In-Flight Origin-Destination Study at Philadelphia International Airport

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Philadelphia International Airport is expecting a threefold increase in air travelers between 1967 and 1990. In order to plan properly for such growth, a comprehensive survey of airport activity was completed in November 1967. The comprehensive analysis involved an in-flight survey to determine the travel characteristics of over 15,000 average weekday air travelers arriving at or departing from Philadelphia.

•IN its opening year 15 years ago, Philadelphia International Airport handled less than one million air travelers. Last year the volume exceeded five million, and 1990 projections forecast 15 million travelers. Faced with this threefold increase, Philadelphia has developed an extensive improvement plan, including a new terminal. The cost of these improvements demands careful testing of their adequacy to handle anticipated air travelers. This research was undertaken to analyze the interface problems—ground to air—and traffic circulation to and through the new facility. Time and cost limitations required that considerable data be collected quickly and inexpensively. The data collection procedures developed for this analysis and reported in this paper permitted detailed interviews of 15,070 air travelers at an average cost of $1.49 per interview including all planning costs, coding, keypunching, and summarizing of completed questionnaire information.

The present facility is conveniently located about 9 miles, or 22 minutes, southwest of center city Philadelphia with highway access provided solely by the Industrial Highway (Pa. Traffic Route 291). This single access route carries 51,000 vehicles on an average weekday, with 33,400 of those vehicles entering and leaving the airport complex (Fig. 1). This route is currently carrying approximately 30 percent more traffic than its rated capacity, and an at-grade solution can only be viewed as a short-range answer. Plans for terminal redesign and integration with the Interstate Highway System recognize the need for grade-separated access.

In addition to the private automobile, limousine and taxi services are provided to the airport from most major points of population concentration in the Delaware Valley. There is no direct "public transit" service from center city to the airport. Three bus routes of the Philadelphia Transportation Company serve the airport, but all require transfers to reach center city.

Airport parking is currently operating at capacity, inasmuch as the maximum weekday accumulation of vehicles is almost 98 percent of the parking lot capacity. The weekly pattern shows more "in" than "out" vehicles on Monday, Tuesday, and early Wednesday, building to a peak accumulation Wednesday afternoon. Outs exceed ins for the rest of the week, with a low point Sunday night.

The in-flight survey of air travelers using the terminal provided the substance for projecting segments of the air travel market to test the future design. The principal findings of this analysis included the following:

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The Philadelphia Airport Management would like to have your cooperation for information necessary in planning new terminal, ground transportation and parking facilities. Will you please take a moment and complete the questions on the other side of this card.

If you are transferring from another flight and your trip did not originate in Philadelphia, indicate below the airline from which you are transferring; you do not have to answer the questions on the other side of this card.

Other Airline_____

Thank You

Wm. T. Burns

WILLIAM T. BURNS
Deputy Director of Commerce for Aviation

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1. Where did you begin this trip?_____ (City/Town) _____ (State) Is this Home? ☐ Yes ☐ No

2. Is this the return of a round trip? ☐ Yes ☐ No
If yes, on which airline did you leave Philadelphia?_____

3. What is your destination after you leave the airport?

_____ (Address, prominent building or street intersection) _____ (City/Town) _____ (State) Is this Home? ☐ Yes ☐ No

4. How do you plan to travel to your destination? (If you use more than one mode of travel, check each.)

☐ Private car (met at airport) ☐ Taxi ☐ Bus or streetcar
☐ Private car (parked at airport) ☐ Airport Limousine ☐ Motel/Hotel courtesy car
☐ Rental car ☐ Railroad or subway Other (specify)_____

5. What is the MAIN purpose of this trip?

☐ Company business ☐ Military ☐ Accompany family member on business trip
☐ Personal business ☐ School ☐ Pleasure
Other (specify)_____

6. How many pieces of luggage did you check?_____ 7. Are you male ☐ or female ☐
carry-on?_____

№ 4806

After you have completed this questionnaire, please return it to the stewardess.

Figure 2. Inbound flight questionnaire form.

Parking lot and traffic movements were determined from manual and automatic traffic counts and analysis of several weeks of parking lot "time stamp" tickets.

In-Flight Survey

The in-flight survey was conducted during the 5-day period beginning 12:01 a.m. Monday, November 13, 1967, and concluding midnight, Friday, November 17. During this period there were over 2,200 commercial takeoffs and landings. These were comprised of 231 distinct flights in the inbound direction and 229 outbound flights, each of

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If you are transferring from another flight and your trip did not originate in Philadelphia, indicate below the airline from which you are transferring; you do not have to answer the questions on the other side of this card.

Other Airline_____

Thank You

WILLIAM T. BURNS
Deputy Director of Commerce for Aviation

1. Where are you going on this trip? _____ (City/Town) _____ (State) Is this Home? ☐ Yes ☐ No

2. Where in the Philadelphia area did you start your ground trip to the airport?

_____ (Address, prominent building or street intersection) _____ (City/Town) _____ (State) Is this Home? ☐ Yes ☐ No

3. How did you get to the airport? (If more than one mode of travel was used, check each.)

☐ Private car (dropped-off at airport) ☐ Taxi ☐ Bus
☐ Private car (parked at airport) ☐ Airport limousine ☐ Motel/Hotel courtesy car
☐ Rental car ☐ Railroad or subway Other (specify)_____

4. What is the MAIN purpose of your trip?

☐ Company business ☐ Military ☐ Accompany family member on business trip
☐ Personal business ☐ School ☐ Pleasure
Other (specify)_____

5. How many pieces of luggage did you check?_____ carry-on?_____ 6. Are you male ☐ or female ☐

№ 43618

After you have completed this questionnaire, please return it to the stewardess.

Figure 3. Outbound flight questionnaire form.

which was surveyed. Also included in the survey were air-taxi and charter services during this 5-day period.

Two questionnaires were employed, one for inbound (Fig. 2) and one for outbound flights (Fig. 3). On one side of each card instructions were given on card use and an inquiry made as to whether or not the passenger was transferring to another airline at the Philadelphia terminal. The opposite side of the questionnaire contained seven questions for inbound passengers and six questions for those departing Philadelphia. To allow speed in subsequent tabulation, all questions except those pertaining to location and airline names were designed to be answered with a check mark or a number.

AIRLINE _____

FLIGHT NO._____ FROM_____ DAY_____ DATE_____

TO THE STEWARDESS:

The Philadelphia Airport Management and the Airlines serving the Philadelphia area are cooperating in this survey to obtain information necessary for planning new terminal, ground transportation and parking facilities. Your help will be greatly appreciated.

Survey envelopes are being issued to selected flights to and from Philadelphia. On outbound flights, they are being issued in Philadelphia. On inbound flights, they are being issued at the last stop before Philadelphia.

The envelope contains questionnaires to be distributed to all passengers over 12 years of age.

After your passengers are comfortably seated, please distribute the questionnaires and, at your first opportunity, make the following announcement over the public address system:

LADIES AND GENTLEMEN, THE CITY OF PHILADELPHIA IS PLANNING MAJOR IMPROVEMENTS TO ITS AIRPORT TERMINAL, GROUND TRANSPORTATION AND PARKING FACILITIES. _____AIRLINE IS PARTICIPATING IN A SURVEY BY THE CITY OF PHILADELPHIA. WILL YOU PLEASE FILL OUT THE QUESTIONNAIRES WHICH HAVE BEEN (OR WILL BE) DISTRIBUTED. WE WILL COLLECT THEM BEFORE WE LAND. THANK YOU.

After you have collected the questionnaires, place all completed, blank and unused cards in the envelope. Fill in the information below and give the envelope to your Station Manager at the completion of this flight for return to Philadelphia International Airport.

No. in crew _____

No. Passengers _____

Thank You.

PLEASE RETURN TO PHILADELPHIA INTERNATIONAL AIRPORT MANAGEMENT

Figure 4. In-flight questionnaire packet.

Information obtained through the in-flight survey included the following: Trip origin (home or non-home), trip destination (home or non-home), name of airline on round trip inbound flight, name of airline for transfer, mode of ground transportation to/from airport, sex of traveler, trip purpose, number of bags carried, and number of bags checked.

Questionnaires were grouped into packets containing as many cards as seats on a survey flight. On the outside of the packet (Fig. 4) were the name of airline, survey day and date, survey flight number, instructions to airline personnel (who distributed the cards in-flight), and the name of the city from which the flight originated—Philadelphia for outbound flights, the origin immediately preceding the Philadelphia stop for inbound flights.

Packets were distributed to all airlines involved in the survey, and they in turn distributed the questionnaires to the proper origin terminal. Completed packets were returned to the airport management at Philadelphia.

Sampling Procedure for In-Flight Survey

A probability sampling procedure was developed to allow random selection of interview flights in such fashion as to generate an unbiased sample that would accurately reflect travel characteristics of air traffic on an average weekday. Before applying the sampling technique, however, information on airline name, flight number, type of craft, days of service, and city of origin were recorded on cards for each of the 460 flights serving Philadelphia International Airport during the 5-day survey period. These were stratified by direction of travel, then randomly selected and numbered sequentially.

The sampling procedure applied to these cards was as follows:

1. A table of random numbers was selected.
2. Without direction, a 4-digit number was selected from the table; the first 2 digits indicated a row and the last 2 a column on the table.
3. The cell defined by the row and column and the next 2 digits to the right was recorded. These digits indicated one of the numbered cards for selection.
4. If the generated 3-digit number exceeded the last numbered card, the selected column was traced downward until a number within the allowable range was incurred. This number specified the card to be chosen.
5. Once again row and column numbers were generated.
6. The number in the defined cell was recorded. If it was within the range of 1 to 5 (1 = Monday, 5 = Friday), the digit indicated the day on which the flight recorded on the chosen card was to be surveyed.
7. If the flight did not operate on the day selected, or the generated number was less than 1 or larger than 5, the selected column was traced downward until a suitable day was determined.

These steps were repeated until the supply of cards was exhausted.

Table 1 gives the number of flights selected for survey by direction, airline, and day of the week. A breakdown of the number of questionnaires distributed, also by direction, airline, and weekday, is given in Table 2. Table 3 summarizes the totals of the previous two tables to give a more concise picture of the surveying task.

TABLE 1

NUMBER OF SURVEY FLIGHTS BY AIRLINE

Airline	Monday	Tuesday	Wednesday	Thursday	Friday	Total
			Arrivals			
A	19	8	11	12	22	72
B	7	5	10	8	4	34
C	4	4	1	1	1	11
D	7	3	5	4	3	22
E	3	2	0	1	1	7
F	0	1	1	0	1	3
G	10	8	8	7	8	41
H	0	2	4	3	3	12
I	0	0	0	1	0	1
J	3	1	3	2	1	10
K	0	1	0	1	0	2
L	3	3	3	1	6	16
	56	38	46	41	50	231
			Departures			
A	18	11	14	12	17	72
B	6	3	7	9	7	32
C	3	2	3	—	3	11
D	4	3	5	4	6	22
E	1	2	1	2	2	8
F	—	—	1	1	1	3
G	9	9	6	7	9	40
H	1	2	3	3	3	12
I	1	—	—	—	—	1
J	2	2	2	2	2	10
K	1	—	—	1	—	2
L	3	4	2	2	5	16
	49	38	44	43	55	229

Questionnaire Returns

Final tabulation of card returns for the 12 large commercial airlines totaled 10,133. There were 15,070 passengers aboard the surveyed flights and, although 40,000 cards were issued, the return represents a 67.2 percent response. It is notable that less than 1 percent of the returned cards were misunderstood, frivolous, or otherwise contained unusable information.

RELIABILITY OF DATA

Data were provided by the airlines on the number of passengers on every inbound and outbound flight for the survey. Records of domestic and

TABLE 2

SURVEY QUESTIONNAIRE TOTALS BY AIRLINE

Airline	Monday	Tuesday	Wednesday	Thursday	Friday	Total
			Arrivals			
A	1,270	470	710	645	1,375	4,470
B	610	439	845	580	393	2,867
C	418	477	128	93	128	1,244
D	593	236	507	465	315	2,116
E	255	166	0	96	96	613
F	0	147	177	0	177	501
G	807	785	675	793	809	3,869
H	0	264	528	396	396	1,584
I	0	0	0	148	0	148
J	310	100	300	220	110	1,040
K	0	44	0	44	0	88
L	252	271	252	84	597	1,456
	4,515	3,399	4,122	3,564	4,396	19,996
			Departures			
A	1,050	725	830	645	1,205	4,455
B	482	317	696	816	434	2,745
C	314	230	314	0	384	1,242
D	411	167	534	411	427	1,950
E	96	192	70	166	159	683
F	0	0	177	147	177	501
G	861	728	628	678	805	3,700
H	132	264	396	396	296	1,584
I	148	0	0	0	0	148
J	200	200	210	209	210	1,029
K	44	0	0	48	0	92
L	252	391	187	187	439	1,456
	3,990	3,214	4,042	3,703	4,636	19,585

international air traffic, by month and direction for 1966 and 1967, permitted further checks on the accuracy of the survey.

Comparison of average weekday traffic (AWT) for the week of the survey and annual average weekday traffic (AAWT) for 1967 with the population of the survey flights revealed a 0.2 percent deviation of the survey population from either the AWT or AAWT figures (Table 4). The largest deviations, by airline, were in the smaller carriers—less than 500 people on an average weekday. Conversely, the sample population of the larger carriers showed the smallest deviation from average figures. On the whole, these figures indicate that the survey sampling procedures constructed accurately an average weekday of air traffic. Traffic counts and ground transportation survey results support this conclusion.

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Coding of all questions of both the in-flight and employee surveys was a straightforward procedure. Numeric codes were established for answers to all questions. Except for origin, destination, arrival and departure times, the code consisted of 1 digit. For origin and destination, a 6-digit code developed by the Delaware Valley Regional Planning Commission was employed. Time was recorded as a 4-digit number from 0000 to 2400.

Factoring

For some trip information, notably that relating to luggage carried or checked and sex of traveler, the total number of returned survey cards was used. With respect to origin and destination, the card return was well in excess of that required for a uniform degree of reliability. Therefore, subsamples were chosen for analyses by airline. In order to insure statistical reliability, a curve was developed to guarantee a uniform 90 percent confidence level for the subsamples (Fig. 5). Application of the curve provided that for those airlines with low average daily traffic almost all returned cards were coded. As the ADT figures increased, progressively smaller percent subsamples were needed to ensure consistent reliability.

TABLE 3

SUMMARY OF QUESTIONNAIRES AND FLIGHTS

Day	No. of Flights	No. of Seats
	Arrivals	
Monday	56	4,515
Tuesday	38	3,399
Wednesday	46	4,122
Thursday	41	3,564
Friday	50	4,396
Total	231	19,996
	Departures	
Monday	49	3,990
Tuesday	38	3,214
Wednesday	44	4,042
Thursday	43	3,703
Friday	55	4,636
Total	229	19,585
Grand total (arrivals plus departures)	460	39,581

TABLE 4

PASSENGER TRAFFIC COMPARISONS BY AIRLINE

Airline	Passengers on Surveyed Flights (1)	Average Weekday Traffic for Survey Week[a] (2)	Average Annual Weekday Traffic (3)	Absolute Difference (3) - (1)	Absolute Difference (3) - (2)	Percent Difference (3) - (1)	Percent Difference (3) - (2)
A	3,089	3,206	3,151	62	55	2.0	1.8
B	2,642	2,552	2,571	71	19	2.8	0.7
C	821	819	815	6	4	0.7	0.5
D	2,589	2,493	2,501	88	8	3.5	0.3
E	426	465	495	69	30	13.9	6.1
F	204	312	252	48	60	19.0	23.8
G	2,697	2,560	2,550	147	10	5.8	0.4
H	938	961	980	42	19	4.3	1.2
I	15	3	9	6	6	66.7	66.7
J	775	869	939	164	70	17.5	7.5
K	66	46	56	10	10	17.9	17.9
L	808	783	774	26	9	3.4	1.2
Total	15,070	15,069	15,093			0.2	0.2

[a]Week of November 13, 1967.

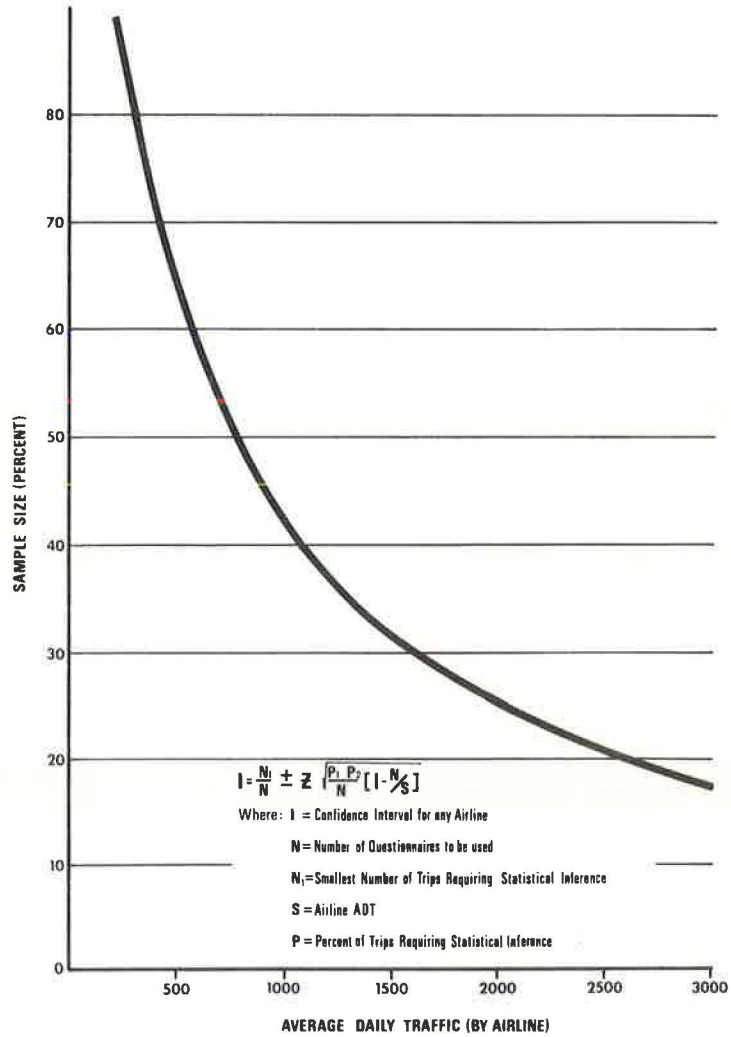

Figure 5. Sample-size selection curve.

TABLE 5

COMPARISON OF ACCESS MODE DISTRIBUTION—ALL SURVEY CARDS VS FACTORED CARDS

Access Mode	Percent From All Cards	Percent From Factored Cards	Absolute Difference	Percent Difference
Private car (met or left)	25.6	26.1	0.5	2.0
Private car (parked)	24.1	23.9	0.2	0.8
Rental car	10.6	10.3	0.3	2.8
Taxi	15.9	16.7	0.8	5.0
Limousine	12.9	12.6	0.3	2.3
Bus	2.0	2.3	0.3	15.0
Motel/hotel courtesy car	0.9	0.9	0.0	0.0
Combinations of modes	5.2	6.0	0.8	15.4
Other	2.8	1.2	1.6	57.1

TABLE 6

COMPARISON OF TRIP PURPOSE DISTRIBUTION—ALL SURVEY CARDS VS FACTORED CARDS

Trip Purpose	Percent From All Cards	Percent From Factored Cards	Absolute Difference	Percent Difference
Company business	60.9	60.7	0.2	0.3
Personal business	10.1	10.3	0.2	2.0
Military	7.4	7.6	0.2	2.7
School	1.5	2.0	0.5	33.3
Accompany family member on business	1.8	1.6	0.2	11.1
Pleasure	14.2	13.8	0.4	2.8
Other	4.1	4.0	0.1	2.4

In total, 4,931 cards were chosen for the subsamples, which represents 48.7 percent of the returned cards and 32.7 percent of the survey population. These cards were factored, by airline, to represent three ridership groups: an average weekday in the survey week, the average weekday in the year 1967, and the survey population. Less than 5 percent difference is evident when comparing the results obtained by using all returned survey cards with those obtained through the sampling technique just described. For example, when examining the distributions of access mode employed by air travelers going to and from the airport (Table 5), it can be seen that in most cases the difference was in the range of 0 to 5 percent, with maximum deviations found for those modes used least. There is also close conformity of trip purpose distributions (Table 6). The sampling technique developed can produce reliable results and eliminate the time and cost involved in coding and analyzing all returned survey cards.

COST

One of the most interesting and vital statistics concerning this survey is the cost. In total, $1.49 per interview was required to complete the surveying task. This cost included charges for engineering work and its support, as well as machine and materials costs. It covered the complete operation, from design of the questionnaires, through coding of returns, to editing and processing the coded data.

CONCLUSIONS

The mounting problems of ground-air interfaces at airports around the country are the present and future challenge for transportation engineers everywhere. They can only be solved with a complete knowledge of the needs and desires of airport users. The techniques described in this research provide a quick and inexpensive way to achieve this goal.