedule types with variations to fit their individual needs. The types most adapted to a fleet of samerange airplanes are skip stopping and cross-connections; for a fleet of at least two general types of airplanes, all four schedule types can be used, with perhaps more emphasis on local service and nonstops.

From the passenger's viewpoint, the goal is safe, speedy, dependable, and comfortable service from point A to point Z. Safety is the overriding and controlling factor in all airline operations. To gain the other three in the greatest possible measure, the passenger naturally prefers (1) a nonstop flight from point A to point Z, or (2) if that service is not available at a convenient time, a through flight, or (3) if the journey can be speeded, a



FIGURE 12-14 Cross-connection (hub-and-spoke) service (hypothetical case).

connecting flight with adequate connecting time to ensure dependability and with fast equipment and as few stops as possible.

From an airline standpoint, the desire to meet every individual passenger's needs must be weighed against profitability. A nonstop flight costs less to operate from point A to point Z than one on the same type equipment that makes intermediate stops. If sufficient traffic demand is not available to justify nonstop operation, through service means that each passenger is handled only once and therefore costs are lower than they are on connecting service.

HUB-AND-SPOKE SCHEDULING

Deregulation has led to significant changes in the routings and schedule patterns of the carriers. A catalyst for these changes has been the greatly increased emphasis on hub-and-spoke scheduling. Deregulation eliminated airlines' incentive to dissipate their added revenues through wasteful expenditures on extra (and underutilized) flights along the route structure mandated by the CAB. In addition, deregulation allowed carriers to create new schedule patterns that lowered the costs of providing new flights.

In the past, there was constant pressure (from communities and from the CAB) for more and more direct point-to-point nonstops. If a carrier did not exercise its franchise of nonstop operations in a particular market, it risked having that community induce another airline to seek the unused authority from the CAB. This concept of nonstop obligation was carried right into the Airline Deregulation Act, which classified "dormant authority" as any route segment not then actually served nonstop and, as the first step toward liberalized route grants, provided for the transfer of dormant authority to other carriers.

Many city-pair markets, however, could not support nonstop service in terms of their own origin and destination traffic. Economic viability frequently depended on adding traffic flows from backup markets on either end of a nonstop route. In CAB route cases, cities often were added to a carrier's route system specifically for the purpose of providing enough traffic to make nonstop service viable. Because of the protection afforded by a regulated route franchise system, the backup markets for some nonstop routes could be expected to remain relatively stable over long periods of time.

In this framework, the airline route structure evolved gradually into many "linear" patterns, in which one city would mainly serve as backup to some specific route segment, while other cities would back up other routes, and so forth. With deregulation, carriers could no longer regard their backup traffic markets as stable or secure. There were, of course, some hub-and-spoke connecting operations, but their scope was limited by the route franchises then in effect.

In response to competitive pressures following deregulation, carriers rapidly replaced the old structure with a **hub-and-spoke system**. In hub-and-spoke systems, several points of departure are fed into a single airport (the "hub"), from which connecting flights transport passengers to their various destinations (along the "spokes").

Advantages of Hub-and-Spoke Systems

The main advantage of the highly developed airline hub-and-spoke operation is that it provides an enormous "multiplier" effect as to the number of city-pairs an airline can serve

with a given amount of flight mileage. This is demonstrated in Figure 12-15. The top portion of the chart shows eight hypothetical cities, linked in pairs with direct nonstop service. The number of city-pairs receiving air service in this pattern is four. The middle portion of the chart shows what happens if, with approximately the same amount of



Service via Cross-Connection (Hub)



Growth in the Power of a Hub

n Spokes	n(n - 1)/2 Connecting Markets	<i>n</i> Local Markets Terminating at the Hub	Total Markets Served
2	1	2	3
6	15	6	21
10	45	10	55
50	1,225	50	1,275
100	4,950	100	5,050

Source: Dennis and Dogaris (1989).

FIGURE 12-15 Multiplier effect of hub connections.

mileage flown, each city is linked to a centrally located hub.

With the permutation of routings possible via the hub, there would now be a total of 24 city-pairs served (the 16 city-pairs obtained by the connection linkage of each of the four eastern cities with each of the four western cities, plus the linkage of the four eastern and four western cities to the hub city itself). Obviously, this multiplication of traffic greatly increases the chances of obtaining strong load factors. Full airplanes result in lower costs, which permit lower fares, and these savings have also allowed the airlines to increase the frequency of flights.

Once a carrier establishes itself with a solid network of spokes at a particular hub, it becomes difficult for any other carrier to challenge it competitively, unless the other carrier has the resources to undertake a similar feed network. To attempt to compete on only one or two of the individual spokes into that hub becomes difficult, because the challenging carrier in this situation must rely mainly on just the local O & D traffic on those few segments while the hub operator can support a much broader pattern of service with the support of all of the "feed" traffic. By dominating a hub, an airline can also charge higher airfares to passengers originating from the hub region, thus achieving a greater potential for profits.

Hubbing also offers advantages to travelers. Passengers flying in low-traffic markets might not enjoy low airfares or fly in large jets if the airlines were to fly them nonstop between the end cities. Small planes cost more per seat-mile to operate and may require multiple stops for refueling. In fact, through multiple-hub systems, passengers from small cities can fly to any small or large city in the world with relatively low airfares. By connecting at a hub, passengers can also enjoy the convenience of frequent flights to and from that hub. This usually results in lower *schedule delay*, which is defined as the waiting time between a passenger's most desirable departure time and the actual scheduled flight. The use of large jets also increases travelers' chances of finding a seat on their desired flight.

Disadvantages of Hub-and-Spoke Systems

Although hubbing seems to benefit airlines and offers some advantages to travelers, the extent of excessive concentration at the hub can result in some negative economic impacts, namely, congestion delay. As aircraft volume approaches the capacity of the hub airport, congestion delay increases rapidly, which may outweigh some of hubbing's benefits to both airlines and passengers. This additional delay increases passengers' total travel time and adds to the airlines' operating costs (for example, wages for the crew and fuel and maintenance expenses for the airplane). Congestion during peak periods also puts a tremendous strain on airport and airline personnel. It requires maximal staffing for each 45-minute peak-staffing at the gate, on the apron, at the ticket counter, and at curbside. Moreover, for each city feeding into the hub, a separate gate is required, and adding more cities requires more gates.

On the tarmac, the launching of 30 aircraft within a 5- to 10-minute period can cause excessive taxi waits, forcing schedulers to build additional minutes into block times. During bad weather, delays at one hub airport create delays systemwide. The requirement that aircraft arrive at the hub at the same time is costly. Airplanes serving the shorter spokes must sit on the ground at the out-stations, often for hours, to compensate for those airplanes on the longer segments. Also, because scheduling into the hub is based on the times of the connecting complexes, actual departure times at the out-stations may not be the most convenient for the communities. Some portion of the potential local O & D market is at risk of being left unsatisfied. To compensate for this, some carriers have increased the use of the regional jet (RJ) concept. Consumer demand in out-station markets continues to grow rapidly as more and more passengers are flown from secondary locations through hubs and on to secondary locations.

Still another problem is baggage. Most complexes provide between 30 and 45 minutes for passengers to make their connections. When flights are late, however, there is very little leeway for the baggage to make the same connection. Passengers simply walk from one gate to the other and board their new flight. Baggage, on the other hand, must be off-loaded, sorted, transferred, and loaded aboard the new aircraft. When off-schedule operations occur, the 30- to 45-minute connecting time guarantees a high mishandledbaggage expense. Congestion delay also creates additional work for air traffic controllers and increases their stress levels. It may require upgrading the ATC facilities and adding more personnel at the ATC centers and airport towers. Finally, excessive aircraft concentration at the hub can have adverse environmental impacts, such as noise and pollution. These negative economic effects of aircraft concentration must be taken into account when conducting cost-benefit analyses into building or expanding major hubs.

DATA LIMITATIONS IN AIRLINE SCHEDULING

Since the early 1980s, sophisticated computer programs, which use complex mathematical algorithms, have been developed to address the complete scheduling task. The most widely used are those programs that assist with the mechanical complexity of assembling up to 1,000 flights, efficiently routing aircraft across flight segments, and assisting the carrier in meeting constraints imposed by such factors as maintenance requirements, flight operations and crew scheduling, ground operations and facility limitations, and passenger service needs. However, airline scheduling remains a function that involves as much art as science.

Although detailed traffic data are available on-line, historically, airline scheduling has been performed with limited sources of traffic data. Station managers observe competitor enplanements, and many carriers participate in informal information exchanges with one another. The problem with this type of information is that its accuracy is questionable and it is only available on an aggregate basis. The DOT forms 41, T-100, and Ten Percent Surveys of Domestic and International Traffic are basic schedule planning and route analysis tools, and although the information they provide is beneficial, there are problems concerning data accuracy and level of detail. For example, these sources provide limited information on flight numbers and passenger origins and destinations and are typically not available from the DOT until three to six months after the flight date.

The availability and presentation of these data by commercial information service organizations has improved significantly in recent years. The DOT data are available on easy-to-use CD-ROMs and can be abstracted readily for use by scheduling analysts.

Current data regarding international carriers are more difficult to obtain. Organizations such as the IATA and ICAO collect highly aggregated information that is generally not available for years. Not only is the information dated, it is often incomplete because of the reluctance of many carriers to share data for competitive reasons.

Advances in telecommunications and computer science are providing better information sources for the airlines. Along with better information, more sophisticated analytical tools are being developed using electronic data sources. However, even with new information resources and more sophisticated analytical tools, airline scheduling will continue to be a complex and challenging task.

KEY TERMS

scheduling scheduling department committee system maintenance efficiency goals operational factors station plotting chart traffic flow time zone effect equipment turnaround time chain reaction effect hub-and-spoke system

REVIEW QUESTIONS

1. What is the mission of scheduling? Discuss some of the external factors that schedule planners must take into consideration. Why do many airlines use the committee system to analyze a proposed schedule?

- 2. What is the primary purpose of engineering and maintenance and line maintenance with regard to scheduling? Discuss the four maintenance efficiency goals. Name several of the inspection and overhaul periods for a jet as it is routed throughout a system. Why are there different levels of maintenance capability throughout an airline system?
- 3. If an aircraft experienced a mechanical breakdown in Cleveland, how might that affect passengers expecting to board a flight in Youngstown?
- 4. Flight operations is concerned with a number of operational factors in schedule planning. Discuss three of them. How do crew time limits and employee agreements affect flight scheduling? How does the fact that crew members are based at various localities complicate flight scheduling? How are seniority and crew qualifications at a particular locale problems in the scheduling process? Why is so much emphasis placed on reducing crew layovers and deadhead flights?
- 5. What is the objective of ground handling in the scheduling process? What are some of the facility limitations imposed on schedulers? What is a schedule plotting chart? Why is personnel planning so difficult and costly when there is extreme peaking of flights into a particular station? Why is it so expensive for a major carrier to service a small airport with only two or three flights per day? (*Hint:* think about equipment and personnel.)
- 6. "You can please all of the people some of the time and some of the people all of the time, but you can't please all of the people all of the time." How does this relate to scheduling? Why is it important to build up complexes of connecting flights at major gateways?
- 7. Discuss some of the problems faced by an airline scheduling department that are similar to problems of other industries and some problems that are unique to the airline industry. Discuss three marketing related problems. What is meant by *traffic flow? Sensitivity of schedule salability?* Give one example of the latter.
- 8. How do other operating factors, such as time zones, station personnel, and equipment turnaround time, affect the scheduling process? Why might a jet flight scheduled to depart Los Angeles at 11:35 P.M. be popular? What is meant by the *chain reaction effect*?
- 9. Airlines produce revenue passenger miles but sell available seat-miles. What does that mean? Why do the costs of operating a flight vary only slightly with additional passengers?
- 10. What are the three basic in-service equipment assignments? The five out-of-service assignments? Discuss the advantages and disadvantages of skip-stop, local service, cross-connection, and nonstop service.

11. What was meant by *dormant authority* before deregulation? How did it affect scheduling? What is the purpose of hub-and-spoke scheduling? Discuss the advantages and disadvantages of hub-and-spoke scheduling.

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