ARTICLE NO. 78-1556R

C 80-008

Evaluation of Scheduled Air Passenger Service in Domestic Markets

00009
30001

Steven E. Eriksen*
Northeastern University, Boston, Mass.
and
Nawal K. Taneja†
Massachusetts Institute of Technology, Cambridge, Mass.

A nondimensional index to measure the quality of scheduled air passenger service in domestic markets is proposed. This index is a function of frequency (number of daily flights), time-of-day of departures, number of intermediate stops and/or connections, speed of the aircraft, and expected delays due to congestion. The intermediate steps in the development of this index produce interesting and useful byproducts. A relationship to compute expected block flight times, a methodology for estimating time-of-day demand distributions, and a model for predicting market shares are generated. The application of the index for improving demand models is discussed.

Nomenclature

A_i = arrival time of flight i
AFT_i = adjusted time of flight i
d = great circle distance (miles) between two airports
D_i = departure time of flight i
DT_{ji} = displacement time from time point j to flight i
i = index of flights
j = index of time points
LO_A = longitude of airport of arrival
LO_D = longitude of airport of departure
LOS = level of service index
m = number of daily flights
n = number of time points (equally separated) in the travelling day
R^2 = coefficient of multiple correlation
$\bar{t}$ = average total trip time
t_j = time of day at time point j
t_0 = nonstop jet block time
TT_j = total trip time from time point j
Z = number of time zones crossed (positive if west to east, negative if east to west)
β_i = regression coefficients ($i=0, 1, 2$)
γ_i = connection adjustment for flight i = 0.0 for direct flights; 0.5 for online connections; and 1.0 for interline connections
π_j = proportion of daily passengers preferring to depart at time point j

Introduction

A COMMON problem associated with modeling the demand for scheduled air transportation service in a given city-pair market is the inability to effectively measure the quality of service provided by the published flight schedule. Many demand models crudely adopt frequency, or number of daily (or weekly) departures, as such a measure. However, since a variety of factors contributes to the quality of scheduled service, frequency by itself is an inappropriately crude measure. The purpose of this paper is to create a measurable surrogate that reflects the various service characteristics more accurately than merely the number of departures. The main objective is to provide a methodology for the improvement of city-pair demand model specification.

One service characteristic that is not conveyed by frequency alone is the time-of-day of the departures. Time of day is an important consideration since it relates to the needs of the passengers (the consumer value of a 2:30 a.m. departure may be quite different from that of a 5:30 p.m. departure). Time of day also relates to the temporal proximity of the departures (a market in which the competitors schedule head-to-head receives a poorer quality of service than a market with an equal number of departures that are evenly distributed over the traveling day).

In addition to time-of-day considerations, such factors as number of intermediate stops and/or connections, speed of the aircraft, and expected delays due to congestion contribute to the quality of scheduled air service in domestic markets. These attributes are obviously neglected in economic analyses that employ frequency as the service measure.

A level of service index is developed herein to systematically account for the abovementioned issues. Basically, the measure is a dimensionless number scaled from zero to one which represents the ratio of the nonstop jet flight time to the average total passenger trip time. The total trip time is the sum of the actual flight time (including stops and connections) and the amount of time the passengers are displaced from when they desire to fly due to schedule inconveniences.

If "perfect" service were offered in a given city pair (a nonstop jet departing at every instant of the day), there would be no such displacement. The total trip time would be merely the nonstop jet flight time, and the ratio (level of service measure) would be unity. If poor service were offered (few flights, multistops, connections, slower aircraft, etc.), not only would block flight time be substantially greater than nonstop jet flight time, but many passengers would be forced to fly at inconvenient times. This inconvenience would be accounted for by the inclusion of significant "displacement" times, and the resulting level of service ratio would be small.

Behavioral Assumptions

The basic assumed behavioral pattern in the development of the level of service index is that a generic passenger in

Received July 5, 1978; presented as Paper 78-1556 at the AIAA Conference on Air Transportation: Technical Perspectives & Forecasts, Los Angeles, Calif., Aug. 21-23, 1978; revision received July 30, 1979.

Index categories: Aerospace Management; Economics.

*Assistant Professor.
†Associate Professor. Member AIAA.

Table 1 Four levels of equivalent air service.

Level	Direct flights	Connecting flights
1	Nonstop	...
2	One-stop	...
3	Two-stop	Online nonstop/nonstop
4	Three-stop	Interline nonstop/nonstop

accordance with the purpose of his or her trip will predetermine an optimal or preferred time of departure from the origin airport. Given that he is aware of his preferred departure time and is presented with a schedule of available flights, he will then select that flight which minimizes the sum of the "displacement time" and the "adjusted flight time." The displacement time is the absolute value of the difference between the scheduled departure time and the preferred time of departure. The adjusted flight time is defined as the scheduled flight time (including intermediate stops) for the direct flights, the scheduled flight time plus one-half hour for online connections, and the scheduled flight time plus one hour for interline connections.

The motivation for the inclusion of the additional time assessments for connecting flights is that the consumer disutility of a connecting flight is greater than merely the increase in flight time. For an online connection, the passenger faces the chance of a broken connection due to a late arrival of the first leg or cancellation of the second. Also, the passenger is burdened with the inconvenience of having to change aircraft. For an interline connection, the passenger faces not only the possibility of a broken connection, but also a greater chance of having his or her baggage miss the connection. In addition, the passenger is frequently forced to walk to a different terminal.

Table 1 lists four hierarchial levels of service, based on airline scheduling and marketing experience.‡ The table indicates that an online nonstop/nonstop connection, which actually requires only one stop, is equivalent in consumer value to a two-stop direct flight. Hence, the presence of a connection within the same airline is the consumer equivalent of adding an additional intermediate stop. By the same argument it can be inferred that an interline connection bears the equivalent disutility of two additional stops. Assessing an additional one-half hour of effective flight time for each equivalent stop yields the already mentioned adjustments of one-half hour and one hour for online and interline connections, respectively.

An additional assumption is that the loss function for departure time displacement is linear and symmetric. In other words, the disutility incurred by being displaced by p hours is p times the loss incurred by being displaced one hour. Furthermore, the symmetry of the loss function assumes that the cost of departing late by p hours is equivalent to the cost of departing early by p hours.

Total trip time, as defined in this analysis, is quite different from what it is commonly referred to in transportation analysis. In addition to merely waiting (or displacement) and line haul travel time, total trip time usually includes access and egress times to and from the line haul terminals. This inclusion is particularly significant in air transportation, in which an airport commonly serves a large geographical region. However, since the purpose of this analysis is to measure the effect of airline scheduling independent of access and egress times, these aspects are not considered.

A further assumption in these models is that of infinite capacity. A passenger who elects (by the governing behavioral assumptions) to board a particular flight may do so without a chance of its being fully booked; therefore, load factor is not a consideration in this analysis. This assumption can be justified in light of the fact that generally, if a particular flight is consistently overbooked, the airline serving that market will add capacity or additional service near that particular time of day. Therefore, in most instances, undercapacity problems are corrected within a reasonable length of time.

Development of the Index

Given the behavioral assumptions described in the preceding section and a published flight schedule for one direction of a particular city pair, the total trip time, defined as the sum of the displacement time plus the adjusted flight time, for a passenger desiring to depart at any particular time of day can be determined. Then, given a distribution of passenger departure demand over the entire day, the average total trip time, weighted by this distribution, can be generated.

In order to compute the average total trip time, clock time has been divided into a finite number of discrete time points which are separated by equal intervals throughout the traveling day. The time length of these intervals (and hence the number of time points) may be arbitrarily set (perhaps 15, 30, or 60 minutes). The analysis is performed by considering passengers desiring to depart at only these time points rather than continuously. Therefore, the smaller these intervals (greater number of time points) are, the less restricting this approximation will be. However, as the number of time points increases, so does the computation time.

The adjusted flight time for any flight i, AFT_i, is defined as the difference between the arrival and departure times, $A_i - D_i$ minus the time zone change Z plus the connection adjustment γ_i.

$$AFT_i = A_i - D_i - Z + \gamma_i \qquad (1)$$

The displacement time for any passenger preferring to depart at time point j and selecting flight i, DT_{ji}, is the absolute value of the difference between the departure time of flight i, D_i, and the time of day at time point j, t_j.

$$DT_{ji} = |D_i - t_j| \qquad (2)$$

By the governing behavioral assumptions described in the preceding section, a passenger preferring to depart at time j will select that flight which will minimize the sum of displacement time plus adjusted flight time. This minimized sum is the passenger's total trip time TT_j.

$$TT_j = \min_i (DT_{ji} + AFT_i) = \min_i (|D_i - t_j| + A_i - D_i - Z + \gamma_i) \qquad (3)$$

The average total trip time $\bar{t}$ is the weighted (by the π_j factors) average of the total trip times of the passengers who prefer to depart at each of n times over the traveling day.

$$\bar{t} = \sum_{j=1}^{n} \pi_j TT_j = \sum_{j=1}^{n} \pi_j \min_i (|D_i - t_j| + A_i - D_i - Z + \gamma_i) \qquad (4)$$

The level of service index LOS is defined as the ratio of the nonstop jet time t_0 to the average total trip time $\bar{t}$.

$$LOS = t_0/\bar{t} = t_0 \left[\sum_{j=1}^{n} \pi_j \min_i (|D_i - t_j| + A_i - D_i - Z + \gamma_i) \right]^{-1} \qquad (5)$$

Determination of Nonstop Jet Time

A necessary component for the computation of the level of service index LOS for a given city pair is the nonstop jet time t_0. Nonstop jet service may be offered in markets selected for this type of analysis, and so for these markets this value can be readily determined by examination of the flight schedules. However, for those markets in which nonstop jet service is not offered, a procedure for estimating this value is required.

‡Interview with Frederick J. O'Brien, Lockheed-California Company, Burbank, California, March 5, 1976.

The following relationship has been hypothesized:

$$t_0 = \beta_0 + \beta_i d + \beta_2 (LO_A - LO_D) + \epsilon \tag{6}$$

where d is the great circle distance, in miles, between the two airports, and LO_A and LO_D are the longitudes of the arrival and departure airports. The β_i values ($i = 0, 1, 2$) are coefficients to be estimated by multiple regression analysis, and ϵ is the error term. Using 213 observations the ordinary least squares estimates of the regression coefficients provide the following equation:

$$t_0 = 0.3370 + 0.001976d + 0.009369(LO_A - LO_D) \tag{7}$$

where $R^2 = 0.984$, the standard error = 0.0278 h = 1.66 min, and 111.60 and 13.03 are the corresponding t ratios.

The constant term represents the startup time involved in a flight (taxiing, accelerating to cruise speed, etc.). The second term is included to account for the obvious fact that the trip time is a linear function of distance. The third term measures the effect of the prevailing west to east air flow, resulting in the fact that it requires roughly one additional hour to fly a commercial jet across the country east to west than it takes flying west to east.

The observations were selected from the Official Airline Guide of Dec. 1975.[1] Since in markets where nonstop jet service is offered in one direction it usually is offered in both directions, the correlation between the explanatory variables is virtually zero.

Determination of Time-of-Day Demand Functions

An additional input variable necessary for the computation of the level of service index LOS for a given directed city pair is the relative demand for air transportation service as a function of time-of-day. A uniform time-of-day distribution is of course rarely, if ever, observed. For example, the daily demand for air transportation in short and medium haul business markets is typically bimodal. There is a peak period between 8:00 and 10:00 a.m. and another between 5:00 and 7:00 p.m. Other markets may observe quite different time-of-day variations. In transcontinental west to east markets, there actually is a lull in what one would normally expect to be a peak period in the late afternoon. This is caused by the fact that few passengers would choose to arrive at the destination (east coast) at two or three o'clock in the morning. The demand, however, picks up considerably in the late evening for the night flights which arrive on the east coast between eight and ten o'clock the next morning.

The time-of-day distribution unfortunately is, for nearly all markets, virtually impossible to determine. When passengers do fly is, in most cases, a function of the air transportation schedule by which they are constrained. However, data has been provided by Eastern Airlines from their New York/Boston shuttle, a demand-responsive service, which reflects, as would be expected, the bimodal time-of--day distribution described above. This distribution is plotted in Fig. 1 and is used as a basis for deriving theoretical time-of-day demand distributions for all city pairs.

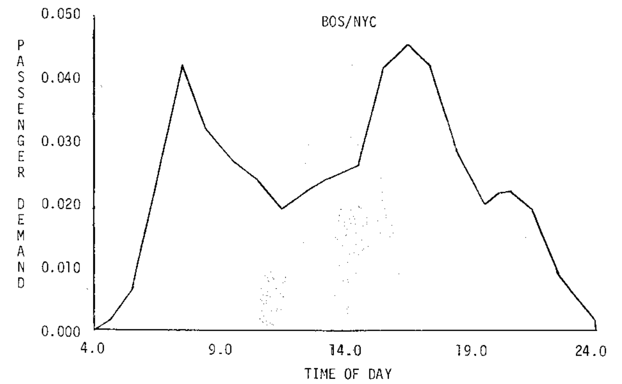

Fig. 1 Empirical time-of-day demand distribution for Eastern Airlines Boston/New York air shuttle.

The initial step in this analysis is to discretize time-of-day into 41 time points (j = 1,2,...,41) at half-hour intervals starting at 4:00 a.m. and ending at midnight [$t(1)$ = 4.0, $t(2)$ = 4.5,...,$t(41)$ = 24.0]. At each time point j a proportion $p(j)$ of the total number of daily passengers desires to depart from Boston to New York or vice versa, as indicated by the empirical data provided by Eastern.

A basic assumption in these derivations is that the proportion $p(j)$ of the total daily passengers desire to depart at time $t(j)$ for one of two reasons: 1) the time-of-day $t(j)$ is a preferred time to depart, or 2) the time of day $t(j+2)$ is an attractive term to arrive. The arrival time $t(j+2)$ is employed because the time points j are separated by half-hour intervals, and one hour is the approximate flight time between Boston and New York.

In order to project this distribution over all markets, the following assumptions are made: 1) the distribution of preferred departure times from any region is $P_D(j) = p(j)$ for j = 1,2,...,41, and 2) the distribution of attractive arrival times at any region is $P_A(1) = P_A(2) = 0.0$, $P_A(j) = p(j-2)$ for j = 3,4,...,43, where $t(42)$ is 12:30 a.m. and $t(43)$ is 1:00 a.m.

We believe that for most domestic markets, particularly those in which a major portion of the traffic is business oriented, these are reasonable assumptions. We recognize, however, that there are certain vacation oriented cities, such as Miami, in which mid day departures and arrivals would be preferred, and Las Vegas where popular middle-of-the-night departures are not uncommon. The validity of this time-of-day analysis is uncertain for markets that involve cities with such unusual traffic characteristics.

A final assumption in this derivation is that the proportion of daily passengers wishing to depart a given origin for a given destination at time $t(j)$ is a *multiplicative* function of the preferability of departure at $t(j)$, $P_D(j)$, and the attractiveness $P_A(j_{arr})$ of arriving at the destination at the arrival time $t(j_{arr})$. A multiplicative form was chosen over an additive form after consideration of a typical west to east transcontinental market. Seven o'clock in the evening, $t(j)$ = 19.0, is, referring to the basic $p(j)$ distribution, a reasonably preferable time of day for departure. However, a departure from a west coast region for an east coast region at 7:00 p.m. on a nonstop jet would result in an arrival on the east coast at 3:00 a.m. (five hours flying time plus three time zones), which is hardly desirable to anyone. If an additive form were employed, the preferability of departing at 7:00 p.m. would make this flight look desirable, whereas in using the multiplicative form the null attraction of a 3:00 a.m. arrival, $P_A(j_{arr}) = 0.0$, will completely eliminate the desirability of this time of departure.

The functional form of π_j for any given market is as follows:

$$\pi_j = \frac{\sqrt{p(j) \cdot p(j+\delta)}}{\sum_{j=1}^{41} \sqrt{p(j) \cdot p(j+\delta)}} \tag{8}$$

where $\delta = 2(t_0 + Z) - 2$ rounded to the nearest integer.

The first term in the definition of δ, $2(t_0 + Z)$, is the local clock time difference, in half-hours, between the departure and arrival times of a nonstop jet. The second term, -2, accounts for the shift in time axis between $P_D(j)$ and $P_A(j)$ as mentioned above. The motivation for the radical is that the use of the straight multiplicative form, $p(j) \cdot p(j+\delta)$, would not result in the original distribution $p(j)$ for one-hour markets such as New York to Boston, where the radical form

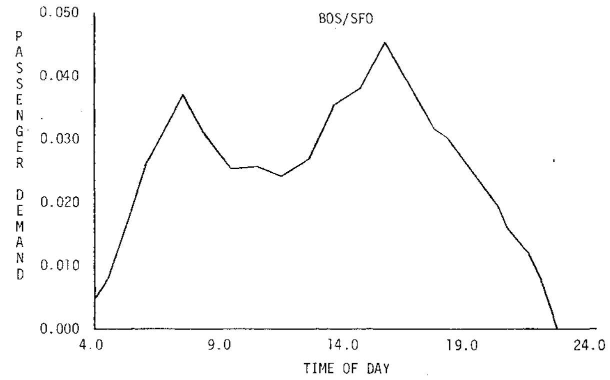

Fig. 2 Theoretical time-of-day demand distribution for Boston to San Francisco.

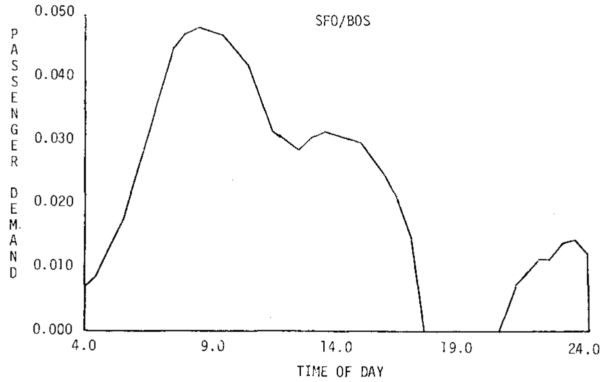

Fig. 3 Theoretical time-of-day demand distribution for San Francisco to Boston.

does. The summation term in the denominator normalizes so that the sum of the π_j terms over the entire day equals unity.

For example, from Boston to San Francisco the nonstop jet time t_0 is 6.0 h, and the time zone adjustment is $Z = -3$. Therefore,

$$\delta = 2(t_0 + Z) - 2 = 2(6.0 - 3) - 2 = 4$$

The resulting π_j distribution for Boston to San Francisco is shown in Fig. 2.

From San Francisco to Boston, the nonstop jet time t_0 is 5.0 h and the time zone adjustment is $Z = 3$. Therefore,

$$\delta = 2(t_0 + Z) - 2 = 2(5.0 + 3) - 2 = 14$$

The resulting π_j distribution for San Francisco to Boston is shown in Fig. 3.

Numerical Example

Table 2 is a reproduction of the flight schedule from Houston to Washington as listed in the September 1, 1975 edition of the Official Airline Guide.[2] The flights have been renumbered in temporal order of departure times. The departure and arrival times are shown in the decimal equivalent of military time; for example, flight 9 arrives at 15.75, or 3:45 p.m. The "status" column identifies whether the flight is direct or an online or interline connection. The computation of the level of service index *LOS* is illustrated in Table 3. Observe, for example, point 13 (10:00 a.m.) at which time 2.7% of the daily demand desires to depart. Flight 7, a 9:35 a.m. departure (9.58 in Table 2), is that alternative which minimizes total trip time. Total trip time is the sum of the displacement time (25 min or 0.42 h) and the flight time (3 h, 33 min or 3.55 h) totaling 3.97 h. The rightmost column is the product of π_j and the trip time. Therefore, the sum of this column, 4.4222 h, is the average trip time (weighted by the time-of-day demand distribution) $\bar{t}$.

The level of service index is the ratio of the nonstop jet time t_0 to the average total trip time $\bar{t}$. This ratio is equal to 0.577. Its interpretation is that if perfect service (a nonstop jet at every instant of the day) were offered, the average total trip time would be 57.7% of the current value. Additional numerical examples involving a variety of different types of markets are presented in Ref. 3.

Table 2 Flight schedule for Houston to Washington

Flight	Depart	Arrive	Adjusted flight time	Status	Carrier
1	6.67	11.70	4.53	Online	DL/DL
2	7.00	12.08	4.58	Online	BN/BN
3	8.00	11.78	2.78	Direct	EA
4	8.00	13.62	5.12	Online	BN/BN
5	8.63	14.60	4.97	Direct	EA
6	8.67	13.58	4.42	Online	DL/DL
7	9.58	14.13	3.55	Direct	DL
8	9.58	14.98	4.40	Direct	DL
9	10.00	15.75	5.25	Online	BN/BN
10	10.92	16.93	6.02	Intlin	TT/AA
11	11.00	16.93	5.93	Intlin	BN/AA
12	11.33	16.63	4.30	Direct	EA
13	11.50	16.42	4.42	Online	DL/DL
14	12.00	17.50	5.00	Online	BN/BN
15	14.42	19.53	5.12	Intlin	DL/UA
16	14.42	20.25	4.83	Direct	BN
17	14.73	19.58	4.85	Intlin	EA/DL
18	15.00	20.58	5.08	Online	BN/BN
19	15.58	20.60	5.02	Intlin	DL/EA
20	15.92	21.03	5.12	Intlin	AA/UA
21	16.00	21.33	4.83	Online	BN/BN
22	16.58	22.23	5.65	Intlin	BN/AA
23	16.83	21.83	4.00	Direct	DL
24	16.83	22.00	4.67	Online	DL/DL
25	18.98	22.72	2.73	Direct	EA
26	18.98	23.33	3.35	Direct	EA
27	21.00	25.90	4.40	Online	DL/DL
28	23.50	31.07	7.57	Intlin	BN/AA

Market Share Estimation

In the level of service index computation proportion π_j of total daily passengers that wish to depart at any time point j is assigned to a particular flight in accordance with the behavioral assumptions outlined previously. From these assignments the market shares of the various carriers can be estimated. In the Houston to Washington example of the previous section, Eastern's flights received 48.7% of the traffic, Delta received 31.6%, and Braniff 19.7%.

A similar analysis was performed on the Washington to Houston schedule and the results were Eastern 85.4%, Delta 10.2%, and Braniff, 4.4%. Taking the average of the results yields market share estimates of Eastern 67.1%, Delta 20.9%, and Braniff, 12.0%. The actual values as reported in Table 10 of the Civil Aeronautics Board Origin to Destination Survey[4] for the fourth quarter of 1975 are Eastern 66%, Delta 24%, Braniff 7%, others and unknown 3%.

One obvious shortcoming in the demand distribution formulation is the insensitivity to time-of-day fare structure. This problem has been apparent in markets where night coach fares are in effect. The theoretical market shares have not been in good agreement with the empirical values since the flights offering night coach discounts are in reality more attractive than the model implies. A multiattribute assignment process that considers both trip time and fare is a possible area for future research.

An Application for Demand Analysis

In addition to comparing quality of service between airline markets and prediction of market shares between carriers, the level of service index may be used to improve the specification

Table 3 Computation of the index[a]

J	$T(J)$	$PI(J)$	Flight boarded	Displace-ment time	Adjusted flight time	Trip time	Contribution to total trip time
1	4.00	0.006	3	4.00	2.78	6.78	0.040
2	4.50	0.010	3	3.50	2.78	6.28	0.061
3	5.00	0.016	3	3.00	2.78	5.78	0.095
4	5.50	0.019	3	2.50	2.78	5.28	0.101
5	6.00	0.025	3	2.00	2.78	4.78	0.119
6	6.50	0.029	3	1.50	2.78	4.28	0.126
7	7.00	0.034	3	1.00	2.78	3.78	0.128
8	7.50	0.038	3	0.50	2.78	3.28	0.123
9	8.00	0.034	3	0.00	2.78	2.78	0.095
10	8.50	0.030	3	0.50	2.78	3.28	0.098
11	9.00	0.027	3	1.00	2.78	3.78	0.104
12	9.50	0.027	7	0.08	3.55	3.63	0.099
13	10.00	0.027	7	0.42	3.55	3.97	0.109
14	10.50	0.027	7	0.92	3.55	4.47	0.122
15	11.00	0.027	12	0.33	4.42	4.63	0.123
16	11.50	0.026	13	0.00	4.42	4.42	0.113
17	12.00	0.027	13	0.50	4.42	4.92	0.133
18	12.50	0.032	13	1.00	4.42	5.42	0.171
19	13.00	0.036	13	1.50	4.42	5.92	0.212
20	13.50	0.037	16	0.92	4.83	5.75	0.215
21	14.00	0.039	16	0.42	4.83	5.25	0.204
22	14.50	0.039	16	0.08	4.83	4.92	0.190
23	15.00	0.043	18	0.00	5.08	5.08	0.218
24	15.50	0.043	19	0.08	5.02	5.10	0.220
25	16.00	0.040	21	0.00	4.83	4.83	0.192
26	16.50	0.038	23	0.33	4.00	4.33	0.163
27	17.00	0.034	23	0.17	4.00	4.17	0.141
28	17.50	0.035	25	1.48	2.73	4.22	0.146
29	18.50	0.032	25	0.98	2.73	3.72	0.119
30	18.50	0.028	25	0.48	2.73	3.22	0.089
31	19.00	0.025	25	0.02	2.73	2.75	0.068
32	19.50	0.020	25	0.52	2.73	3.25	0.064
33	20.00	0.017	25	1.02	2.73	3.75	0.063
34	20.50	0.015	25	1.52	2.73	4.25	0.063
35	21.00	0.012	27	0.00	4.40	4.40	0.053
36	21.50	0.008	27	0.50	4.40	4.90	0.040
37	22.00	0.000	27	1.00	4.40	5.40	0.000
38	22.50	0.000	27	1.50	4.40	5.90	0.000
39	23.00	0.000	27	2.00	4.40	6.40	0.000
40	23.50	0.000	27	2.50	4.40	6.90	0.000
41	24.00	0.000	27	3.00	4.40	7.40	0.000
							$\bar{t} = 4.422$[a]

[a] $LOS = t_0/\bar{t} = 2.55/4.42 = 0.577$.

of market demand models. Consider the following demand model structure:

$$Q_D = f(SE, F, LOS) \qquad (9)$$

where Q_D is the origin to destination demand in a given market, SE is some measure or set of measures of socio-economic activity, F is one or more fare-related variables, and LOS is the level of service index. This model structure measures the impact upon demand of not only changes in market size, price, and frequency, but also of other technological factors not directly measurable in traditional demand models. For example, a model that has frequency as its supply variable cannot measure the impact upon demand due to the introduction of faster aircraft. Changes in aircraft speed are, however, picked up in the LOS variable Eq. (9).

For further discussion on modeling the relationship between the level of service and demand, the reader is referred to Eriksen.[3]

References

[1] Donnelley Corporation, *Official Airline Guide*, Dec. 1975.

[2] Donnelley Corporation, *Official Airline Guide*, Sept. 1, 1975.

[3] Eriksen, S.E., "Demand Models for U.S. Domestic Air Passenger Markets," M.I.T. Flight Transportation Laboratory Report FTL-R78-2, June 1978.

[4] Civil Aeronautics Board, *Origin-Destination Survey of Airline Passenger Traffic*, Table 10, 1975.

[5] Taneja, N.K., *The Commercial Airline Industry*, Heath Lexington Books, Lexington, Mass., 1976.