Estimation of Aircraft Operations at Nontowered Airports in the Delaware Valley Region

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Described are the development and application of a statistical model for estimating aircraft operations at nontowered airports in the Delaware Valley Region. The model produces daily, seasonal, and annual operations based on a sample of 8 weeks of counts at each airport. A stratified cluster sample of departure counts by type of aircraft, such as single and multiengine, jet, and helicopter, was obtained from a survey that sampled 11 airports for 2 weeks in each of the 1986 seasons. The traffic demand counts were collected by means of an acoustical activity counter, which records aircraft noise at takeoffs or other activities. The model was tested with actual count data for two towered airports. The sensitivity tests indicated that the model produces good results based on survey data obtained from an 8-week sample selected at random at each airport. The margins of error in the estimates of annual operations at the airports surveyed are generally small, ranging from 9 to 21 percent of the estimated operations. These estimates are being used for managerial and operational decisions, and for long-range traffic demand projections to update the Regional Airport System Plan for the Delaware Valley Region.

Past, present, and projected traffic trends for airports are required for the planning and programming of airport improvements. To be useful for planning facilities, traffic demand data should include all airport operations (departures and arrivals), including commercial air carrier and commuter services, business, flight schools, recreation, and cargo. The data should be classified by day, season, and year and by type of aircraft (*1*). The number of operations is also needed for airport management and provision of daily services and for forecasting future activities. Such traffic demand information is generally available at towered airports with air traffic controllers. At nontowered airports, however, traffic data are usually estimated. Such facilities are generally classified as reliever or general aviation airports (Figure 1).

Since the present information on annual operations at nontowered airports in the region is not reliable, the Delaware Valley Regional Planning Commission (DVRPC) recently developed a model to estimate aircraft operations at 21 nontowered airports (*2*). In consideration of practicality, administration, and cost, a sampling plan which identifies the days and weeks of aircraft counting at each airport was also developed. The DVRPC model provided estimates of annual operations at a reasonable level of sampling error (*3*).

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The purpose of this paper is to describe briefly the DVRPC aircraft counting program for nontowered airports, with particular emphasis on sample design, model structure, data collection, and analysis of the estimated operations at 11 airports surveyed in Calendar Year 1986.

SAMPLING METHODOLOGY AND MODEL DEVELOPMENT

Analysis of aircraft activities at towered airports indicates that airport operations vary by hour, day, and season as a result of flight characteristics and changes in weather conditions (*4*). Traffic operations usually increase during good weather [Visual Flight Rules Conditions—Modified Visual Flight Rules (MVFR) and Visual Flight Rules (VFR)] and decrease during bad weather [Instrument Flight Rules Conditions—Limited Instrument Flight Rules (LIFR) and Instrument Flight Rules (IFR)]. Daily airport operations also depend on the purpose of flying; they increase on the weekend, if the airport is used predominantly for pleasure.

In order to determine variations in airport operations, the sample must include counts by hour of the day for at least 7 consecutive days. This should be repeated four times, one for each of the four seasons of the year.

Sample Size

The sample size depends on the desired accuracy and the funds available for the survey (DVRPC budget for the FY 1986 counting program was about $50,000). Statistical inference methods indicate that the greater the precision desired in the estimate, the larger the sample size and cost (*5–7*). In addition, the greater the variation in aircraft operations during the days of the week and seasons of the year, the larger the sample size needed for estimating seasonal or annual airport operations. Finally, the larger the number of airport operations, the smaller the percentage sample size needed for achieving a specific precision in the estimate of airport operations.

Based on the experience of the Oregon and Utah Departments of Transportation, and the Southwestern Pennsylvania Regional Planning Commission, DVRPC selected a stratified cluster sample for each airport consisting of a total of eight weeklong samples, two in each season (*8–10*). As will be discussed in the sections of this paper, this sample resulted in a reasonable sampling error (± 9 to 21 percent) in the estimate of annual airport operations. The eight weekly samples at each

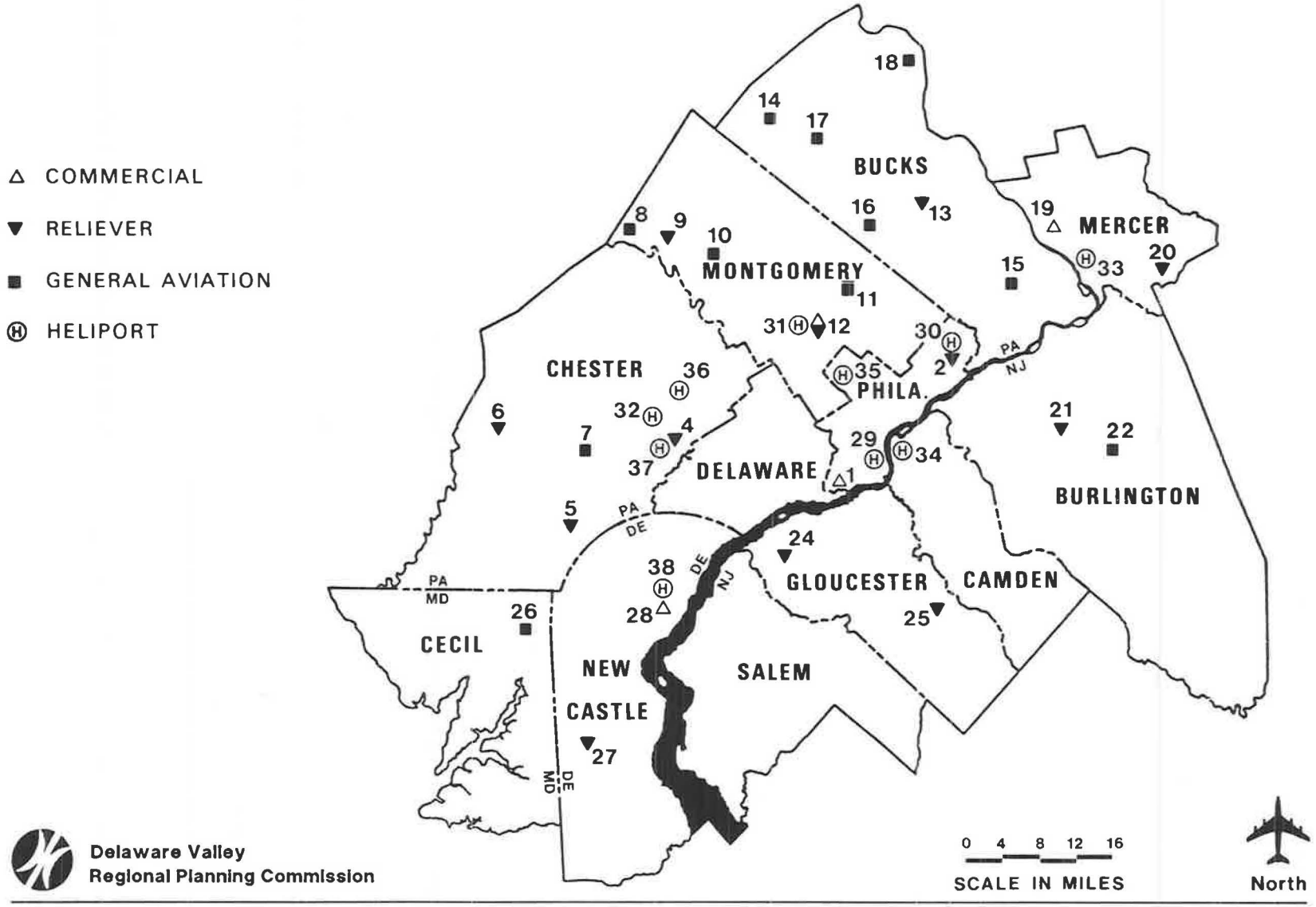

FIGURE 1 Regional airport system plan.

airport were selected at random with a sampling interval of about 6 weeks (52 weeks/9) (*3*), with the first cycle of airports being counted chosen arbitrarily in January or February 1986 in order to maximize the utilization of DVRPC's two acoustical counters during the year. This selection ensured a proportional sample at approximately equal intervals throughout the year.

Estimation of Annual Airport Operations and Sampling Error

Seven steps were used by DVRPC to estimate airport operations and compute the sampling error at 95 percent confidence interval in the estimate of annual operations for each airport counted in 1986. The following model equations are a simplified version of the standard statistical equations for the analysis of variance for the stratified cluster sample (*5, 6*).

1. Given the total daily aircraft counts (X_i) collected during each of the 2 weeks sampled in each season, the average daily counts for each of the 2 weeks were computed by dividing the total weekly counts ($\Sigma_1^7 X_i$) by 7. The average counts were labeled $\bar{X}_1$ and $\bar{X}_2$. Eight values were thus computed for the 8 weeks sampled during the year, two for each season.
2. The average daily counts for the week were subtracted from the daily counts (7 days in each of the 2 weeks of counting) sampled in each season and the differences were squared and summed. The sum was called L.

$$L = \left[\sum_1^7 (\bar{X}_1 - \bar{X}_1)^2 + \sum_1^7 (\bar{X}_2 - \bar{X}_2)^2\right]$$

Four values for L were produced, one for each season, L_w, L_s, L_r, and L_f for winter, spring, summer, and fall, respectively.

3. The average seasonal daily counts ($\bar{X}$) were calculated as follows:

$$X = \frac{\bar{X}_1 + \bar{X}_2}{2}$$

The average daily estimate for the season was subtracted from the average daily counts for the week and the differences were squared and summed for each season. This value was called F. For example, the value of F_w for the winter season is

$$F_w = (\bar{X}_{1w} - \bar{X}_w)^2 + (\bar{X}_{2w} - \bar{X}_w)^2$$

where

$\bar{X}_{1w}$ = average daily counts for the first week sampled in winter,
$\bar{X}_{2w}$ = average daily counts for the second week sampled in winter, and
$\bar{X}_w$ = average daily estimate for the winter season.

4. The variation (V) and parameters for each season and the variance of the annual operations (P) were computed as follows:

$$V = \frac{12F + 6.5L}{90}$$

Four values, V_w, V_s, V_r, and V_f, were computed for the four seasons of the year based on the number of weeks in a season, weeks sampled, and days in the week. The constants in this equation are 13 weeks in a season − 1 = 12, [13 weeks × (7 days in a week − 1)] ÷ [2 weeks sampled × (7 days in a week − 1)] = 6.5, and 13 weeks × 7 days − 1 = 90.

$$P = 476.79\ V_w + 524.81\ V_s + 537.17\ V_r + 476.79\ V_f$$

The coefficients in this equation were estimated for the Calendar Year 1986 based on the number of days in each season and the number of days sampled. For example, 476.79 for the winter season equals

$$\frac{(89)^2}{14} \times \left(1 - \frac{14}{89}\right)$$

5. The total annual operations (J) was computed as follows:

$$J = 89\ \bar{X}_w + 93\ \bar{X}_s + 94\ \bar{X}_r + 89\ \bar{X}_f$$

The coefficients in this equation represent the number of days in the winter, spring, summer, and fall of 1986, respectively.

6. The percentage of annual operations in each season was estimated as follows:

$$89\ \bar{X}_w/J,\ 93\ \bar{X}_s/J,\ \bar{X}_r/J, \text{ and } 89\ \bar{X}f/J$$

7. Finally, the sampling error expressed in percentage terms (h) at the 95 percent confidence level was computed as follows:

$$h = \frac{216\ (P)^{1/2}}{J}$$

The t-value assumed in this equation (2.16) corresponds to 13 (14 − 1) degrees of freedom. It was based on the number of days sampled in each season of the year (*5*).

DATA COLLECTION

DVRPC aircraft counting was made by means of two acoustical activity counters purchased from the RENS company. The counter consists of a microphone, an electronic digital master counter, a tape recorder, and a digital clock that automatically sounds an hourly tone. It is activated by aircraft noise at takeoffs, landings, or other sources. The Oregon Department of Transportation, which pioneered in the use of the RENS counters, provided DVRPC with a special training tape for analysis and audit of tapes. Several types of activities are recorded on the tape, including takeoff, landing, fly by, and taxi, as well as other activity. The tape also includes information on aircraft activities by type of engine (single engine, multiengine, jet, helicopter or other), time of day (24 hours per day), and total daily activities.

In order to minimize the number of activity counters needed, the equipment was installed at an appropriate location near the runway where it can record all aircraft departures. These recorded departures were doubled to account for total operations

(departures and arrivals) assuming that the number of departures is equal to that of arrivals. Nondeparture sounds recorded on the tape were not included in the estimation of seasonal or annual airport operations.

Activity Counter Rotation Cycle

Figure 2 shows the 8 weeks selected for counting at Airports A and B. Two weeks were selected for sampling in each of the four seasons of the year, which approximately correspond to the four calendar quarters. DVRPC started aircraft counting at two airports (A and B) on Monday, December 30, 1985. On the following Monday, the counters were picked up from these airports and installed at Airports C and D to start the first of eight weeks of counting at those facilities. As indicated in Figure 2, the second week of counting at Airports A and B began on February 13, 1986, and the eighth week began on December 1, 1986.

By using two counters, it was possible to sample airport activities at 11 airports during 1986. The remaining 10 nontowered airports in the region are being sampled according to this procedure during 1987.

The counters were installed or removed from airports only on working weekdays in order to decrease the cost of counting. This condition sometimes resulted in more counts than required according to the sampling methodology. However, only required data were considered for processing and running the model. It should be noted that the DVRPC staff has experienced some problems with the counters during the 1986 winter season, and one machine had to be returned to the manufacturer for repair.

Activity Counter Field and Office Sheets

An aircraft activity counter field sheet was designed to include information on airport name, observer name, weather conditions, counter placement in reference to the airport runway layout, and any pertinent remarks by the DVRPC observer responsible for installing the counters. Weather conditions were recorded for the first and last day of the week of aircraft counts, when counters were installed or removed. Cloud cover, precipitation, and wind speed were thus collected in the field for those 2 days in each sample. Other weather data such as cloud ceiling and visibility were recorded for every day of the week. These data were obtained from the National Weather Service and it was determined by DVRPC staff which of the four standard flight rules (LIFR, IFR, MVFR, VFR) was in effect.

An office sheet (Figure 3) was also designed for coding all data collected, including airport name, date of count, and season of the year. Each item was assigned a code number for ease of entry into the computer. The code numbers used are shown in Figure 4. Flight rules or categories were coded based on ceiling and visibility conditions as specified in the table.

Transcription of Airport Operation Tapes

Although the counter accurately records aircraft noise, the correct interpretation of the recordings is necessary to ensure accurate counts of activities. Transcribing the tape and identifying the various sounds are dependent on the skills and experience of the transcriber.

On a weekly basis, airport operation cassette tapes were brought into the office for identifying airport activities by type

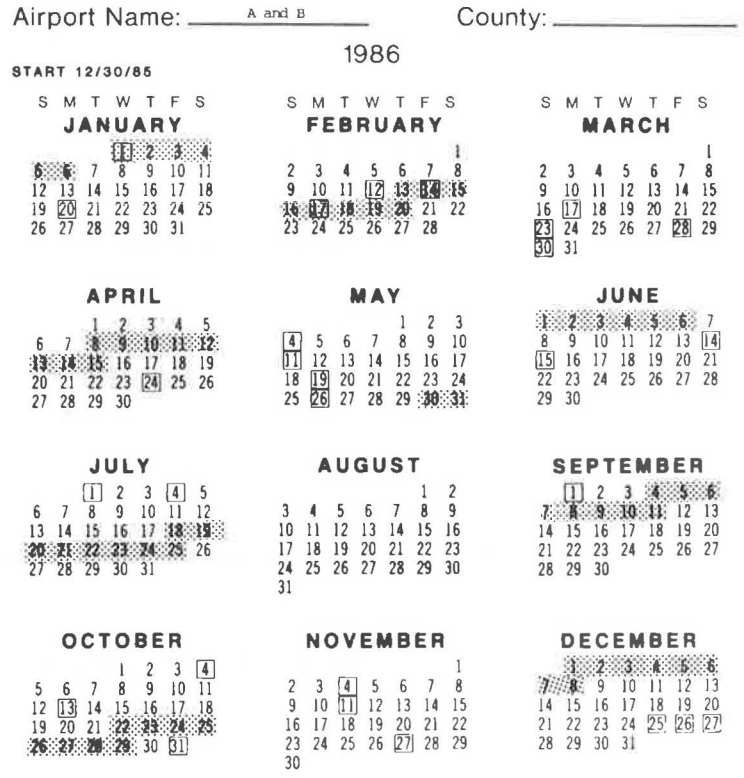

FIGURE 2 Delaware Valley Regional Planning Commission aircraft activity counter rotation cycle.

Airport Name: _____ ( ) (1 - 28) County: _____ ( ) (1 - 12)

Date of Count: __/__/__ Day: _____ ( ) (1 - 7) Holiday: _____ ( ) (1 - 2)

Week of: __/__/__ Season: _____ ( ) (1 - 4)

AIRPORT OPERATION BY TYPE OF ENGINE AND HOUR OF DAY

Hour	Single Engine (S)	Multi-Engine (M)	Jet (J)	Heli-copter (H)	Other (O)	S (1)	M (2)	J (3)	H (4)	O (5)	Total (6)	Hour
Midnight												Midnight
01												01
02												02
03												03
04												04
05												05
06												06
07												07
08												08
09												09
10												10
11												11
Noon												Noon
01												01
02												02
03												03
04												04
05												05
06												06
07												07
08												08
09												09
10												10
11												11
Total Counts												Total Counts

WEATHER CONDITIONS AND FLIGHT RULES

A. Field Observation

Time of Observation: _____

Cloud Cover: ( ) (1 - 3)

Precipitation: ( ) (1 - 3)

Wind Speed: _____ MPH

B. Weather Forecast

Cloud Ceiling: ( ) (1 - 4)

Visibility: ( ) (1 - 4)

C. Flight Rules ( ) (1 - 4)

REMARKS

FIGURE 3 Delaware Valley Regional Planning Commission hourly and daily counts of aircraft operations.

of engine, hour of day, and type of activity. The number of takeoffs by engine type and all other types of activities that occurred in each day during the sample week were determined and recorded on the office sheets (Figure 3). After transcribing the complete tape for the weekly sample period, each category was totaled and the totals entered on the office sheets. The daily totals were then added and compared to the independent weekly count that was taken from the recorder by the field person. In almost all cases, the transcribed counts were equal to the recorded count.

Several difficulties were experienced during the transcription process. It was found that the placement of the microphone with respect to the runway had a significant impact on the quality of the sounds recorded. In some instances, it was necessary to relocate microphones to improve quality of recording or eliminate unwanted activities such as taxiing and

I. AIRPORT CODE

01. Philadelphia International
02. Northeast Philadelphia
03. Oxford
04. Brandywine
05. New Garden
06. Chester County
07. Shannon
08. Pottstown Municipal
09. Pottstown-Limerick
10. Perkiomen Valley
11. Turner
12. Wings
13. Doylestown
14. Quakertown
15. Buehl
16. Warrington
17. Pennridge
18. VanSant
19. Mercer County
20. Trenton-Robbinsville
21. Burlington
22. Red Lion
23. Camden-Burlington
24. Bridgeport
25. Cross Keys
26. Cecil
27. Summit
28. Wilmington

II. COUNTY CODE

01. Bucks
02. Chester
03. Delaware
04. Montgomery
05. Philadelphia
06. Burlington
07. Camden
08. Gloucester
09. Mercer
10. Salem
11. New Castle
12. Cecil

III. DAY CODE

1. Monday
2. Tuesday
3. Wednesday

(DAY CODE Continued)

4. Thursday
5. Friday
6. Saturday
7. Sunday

V. HOLIDAY/NON-HOLIDAY CODE

1. Non-holiday
2. Holiday

V. SEASON CODE

1. Winter
2. Spring
3. Summer
4. Fall

VI. WEATHER FORECAST CODE

Cloud Ceiling
1. Less than 500 feet
2. 500 - 1,000 feet
3. 1,000 - 3,000 feet
4. More than 3,000 feet

Visibility
1. Less than 1 mile
2. 1 - 3 miles
3. 3 - 5 miles
4. More than 5 miles

VII. FLIGHT RULES

1. LIFR -
   Limited Instrument Flight Rules (if ceiling and/or visibility is coded 1)
2. IFR -
   Instrument Flight Rules (if ceiling and/or visibility is coded 2)
3. MVFR -
   Modified Visual Flight Rules (if ceiling and/or visibility is coded 3)
4. VFR -
   Visual Flight Rules (if ceiling and visibility are coded 4)

FIGURE 4 Delaware Valley Regional Planning Commission aircraft counting program instructions.

flyovers. Sometimes, the sensitivity level of the machine was adjusted to obtain the best audio results.

At the beginning of the process, it was difficult to distinguish helicopters from taxiing or idling single-engine aircraft. Normally, the helicopter has a special sound which helps in identification, but this depends on the helicopter's activity at the time of recording. It was almost impossible to determine the helicopter-specific type of activity, such as landing and hovering. Also, single-engine aircraft presented some problems in determining whether the aircraft was taking off or executing a flyover past the microphone. Normally, the sound of the aircraft engine enables the transcriber to make a decision, but it does require exercising judgment.

Finally, the "other" category on the form (Figure 3) was used to record those sounds which were not aircraft departures. Fire trucks, motorcycles, mowers, thunderstorms, animal sounds, and various indistinguishable sounds were observed. In a severe thunderstorm, it was not unusual to find many consecutive observations in this category.

DATA PROCESSING AND MODEL TESTING

All office sheets were reviewed individually and those with apparent error were corrected. The data were then entered into an IBM AT personal computer for processing.

Computer Programming and Generation of Output Tables

A LOTUS-123 spreadsheet template was created for each airport. The templates include input areas for the hourly data of all 7 days from both weeks in each of the four seasons. Other areas

of the template contain the seasonal and annual summaries. The templates have a built-in menu system to aid the user in data entry, computation, and display of seasonal and annual operations, printing reports, and filing.

Three tables were designed to display the computer output by hour of day, day of week and season, and season of year and total annual operations. Tables 1, 2, 3, and 4 are examples produced for Wings Field Airport in Montgomery County. Table 1 shows the daily counts (departures only) by type of aircraft and hour of day. Weather conditions and flight rules are also indicated for the day. The information in Table 1 is identical to that coded on the office sheet. Fifty-six sheets of this form were produced for displaying departure data collected in 8 weeks at each airport.

Table 2 shows the daily and weekly counts (departures and arrivals) at Wings Field Airport for the spring season. Four sheets of this form were produced for the four seasons of the year. The average daily operations in a season were estimated based on the data collected in 2 weeks during the season. As stated before, the estimates of seasonal operations by type of engine were obtained by multiplying the average daily operations in a season by the number of days in that season.

Table 3 indicates the seasonal and annual operations at Wings Field Airport. One sheet of this form was prepared for each airport. The total annual airport operations was obtained by adding the four season estimates for the year. As shown in Table 3, the seasonal operations are also expressed as a percentage of annual operations. Finally, the sampling error was computed by the model according to the statistical equations and assumptions described previously. The actual annual operations at this airport could be any number between 36,470 and 43,684 (40,077 ± 9 percent). It should be noted, however, that the model was designed to compute the margin of error in the annual estimates of airport operations. The error in the daily or seasonal estimates could be smaller than, equal to, or larger than the sampling error in the annual estimates.

Model Testing with Actual Counts

The model was tested four times using actual counts from the towered Greater Wilmington and Mercer County Airports (*4*), where departure and arrival information is recorded for every day of the year. The annual operations at each airport were estimated twice (Tests 1 and 2) by using two different 8-week samples chosen at random. None of the weeks selected for Test 1 overlapped with the weeks for Test 2. The estimated annual operations in each test were compared to the actual counts, along with the margins of error in the model estimates.

TABLE 1 DAILY DEPARTURE COUNTS BY HOUR OF DAY

DVRPC AIRCRAFT COUNTING PROGRAM - DAILY COUNT DATA Screen 1
AIRPORT: WINGS FIELD COUNTY: MONTGOMERY
DATE OF COUNT: 5/12/86 DAY: MON HOLIDAY: NO
WEEK OF: 5/6/86 SEASON: SPRING WEEK #1 DAY 7

	SinEng	MultiEng	Jet	Helcptr	Other	Total
MIDNIGHT	0	0	0	0	0	0
1 AM	0	0	0	0	0	0
2 AM	0	0	0	0	0	0
3 AM	0	0	0	0	0	0
4 AM	0	0	0	0	0	0
5 AM	0	0	0	0	0	0
6 AM	0	4	0	1	0	5
7 AM	1	3	0	1	1	6
8 AM	1	5	0	0	0	6
9 AM	2	3	0	0	0	5
10 AM	0	2	0	0	1	3
11 AM	0	2	0	1	2	5
12 NOON	2	2	0	0	1	5
1 PM	1	3	0	0	1	5
2 PM	0	3	0	0	1	4
3 PM	2	1	0	0	0	3
4 PM	0	4	0	0	2	6
5 PM	1	3	0	0	0	4
6 PM	1	3	0	0	1	5
7 PM	0	2	0	0	0	2
8 PM	0	3	0	0	0	3
9 PM	0	3	0	0	0	3
10 PM	0	0	0	0	0	0
11 PM	0	0	0	0	0	0
TOTAL	11	46	0	3	10	70

FIELD OBS TIME: CLOUDS: PRECIP:
FORECAST CEILING: 4 VISIBLTY: 4 FLT-RULE: 4
WIND:

TABLE 2 AVERAGE DAILY AND SEASONAL OPERATIONS FOR SPRING

DVRPC AIRCRAFT COUNTING PROGRAM — SEASON SUMMARY: SPRING
AIRPORT: WINGS FIELD — COUNTY: MONTGOMERY

Date of Count	Day of Week	AIRCRAFT OPERATIONS BY TYPE OF ENGINE Single	Multi	Jet	Helicptr	Total
Week #1						
5/6/86	TUES	18	98	6	14	136
5/7/86	WED	20	92	4	14	130
5/8/86	THUR	30	90	6	12	138
5/9/86	FRI	54	92	8	8	162
5/10/86	SAT	52	50	2	4	108
5/11/86	SUN	84	60	0	2	146
5/12/86	MON	22	92	0	6	120
Total Operations:		280	574	26	60	940
Daily Average:		40.0	82.0	3.7	8.6	134.3
Week #2						
6/27/86	FRI	64	82	20	14	180
6/28/86	SAT	22	30	4	0	56
6/29/86	SUN	70	42	0	2	114
6/30/86	MON	50	90	4	16	160
7/1/86	TUES	38	78	10	16	142
7/2/86	WED	10	52	6	6	74
7/3/86	THUR	52	90	6	12	160
Total Operations:		306	464	50	66	886
Daily Average:		43.7	66.3	7.1	9.4	126.6
Season Estimates						
Daily Average:		41.9	74.1	5.4	9.0	130.4
Total Operations:		3893	6895	505	837	12130

TABLE 3 SEASONAL AND ANNUAL OPERATIONS

DVRPC AIRCRAFT COUNTING PROGRAM — ANNUAL SUMMARY
AIRPORT: WINGS FIELD — COUNTY: MONTGOMERY

Season & Year	Average Daily Operations	Total Seasonal Operations	Percent of Annual Operations
WINTER 1986	88.0	7,832	20%
SPRING 1986	130.4	12,130	30%
SUMMER 1986	122.3	11,495	29%
FALL 1986	96.9	8,620	22%
Total Annual Operations:		40,077	100%
Margin of Error:		± 9 Percent	

Table 4 compares the actual counts to the estimated operations at Greater Wilmington Airport for the two tests. As shown in this table, the differences between the counts and estimated annual operations are very small—4.4 and 0.3 percent for Tests 1 and 2, respectively. The differences are also smaller than the margins of error in the estimates (±10 and ±11 percent). Table 4 also indicates that the differences between the actual and estimated seasonal operations are generally small, ranging from −14.4 percent for the winter season in Test 2 to 8.6 percent for the spring in Test 1.

According to the 1986 official air traffic records, there were 184,780 operations at Mercer County Airport. The annual operations estimated by the model for this airport were 176,663 and 198,415 for Tests 1 and 2, respectively. The margins of error in

TABLE 4 COMPARISON OF ACTUAL AND ESTIMATED AIRCRAFT OPERATIONS AT GREATER WILMINGTON AIRPORT

		Test 1			Test 2		
			Difference from Acutal Operations			Difference from Actual Operations	
Season	Actual Operations	Estimated Operations	Absolute	Percent	Estimated Operations	Absolute	Percent
Winter 1986	38,280	37,622	(658)	−1.7	32,752	(5,528)	−14.4
Spring 1986	49,422	53,661	4,239	8.6	52,890	3,468	7.0
Summer 1986	46,577	40,930	(5,647)	−12.1	48,437	1,860	4.0
Fall 1986	49,015	42,987	(6,028)	−12.3	49,802	787	1.6
Total 1986	183,294	175,200	(8,094)	−4.4	183,881	587	0.3

NOTE: Margin of error at 95 percent confidence level—Estimated operations is ±10 percent for Test 1; ±11 percent for Test 2.

these estimates were ±10 and ±11 percent. The differences between the actual counts and estimated annual operations were −4.4 and 7.4 percent for Tests 1 and 2. In addition, the differences between the actual and estimated seasonal operations for Test 1 were −3.0, −3.3, −6.6, and −4.8 percent for winter, spring, summer, and fall, respectively. Similarly, Test 2 resulted in −1.7, 14.8, 15.0, and 1.6 percent difference between the actual and estimated seasonal operations. These sensitivity tests indicate clearly that the 8-week sample counts selected according to the DVRPC methodology produce good estimates for seasonal and annual airport operations within small margins of error.

ANALYSIS AND USE OF THE RESULTS

Table 5 presents estimated annual operations for the 11 nontowered airports surveyed in 1986. The margins of error in these estimates are expressed in percentage terms and shown in parentheses. They range from 9 percent for Wings Field in Montgomery County to 21 percent for Pennridge Airport in Bucks County. The estimated annual operations range from 16,947 at Burlington to 68,200 at Cross Keys.

Table 5 also compares the estimated operations produced by the model based on the 1986 survey to those estimated for 1985 according to the DVRPC Regional Airport System Plan (RASP) adopted in 1982 (2). In all cases, the plan numbers are higher than the survey figures. At 8 of 11 airports, the differences between the survey and plan numbers are very significant, ranging from 60 to over 1,000 percent of the 1986 estimated annual operations.

The survey results appear to be quite good, both in terms of airport capacity and current flight operations. The annual estimates are consistent with the level of operations according to aircraft records and observations by airport managers or owners. In 1984, for example, the DVRPC staff made an independent estimate of flight operations at Perkiomen Valley Airport by using airport records and logs and by interviewing airport operations personnel (*11*). The DVRPC estimate of annual operation at this airport was much lower than included in the RASP (16,000 versus 51,000). The 1986 annual operations estimated by the model were 26,091 compared to 58,000 estimated in the RASP for 1985 (Table 5).

If taken at face value, the RASP numbers imply a drastic decline in general aviation in recent years. However, there was no such trend of this magnitude and it is much more likely that the RASP traffic demand figures were overestimated. Essentially, these figures were estimated by multiplying the number of based aircraft by a factor ranging from 400 to 600 operations per year, which seems to be on the high side (*12*). Probably, a factor ranging between 250 and 400 would have been much more reasonable for most nontowered airports in the Delaware Valley Region.

TABLE 5 COMPARISON OF 1986 SURVEY AND 1985 PLAN, ESTIMATED ANNUAL OPERATIONS

Airport			Estimated Annual Operations			Difference	
No.	Name	County	1986 Survey	Margin of Error[a] (%)	1985 Plan[b]	Absolute	Percent
4	Brandywine	Chester	18,108	15	38,000	19,892	110
24	Bridgeport	Gloucester	23,026	17	71,000	47,974	208
21	Burlington	Burlington	16,947	17	193,000	176,053	1,039
25	Cross Keys	Gloucester	68,200	15	109,000	40,800	60
13	Doylestown	Bucks	32,743	15	81,000	48,257	147
17	Pennridge	Bucks	34,598	21	35,000	402	1
10	Perkiomen Valley	Montgomery	26,091	20	58,000	31,909	122
9	Pottstown-Limerick	Montgomery	28,502	14	34,000	5,498	19
14	Quakertown	Bucks	22,603	19	55,000	32,397	143
27	Summit	New Castle	40,371	16	42,000	1,623	4
12	Wings Field	Montgomery	40,077	9	188,000	147,923	369

[a]For example, the actual annual operations at Brandywine Airport could range between 15,392 and 20,824 (18,108 ± 15 percent).
[b]Regional Airport System Plan for the Delaware Valley Region, adopted in 1982 (2).

The 1986 survey results have been mailed to individual airport managers or owners for use in management, planning, and capital investment decisions. They will also be used as a basis for long-range traffic demand projections to update the RASP. The future aviation demand will be greatly influenced by airport improvements, the competitive aviation market, and conversion of some airports to more profitable land uses such as commercial or residential real estate development. The latter is likely in the growing suburban and rural areas of the region. Therefore, annual operations at each airport will be closely monitored by DVRPC to determine a factual trend line based on traffic counts taken over several years.

CONCLUSIONS

The DVRPC model for estimating aircraft activities at non-towered airports has produced good estimates for annual operations at all 11 airports sampled in 1986. It also produced estimates with small sampling or margin of error, ranging from 9 percent for Wings Field Airport to 21 percent for Pennridge. Such errors are acceptable for all planning purposes.

The model was tested with actual data recorded at two towered airports. In all tests, the differences between the actual and estimated annual operations were very small, ranging from 0.3 to 7.4 percent of the actual observations recorded. These figures indicate that an 8-week stratified cluster sample of departure counts during the year, two in each season, is sufficient for producing adequate estimates for airport operations.

Except for some repair problems, the two acoustical activity counters, purchased from the RENS company, were operating adequately throughout the year. Each machine was used for more than 44 weeks in 1986 to record count data specified in the sample design.

The total cost for estimating aircraft operations was about $5,000 per airport. This included the cost of collecting sample data in 8 weeks, transcribing the tapes, coding input data, entering data into the computer, running the model, and tabulating the estimated daily, seasonal, and annual operations output.

The estimates produced are essential for regional planning and programming of airport improvements, and for long-range traffic demand projections. They are being used by airport owners and managers, and by the DVRPC staff for updating the Delaware Valley Regional Airport System Plan.

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