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DEVELOPMENT OF A NON-SURVEY METHOD ESTIMATING TRAFFIC AT NON-TOWERED AIRPORTS

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16. Abstract

This report describes the development of a model for estimating traffic at non-towered airports by non-survey methods for those with insufficient resources to make surveys as described in FAA-RD-73-19.

A companion document "Instruction Manual for Estimating Operations at Non-Towered Airports Using the Non-Survey Method" FAA-RD-74-178 is also available.

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EXECUTIVE SUMMARY

The necessity for an annual reporting of operations at each airport in the United States established the need for this report which defines a standardized procedure that can be utilized in estimating traffic at non-towered airports. This report identifies a method for estimating itinerant, total and local operations at any non-towered airport and presents the reasoning on which these procedures were derived. In addition, procedures for estimating peak traffic per day as well as per hour have been developed and are described in this report.

This report presents an approach that will serve as a NASP tool and therefore may be used to replace the existing methods now used for reporting itinerant and local operations on the FAA form 5010-1. These procedures will reflect a significant improvement in estimating accuracy over the present methods even though complexity to the user and costs of implementation will be minimal and of a similar degree to what is now experienced.

The estimating techniques presented herein enable the measurement of operation levels at individual airports according to the airport's own unique characteristics. These characteristics which are updated annually are readily available in presently published FAA documents. With these procedures an estimate of annual operations may be made with less than a manhour of effort; non-statistically oriented personnel can implement the estimating process and the method is not dependent on computer processing.

As a result of this study, the recommended process for estimating traffic activity at a non-towered airport consists of acquiring and then applying the appropriate data to the following relationships:

- Annual Itinerant Ops = $100\ [.0237\ X_3 + 3.588\ X_4 - .0356\ X_7 + 2.487\ X_9 + .534\ X_{13} + .332\ X_{14} + .1712\ X_{15} - 70.88]$

- Annual Total Ops = $100\ [.0337\ X_3 + 4.921\ X_4 + 1.472\ X_5 - 3.902\ X_{10} + 3.057\ X_{13} + 1.050\ X_{14} - 77.359]$

- Annual Local Ops = Annual Total Ops - Annual Itinerant Ops

Where:

X_3 = Annual Scheduled Air Carrier Departures

X_4 = Airport's Facility Index

X_5 = Portion of Student pilots in the county attributed to this airport

X_7 = Airport Acreage

X_9 = Multi-engine Based Aircraft

X_{10} = Single-engine ($\geq$ 4 place) Based Aircraft

X_{13} = Total Based Aircraft

X_{14} = Registered GA Aircraft in county

X_{15} = Fuel (>100 Octane) Storage Capacity

These formulas, with their appropriate independent variables are the resultant of several hundred regression analysis routines which were systematically implemented in an effort to expose a concise yet accurate relationship that could best estimate airport operations.

The analysis was made on conditions existing at a reference set of 162 airports where actual operation levels were known. The applicability of more than 70 parameters was investigated. Socio-economic data related to the airport's community as well as data concerning physical characteristics at each airport were included in the list of parameters hypothesized as potential measures of traffic. Selection of the reference set of airports which served as the model on which regression routines were applied, was designed to simulate the distribution of the NASP airport population, geographically as well as according to airport size.

The basic approach followed in the conduct of this investigation was to first identify a model consisting of a set of airports sufficiently large to ensure statistical confidence and representative of the airports included in the NASP. Secondly, a group of parameters (airport characteristics) were hypothesized as potential indicators of airport traffic activity. Then, a multiple linear regression process wherein the airports' parameters were treated as independent variables was used to identify the best relationship (appropriate coefficients to be associated with each independent variable) that most closely defined the dependent variable according to the actual operations known at each airport in the model.

This relationship was then evaluated for acceptability by testing the statistical validity of each parameter,(T test),and measuring the multiple correlation coefficient and the standard error of estimate on the model as a whole. In addition, the difference between the actual value and the estimated value of the dependent

variable for each airport within the model was computed and examined individually. Successive regressions were then made after deleting the less statistically valid parameters until a more concise formula was derived wherein each variable as a potential indicator of airport operations could be considered to be at a 95% confidence level.

That relationship and its associated measures of acceptability then constituted the results of one iteration and were directly comparable with other iterations which had similarly been developed but which had originated with a different group of airport parameters. The final selection of the best method for estimating operations was made by testing the better iterations on an independent set of 35 airports whose characteristics had not been used to influence the regression analysis.

In concert with the development of an operations estimating technique, an additional effort was directed towards deriving methods for estimating peak traffic characteristics at non-towered airports. A five-step procedure that yields peak day operations and busy hour operations is the consequence of this effort. The method is based on a statistical analysis of peak operations reported at FAA tower airports and identifies the dependence on three factors: (1) The size of the airport in terms of total annual operations; (2) The type of airport (either general aviation or air carrier) and (3) a geographical factor determined according to FAA regional boundaries. Graphical techniques were developed to aid in this estimating process. The theoretical basis for peak daily operations at the subject airport was determined according to the following expression:

for air carrier airports:

$$\text{Peak Day Ops} = 7.95 - .013T^2$$

for general aviation airports:

$$\text{Peak Day Ops} = 16.15T - 2.74T^{1.26}$$

Where T= annual total operations (in thousands)

This theoretical value was then modified to an estimated value by applying a geographical factor derived according to average conditions which exist at three neighboring tower airports that serve as references. The geographical factor was defined by:

for air carrier reference airports:

$$G_{ac} = \frac{R}{2.90 - .005T}$$

for general aviation reference airports:

$$G_{ga} = \frac{R}{5.90 - T^{26}}$$

Where R = ratio of Peak to Average Daily Ops at reference airports.

T = annual total operations at reference airpor (in thousands)

Busy hour operations at an airport were found to be principally dependent on the airport's total operations and consequently were be estimated with the following relationship:

for air carrier airports:

$$\text{Busy hour operations} = 6.6\ (T)^{.6}$$

for general aviation airports:

$$\text{Busy hour operations} = 2\ (T)^{.85} + (T)^{.75} \ln ($$

Where T = the airport's annual total operations (in thousands)

Graphical techniques for estimating peak day and busy hour operations are later detailed in Sections 3.1 and 3.2.

Although computer processing was used extensively in the development of these estimating relationships, computer processing is unnecessary for the implementation of these techniques. Data which is critical to an understanding of the process or critical to the processes derivation has been documented in this report and is presented either in tabular form or the data base format utilized by the computer. With the exception of operations data for those airports where SCI conducted on-site surveys, all of the data used was collected from existing documents readily available to anyone.

1.0 STUDY PROJECT

1.1 Background

FAA requirements identify the necessity for an annual reporting of operations at each airport in the United States, especially those which are in or candidates for the National Airport System Plan (NASP). Information concerning annual itinerant and local operations at each airport is required so that assessments can be made of the need and the priority of potential airport improvements. Presently, there are approximately 3000 airports in the NASP which are non-towered and without adequate or standardized means for reporting operations data.

The need for a simple and quick method for estimating traffic at non-towered airports has often been provided by individuals somewhat knowledgeable on the subject, who through using their experience and best judgement, specify an estimate. At times these estimates are very good especially when the estimator is an experienced one, yet overall there is considerable inconsistency and unreliability is usually associated with such estimates. It is necessary that a method be developed that will serve as an alternative to the existing means of generating operations data for NASP purposes, acceptable in terms of economy as well as accuracy.

The FAA recently completed a project that encountered some of the difficulties of measuring operations activity at individual non-towered airports. In that effort new, alternative methods for conducting non-towered airport surveys were developed to provide improvements in terms of better accuracy and reduced costs. The

use of the new survey technique however, must be primarily assigned to those instances where the fixed costs associated with providing a statistical degree of accuracy can be afforded, e.g., tower candidate surveys, master plan studies, etc. Its direct application as an alternative to the present method of reporting operations for NASP planning purposes is not economically practical when considerations are made of the existing annual cost expenditures and the more than 3000 airports involved.

As an alternative to the survey method as a means for estimating traffic at non-towered airports, a variety of mathematical models have been created in the past with the hope that a fixed relationship existed between traffic activity levels and some easily acquired parameter indirectly related to airport operations. Proponents of such schemes presumed that by knowing the value of the related parameter, an estimate of annual operations could be easily made and by being dependent on a quantitative value the result would be more credible than those arrived at only through judgement. Recent investigations have shown, however, that these models are also inappropriate and, as in the case of the judgement technique, their use results in inaccurate estimates of annual operations. The difficulty appears to be not so much in their ability to estimate a certain type or size of airport but rather their inconsistency when applied to the variety of airport types and sizes that make up the NASP airports.

The failure of these techniques more likely can be attributed to model development problems rather than the possibility that

a relationship does not exist between annual operations and related airport characteristics. Two reasons may explain the failings of previous models. First, it is unlikely that a single related factor can be solely representative of an airport's annual operations especially when a variety of airports must be considered. Rather, there are numerous factors which are necessary to identify the uniqueness of any particular airport and such factors must come into play if that airport's operations are to be measured. Secondly, it must be recognized that model development activities, including those that have attempted to relate more than one parameter, have always been plagued by the absence of sufficient and accurate operation data about non-tower airports on which the model is to be based. Consequently those models prove to be inadequate because they have inadvertently been designed to reflect inaccurate or inadequate airport operations data.

Yet there is soundness to the reasoning that modeling is fundamental to the solution of the estimating problem. It offers simplicity, ease of implementation and economy. It is perhaps the only practical means to use if more than 3000 airports are to be estimated annually. Such attractions therefore, suggest an effort be made in that direction. With sufficient attention given to deriving an accurate and comprehensive data base about airport characteristics and with a careful analysis of this data it should be expected that an appropriate mathematical model could be developed. By ensuring that modeling development is based on a large group of airports, sufficiently varied by type

and size to reflect the spectrum of NASP airports, the inaccuracy quality that has been associated with previous models can be minimized and an acceptable standardized process achieved. Finally, by implementing the recently improved survey method for estimating traffic at non-towered airports, adequate and accurate airport operations data may be acquired to enable a sound basis on which modeling activities may be designed.

1.2 OBJECTIVE

The purpose of this study is the development of a specific procedure for estimating annual levels of itinerant, local and total operations at non-towered airports. This procedure should be centered about a mathematical formula that relates airport operations as a function of the airport's or its community's characteristics. The new procedure is intended as a NASP tool and as a replacement for the existing methods now used for reporting itinerant and local operations on the FAA Form 5010-1. The procedure should reflect an improvement in estimating accuracy over present methods, however, its complexity to the user and its costs of implementation should be similar to the degree to what is now experienced. The procedure shall be applicable to any non-towered airport in the NASP and therefore responsive to regional, climatic or seasonal differences that exist nationally.

The estimating technique to be developed in this study must be able to measure operation levels at individual airports according to the airport's own unique characteristics. The only restriction as to

the type of characteristics to be used is that such information must be readily available so that implementation of the estimating technique may be unincumbered. To accommodate, annually, the many airports in the NASP and still be economically acceptable, the technique will be one which will enable several airports to be estimated in less than a man-day. The actual application of the estimating technique by non-statistically oriented personnel must be accounted for and the method shall not require computer processing.

A supplementary objective of this study is the development of a methodology for estimating peak hour and peak day operation levels at non-towered airports. Similar to standards specified for the operations estimating process, the method should be readily implemented without specialized training or equipment.

1.3 APPROACH

The philosophy for the study plan centered about a statisical approach as the means for achieving the project's objectives. In light of previous failings it was intended that in addition to the development of a formula for estimating operations, the question concerning the propriety of a mathematical model would conclusively be answered. Impartiality and thoroughness were therefore critical requirements in the performance of the study. Rather than a confined analysis of one or two or even several parameters, traditionally considered as determinants to airport operations, all reasonably related factors were to be examined in such a way that, regardless of intuitive biases, the resultant

relationship would be the best standardized means with which airport operations could be estimated. Certain findings made in the conduct of the study have, in retrospect, borne out the validity of such an approach; intercorrelation characteristics of the operations-related parameters suggest a complexity that otherwise could not easily be overcome.

Most simply stated, the approach was to select a representative group of airports and then collect data about these airports so that regression analysis could be used to identify the most appropriate formula for estimating airport operations. Evaluation, testing and documentation of the estimating procedures would then complete the effort.

More specifically, the study consisted of five major areas of investigation for which the following tasks were directed:

1. Selected an appropriate number of airports which were typical of each type of secondary and feeder system of non-towered airports within the NASP. These airports and their physical characteristics and operation levels then served as a representative data base. A sufficient number of each airport type needed to be included to assure statistical integrity. As the base on which all subsequent analysis was dependent and especially because the resultant findings were to have a universal application, this task was particularly critical.

2. For each of the airports in the "NASP Airports Model" collected data concerning their annual level of itinerant

and local operations. Where such data was unavailable, conducted field surveys at those airports and estimated operations according to the instructions given in the recently developed Survey Method for Estimating Traffic at Non-towered Airports.

3. Compiled from a list of readily available information, a variety of data parameters, pertinent to each airport, which could affect airport operations. The list of parameters was not constrained and addressed social and economic characteristics of the community as well as well as specific features of the airport itself. Included in these parameters were such statistics as number of based aircraft, type of aircraft, airport configurations, airport services, hours flown, number of pilots, community population, wealth, employment, services, etc.

4. Performed the necessary computer application procedures in preparation to the development of a model or mathematical relationship which properly correlates the information categories or sets of categories with the previously measured traffic levels at each respective airport. Regression analysis techniques were then used and the sensitivity of the model parameters were identified for each iteration. The resultant recommended estimating formula was selected as the consequence of a comparative analysis on each iteration.

5. Tested the resultant estimating formulas on a set of airports that were independently selected from the NASP airport population and whose characteristics were not used in the regressive derivation of the estimating relationship. By comparing estimated operations with the actual operations known to occur at those airports, a measure of acceptability could be associated with the resultant formula. Descriptions of the study process, rationale for the derivations and instructions for field implementation of the estimating procedure was then documented.

In addressing the supplemental objective of the study, that is, the development of a procedure to estimate peak traffic characteristics at non-towered airports, there again was the necessity to rely on statistical analysis. In this case, data from tower airports was the sole basis on which the analyses could be made; the necessity for knowing the actual peak day values to use as a reference for basing the estimating procedure, dictated the need for daily traffic measurements and only at tower airports is such information collected every day of the year. Data from a two year period (1971 and 1972) was the basis for this analysis. Data considered as most representative of today's conditions (the two latest years of record, 1971 and 1972) was the basis for this analysis.

1.4 RESULTS

Two products have been developed in this study; a procedure for estimating traffic at non-towered airports and a procedure for estimating those airports' peak traffic characteristics. Both of the procedures require solutions to a mathematical formula as the means of arriving at the estimates. The only other procedural requirement is the collection of appropriate data statistics to use in defining the independent variables of the estimating equations. This latter step can be accomplished simply by extracting the information from several reference documents that are normally present or at least readily available to everyone. Both procedures may be implemented on a single airport in less than an hour.

Solutions to the equations that yield estimates of annual itinerant or total operations require relevant statistics of the airport's air carrier departures (if any), acreage, based aircraft (multi-engine, four place single engine, and total B.A.), registered aircraft in the county, fuel storage capacity ($>$ 100 octane), student pilots, and the airport's facility index (a term coined in this study that represents a composite measure of several airport features and services). Local operations are estimated as the difference between total and itinerant operations estimates. The actual formula for estimating annual itinerant operations is:

$$\text{AIRPORT ITINERANT OPERATIONS} = 100\,(.0237X_3 + 3.588X_4 - .0356X_7 + 2.487X_9 + .534X_{13} + .332X_{14} + .171X_{15} - 70.880)$$

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The relationship for estimating total operations is:

$$\text{AIRPORT TOTAL OPERATIONS} = 100\,(.0337X_3 + 4.921X_4 + 1.472X_5 - 3.902X_{10} + 3.057X_{13} + 1.050X_{14} - 77.359)$$

where:

X_3 = Annual Scheduled Air Carrier Departures

X_4 = Airports Facility Index

X_5= Portion of Student pilots in the county attributed to this airport (Pilots in County times X_{13}/X_{14})

X_7 = Airport Acreage

X_9 = Multi-engine Based Aircraft

X_{10}= Single-engine ($\geq$ 4 place) Based Aircraft

X_{13}= Total Based Aircraft

X_{14}= Registered GA Aircraft in county

X_{15}= Fuel ($>$ 100 Octane) Storage Capacity

The independent variable X_3 can be defined from the CAB & DOT(FAA) published document "Airport Activity Statistics of Certified Route Air Carriers" using Table 7 - Aircraft Departures Scheduled. The Office of Management Systems within the FAA publishes "Census of U.S. Civil Aircraft" and Table 43 of that report (U.S. Active Civil Aircraft by Type, Region, State and County) contains data that can define variable X_{14}.

Another MS document, "U.S. Airmen," RIS-MS-8070-37 is the source of data for defining variable X_5 , student pilots in the airport's county, although this basic value is then multiplied by the ratio of parameter X_{13} and parameter X_{14} . The variable X_4 , Facility Index, is a composite measure of airport characteristics and addresses such features as runways, their surfaces and corrected lengths, fuel

storage capacities, hangar facilities and service buildings. The method for establishing an airport's index is detailed later in Table 2.4.4-1. All of its requisite data is contained in the FAA Airport Master Record, Form 5010-1.

The procedure for estimating peak traffic characteristics at a non-tower airport also requires the solution of several equations. Using the estimated value of annual total operations from the above step as a starting point, the subject airport's theoretical peak day operations are computed as follows:

$$P = 7.95\ T - .013\ (T)^2$$

when the subject airport is an air carrier airport

$$P = 16.15T - 2.74(T)^{1.26}$$

when the subject airport is a general aviation airport

Where

P = theoretical peak day operations

T = annual total operations (in thousands)

The above formulas which show peak operations to be a function of annual total operations describe the mean relationship based on an analysis of all tower airports within the United States. A more precise estimate can be made however by correcting for the actual variations that exist about this mean. Analysis verified that such variations are predictable according to the airport's location (i.e.: according to FAA regional boundaries). A geographical factor has therefore been designated to provide this correction.

It is based on the assumption that airports in the same vicinity, regardless of their size, have a similar percentage variation. The geographical factor is derived by averaging conditions at three neighboring tower airports where actual peak day operations and actual average day operations are recorded. Depending on whether the reference tower airport is an air carrier or a general aviation type of airport, the following expressions define their appropriate geographical influence:

$$G = \frac{R}{2.90 - .005T}$$

when the tower airport is an air carrier airport

$$G = \frac{R}{5.90 - T^{.26}}$$

when the tower airport is a general aviation airport

Where

R = ratio of peak day to average day operations at the tower airport

T = annual total operations (thousands) at the tower airport

The product of the airport's theoretical peak day operations and the average geographical factor constitutes the estimated value of peak day operations. That is:

$$P_e = \bar{G} \times P$$

PEAK OPERATIONS ESTIMATE = AVERAGE GEOGRAPHICAL FACTOR x THEORETICAL PEAK OPERATIONS

Busy hour operations at a non-tower airport can be readily estimated as it has been found to be a direct function of the airport's annual total operations. The following expressions apply:

$$B_{ac} = 6.6(T)^{.6}$$

$$B_{ga} = 2(T)^{.85} + (T)^{.75} \ln (85/T)$$

Where

B_{ac} = Busy hour operations at a non-tower air carrier airport

B_{ga} = Busy hour operations at a non-tower general aviation airport

T = Annual total operations (thousands) at the non-tower airport.

An alternate process for estimating peak traffic has been developed which does not require the formal solutions of the associated equations. This simplified procedure yields identical results but relies on graphical interpretations of the pertinent relationships instead of computational techniques. Otherwise the estimating methodology is similar to that previously described. This graphical solution is detailed on pages 117 through 122.

1.5 EVALUATION

The procedures derived in this study for estimating annual itinerent, local and total operations as well as peak day and busy hour operations will satisfy the basic objectives of the study. The procedures are straight forward and simple to implement; less than one man-hour effort should be sufficient to develop these estimates at a non-towered airport; just five source documents are needed to provide necessary data and the computation procedures involve only arithmetic processes. The method is a standardized one; it has been designed to be applicable at any non-towered location throughout the continental United States.

Acceptability of the estimators is based on two considerations, the foundation on which the modeling process was based and the testing performed on an independent set of airports. Considerable care was taken during the early part of the study to ensure that the airports model, on which the regression analyses were subsequently made, was in fact representative of the overall spectrum of NASP airports. This effort enabled a confidence to be associated with the theoretical aspect of the results in that attention necessarily had to be given to the numerous real and hypothetical airport conditions that might exist within the NASP population of airports. On the other hand the testing activity, wherein the estimating procedure was actually put into practice on 34 independently selected airports, has contributed to the practicality aspects of the procedure's acceptability. This latter evidence, though indicative, shows the application only on a limited and finite number of airports,

and by itself is not conclusive. Yet these practical results do bear out the theoretical anticipations from the modeling analyses which operated on the variety of characteristics at 162 different airports.

A measure of the acceptability of the estimating method is a difficult and subjective item to produce. Even the acceptable method will, for certain conditions, generate undesirable estimates. For example, the proposed method has estimated for Medford, Oregon, one of the airports independently selected for testing, 47,600 annual itinerant operations when in fact that airport is known to have 72,100 itinerant operations. This discrepancy of 24,500 operations could not be considered as a good estimate, so how can the estimating process which generated it be considered as acceptable?

The reason is that the process, though fallible, in most cases yields good results and overall is a better estimator than another method. Of course, some other method might be designed such that it could predict itinerant operations at Medford, Oregon to be exactly 72,100, yet that same method would then likely give very poor estimates for Dawson, Georgia, Paso Robles, California, or Pasco, Washington, each of which were similarly selected for testing by the proposed method and were each estimated to be within 400 operations of their actual annual values.

Acceptability must be determined from an overall assessessment of the estimating method rather than from isolated evaluations of a few individual cases. This is especially important when the method is intended to be standardized and anticipated to have a wide

application. This latter requirement indicates that the resultant estimator must represent a compromise of sometimes divergent factors. Hence, the acceptable method must be expected to possess inherent errors and yield improper estimates at times. From a statistical standpoint, there has been more than an adequate number of observations (162), on which to base the regression analysis and sufficient testing at independent sites (34) to suggest the propriety and the repeatability of the study's conclusions. However, only the test of time, i.e. the multiple application of the technique, can fully evaluate the method.

A general evaluation of the estimators might describe the formula for estimating itinerant operations as good, and total operations as reasonably good. Difficulties in estimating local operations which are included in total operations accounts for the poorer performance of the total operations formula. A more specific evaluation shows the itinerant operations model to have a multiple regression coefficient of 0.853 and a standard error of estimate of 7195. An overall description of the model shows the mean airport itinerant operations level to be 26,499 with a standard deviation of 13,799. Examination of the resultant variables for the estimating formula, exposed by the regression analysis, establishes a confidence level of greater than 96% that the seven parameters are, in fact, significant contributing elements to the estimate.

Testing of the itinerant operations estimator on the 34 independently selected airports which ranged in size from 4,100 to 72,100 annual itinerant operations resulted in 24 good estimates, four poor estimates,

and six marginal estimates not easily categorized as good or bad though they are certainly "ball park." These 34 test airports were known to have had an average of 36,200 actual annual itinerant operations. They were estimated to have an average of 31,600 operations, i.e. a 12% average error.

In the case of estimating total operations on the test group, 23 were good estimates, six were poor and five were marginal. This group as an average had 62,650 total operations per year. They were estimated to have an average of 57,900, i.e. a difference of 4,750 per airport or a 7.5% average error. By comparison the model's average airport had 49,950 total annual operations.

Certain features about the model as well as the consequence of the testing program require amplification. In the first place it must be recognized that there is no single quantitative measure to adequately identify the acceptability of the estimating formulas. Secondly, the measures that are used must be cautiously evaluated. Average error values tend to oversimplify the unfavorable conditions associated with large errors by enabling an overestimate to be cancelled by an underestimate. The standard error of estimate can be equally misleading in that its value is disproportionately influenced by the absolute errors from large airports even though the estimates for those airports represent a small percentage error. Consequently to rule on the merits of one or another estimating method the following considerations must be accounted for:
1) an evaluation of individual airport estimates, 2) an overall evaluation on the set of airports, and 3) a critical review of

the type of airports selected for testing.

For practical reasons both the "airports model" and the group of test airports include a significant number of tower airports. Such sites, with their already recorded number of operations can readily be made part of either airport set and thereby increase the number of observations and hence the statistical validity. Yet tower airports are normally large airports and not necessarily typical of the sites where the estimating formula is intended to find application. In spite of the efforts made to select only the "small" tower airports to be part of the model, there probably is an undue influence, at least in the measurement characteristics of the model, caused by these larger airports. For example, the tower airports within the test set have a standard error of estimate of 14,700, whereas the non-towered airports have a 6,700 standard error of estimate.

One other critique should also be addressed to the study; it concerns the data on which the regression analysis has been derived. For each of the 162 airports in the model, data was collected about the airport's community together with data about the airport itself so that it could be correlated with other data concerning the airports' numbers of operations. Because the validity of the study is dependent on the validity of all input data, considerable attention was directed toward insuring data propriety. However, the practicalities of data collection, in certain cases, imposed limitations. Primarily the problem concerned the data's timeliness

rather than its absence or its inaccuracy. At times certain data sources that had to be used reflected outdated information and the applicability of such data necessarily was based on conjecture rather than assurance. In addition, with the exception of tower airports, the data about the airports' annual numbers of operations were the result of field surveys and it must be recognized that such procedures yield estimates of operations rather than a true reference level as necessarily assumed in the study. In the main these data difficulties were of a minor nature, however in certain cases when either the airport data or the operations data was really suspect, such airports were deleted from the model.

In summary, a favorable evaluation can be made of the estimating methods developed in this study. In theory, the accuracy of the operations model proves to be good and the test program has borne out the model's practicality. Though it is somewhat surprising that the operations estimates are not more dependent on socio-economic factors, there are a variety of parameters that are influential and necessary distinction is therefore provided for within the spectrum of airports. The study has been conducted honestly and objectively and has resulted in a simply implemented technique which can be standardly applied at all non-towered airports.

On the other hand, little can be said that will similarly verify the estimating formula applicable to non-towered airports' peak

operations. Their validity can not be tested (short of conducting a full years survey); rather the process is totally dependent on the assumption that peak operations at non-tower airports are similar to and an extension of peak operations at tower airports, i.e. a function of the airports annual number of total operations. The characteristics of the peak data concerning tower airports suggest that this assumption is appropriate; certainly there is sufficient data to indicate a definite correlation between peak and total operations. However the total absence of similar data for non-towered airports prohibits a testing of the assumption and therefore makes a definite conclusion improper.

The peak operations estimating technique is recommended for use not just because it is available, but because it is based on the best information that is available. The method of application permits either formal computation of several equations or the use of graphs to yield estimates of peak characteristics.

2.0 DEVELOPMENT OF OPERATIONS ESTIMATES

2.1 Theoretical Considerations

Before entering into the process of creating an operations estimating method that will possess those qualities dictated by the study guidelines, i.e., accuracy, inexpensiveness, simplicity and standard application, it is appropriate to consider certain theoretical aspects about the effort. Beginning with a given need for estimates of aircraft operations at non-tower airports, the problem to be addressed is, "what procedures can be employed to obtain such estimates?" There appear to be three possible approaches to this problem: 1) a sample survey to estimate aircraft operations, 2) an estimate based upon the judgement of knowledgeable personnel and 3) a model which will estimate operations by using certain variables which are descriptive of the airport and its environs.

The FAA has had sufficient experience with the first two estimation procedures to be familiar with their pitfalls and advantages. A field survey to collect a sample of operations data, such as is performed to obtain operations estimates for tower candidate airports, can be quite accurate but is expensive and there can be a considerable delay before such an estimate is completed. Judgement estimates have been employed to provide operations data for the FAA Form 5010-1 for some time and though they may at times be excellent, more frequently they suffer from the hazard of wide variation due to the varying qualifications of the individuals making such estimates. Moreover, such estimates may be biased, either intentionally or unintentionally, to meet some special purpose.

A model, on the other hand, has several clear advantages over the other two estimation procedures. It is much less expensive than a survey. Since it is an objective combination of variables which are generally available, its estimates will not vary depending upon the individual who makes the estimate. Its major disadvantage is that it can not be expected to give as accurate an estimate as a good sample survey. Consequently in those situations where inexpensive, unbiased and repeatable estimates of aircraft operations are desired, the employment of a model is strongly indicated.

In order that a model of aircraft activity at non-tower airports be considered as a viable alternative to a sample survey for obtaining accurate operations estimates or as a means for accomodating the objectives of the study, three model criteria must be met. First of all, the model variables must be readily available to all users. Clearly, if not all users of the model have equal access to model variables, the possibility of a standard estimation process throughout the United States would be lost. Moreover, if the variables were available but only by the expenditure of considerable time or money, the cost advantage of the model over a survey would be reduced or even lost.

Secondly, the model should not require a computation procedure which is lengthy or involves the use of computer facilities. Again here, as in the first criterion, a costly or lengthy model estimate would reduce the cost/benefit argument in favor of a model. Finally, the estimate of aircraft operations must be accurate enough to meet the purpose of the estimate. It is this objective which is sacrificed relative to the survey approach, however, unless model

estimates are adequate to requirements, there is really no benefit in employing a model. Insofar as these criteria are met, a model is a useful alternative to other estimation procedures.

The choice among the many possible model types is determined largely upon the feasibility of model development. Certain hypothetical models may have many attractive features but if the process of determining model constants does not meet certain requirements, such models can not in fact be adequately defined. Among these requirements are:

1. The mathematical model that will correlate airport data with operations must be such as to allow the simultaneous employment of many variables. Moreover, it is vital that it be practical to delete or add variables to the list as the development process continues. This requirement is essential in order that hypotheses as to the effectiveness of certain variable sets can be fully tested.
2. The computation procedure for constant determination must be able to accommodate a number of airports sufficient to validate the statistical adequacy of the model. An approach which does not allow the employment of a large number of observations (airports) would suffer in that the user would have little assurance that the estimates given by the model were valid for an extended set of airports.
3. The model chosen should be such as to permit statistical inferences to be drawn concerning the accuracy of model estimates. Moreover, the model should be such as to allow one to choose among potential model variables on a statistical basis. Without such a statistical foundation on which to base decisions

made during model development one can have no assurance that real progress is being made in designing an effective model.

4. Finally the extensive amount of computation required for model development must be accomplished within the framework of the contract, i.e. a timely and economical manner. To achieve this it may be necessary to have a computer program perform the required computation.

One model that can fully meet these requirements is a Multiple Linear Regression model and consequently attention during the course of this study was directed toward developing such a model. The multiple linear regression model equates aircraft operations, Y, to a linear combination of variables X_i, hence:

$$Y = a_o + a_1 X_1 + a_2 X_2 + \ldots + a_n X_n$$

The problem posed in developing such a model is to determine the values of the constants a_i as well as discovering variables X_i which can give good estimates of Y. The fundamental assumption made by this linear approach is that aircraft operations can be considered to be the resultant of a sum of separate effects. Hence, such a model proposes that aircraft operations are the result, for example, of the sum of effects due to the number of pilots in the area, number of based aircraft on airport, airport facilities and airport services.

The procedure for determining the constants a_i for a given sample of airports and a given set of variables X_i can be automated on a computer and no computational difficulties are presented as long as the number of variables employed in any one run does not

exceed 50 or so. Such computer programs can also supply information on the performance of each variable in the model as well as overall model accuracy so that informed decisions can be made as model development proceeds.

This theoretical approach forms the basis for the subsequent analytical procedures. The five major areas of investigation, airports model, data collection, computer preparation, analysis and testing, as mentioned in Section 1.3, Study Approach, were designed to supply the practical requirements that would verify the approach. Each of these major areas are described in the following sections.

2.2 AIRPORTS MODEL

The first and perhaps the most critical task to be performed in the study is the selection of a group of airports, i.e., an airports model, that will be used as a test bed for all subsequent analysis. Its importance stems from an interdependence with each of the other tasks and its inherent influence on the kind of conclusions to be drawn in the study. As the principal factor in dictating subsequent study requirements, this task must also consider the compromises necessary to meet the practical constraints of the study.

The study approach requires that a group of airports be analyzed to determine which of their characteristics affect operations and then define an appropriate mathematical relationship that reflects

annual operations. The selection of which airports should be included in the group of airports to be analyzed is the key step and the objectives of the study must be used to indicate how this step must be performed. The question becomes, "What should be the make-up of this group of airports?" For example if the selected group contains only airports with annual operations greater than 40,000, or only airports with less than 5,000 operations, the bias of the airports model is evident. Though an accurate estimating formula might subsequently be produced from that model, its applicability would be limited to airports similar to those of the limited data base; there could be no confidence in that formula when applied to different airports not in that category.

Consequently, the problem of selecting the airports model reduces to a definition of the resultant formula's applicability. When and on what type of airports will the estimating formula be applied? Airports with operations greater or less than a certain amount should not be included in the model group if there is no intention or no need for estimating operations at such airports.

In addition to the provisions that consider applicability, there must also be provisions made for ensuring statistical validity. Aside from the requirements of statistical ingegrity, validity is enhanced with a greater number of observations which in this case is a larger group of airports. However, attention must also be given to having sufficient representation within each subset category as well as the total group of airports.

Interdependent with all of the airport selection determinants is the matter of practicality and study constraints. Finite limits of time and resources necessitate compromises between the conflicting aspects of validity and the data collection/analysis which is required with each airport added to the airports model. The desire for a model totally representative of the intended application must be weighed against not only the difficulties of acquiring the necessary information but the practicality of getting a sufficient amount to ensure statistical accuracy.

2.1.1 SELECTION PROCESS

The initial event in creating the airports model was the random selection of 200 airports from a listing of approximately 3,100 airports throughout the country who had some type of federal agreement (FAAP, WAA, ect.). These were the airports formerlv identified as NAP airports. The process used a table of random numbers to specify the page number and the item entry from the FFA Source Document RIS-AS-5010-2 dated January, 1972, as the method for selecting the 200 airports. This listing was immediately culled by eliminating the very large tower airports such as L. A. International, Chicago O'Hare, etc. The remaining airports were then grouped according to their state and their number of itinerant operations as specified in the 5010-2 document.

Given that the resultant estimating formula is intended for use as a NASP tool, particularly in the development of five and ten year plans, such applications direct that the airports model be representative of the set of NASP airports. Consequently this required an analysis of the NASP airport population to be made. An examination was made of all 3,100 NAP airports, assumed to be typical of the then-not-issued NASP listing, to determine airport location and size so they could be categorized accordingly. Figure 2.2.1-1 presents the distribution by size (i.e., aircraft operations) of these airports and it is significant to note that three of every four airports have less than 10,000 annual operations though the activity levels range from almost zero to greater than 600,000 per year. Theoretically then it would be desireable to create an airports model which had a similar distribution so that it would be representative in terms of airport's size.

In the same manner it was concluded that for the model to be equitably representative throughout the country it should simulate the statewide distribution of NASP airports. In this case it was deemed that a geographical reckoning based on FAA regional boundaries would be more meaningful than a state by state basis and each of the 3,100 airports were thereby categorized. A graphical representation of this geographical distribution is shown in Figure 2.2.1-2.

FIGURE 2.2.1-1 SIZE DISTRIBUTION OF NASP AIRPORTS

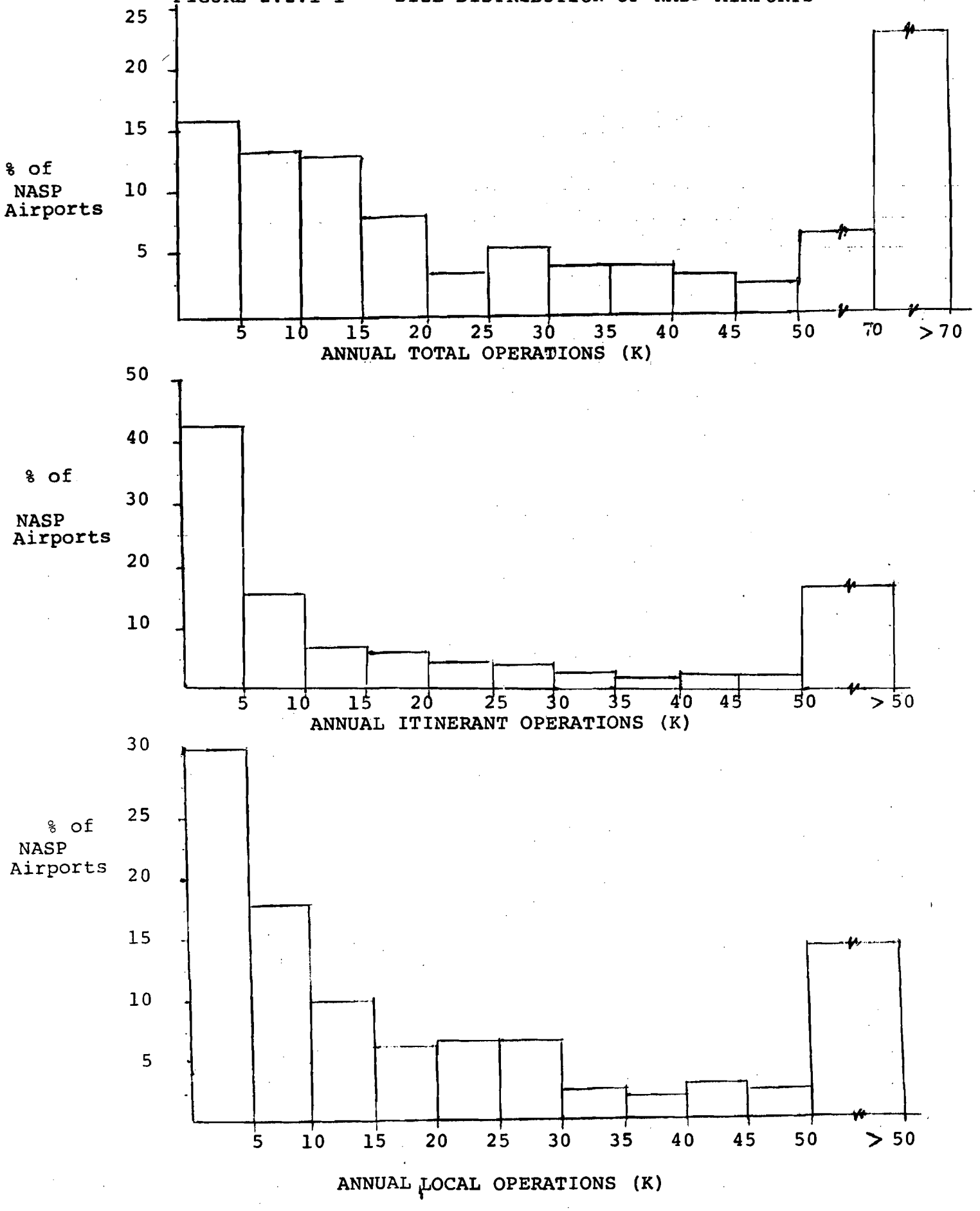
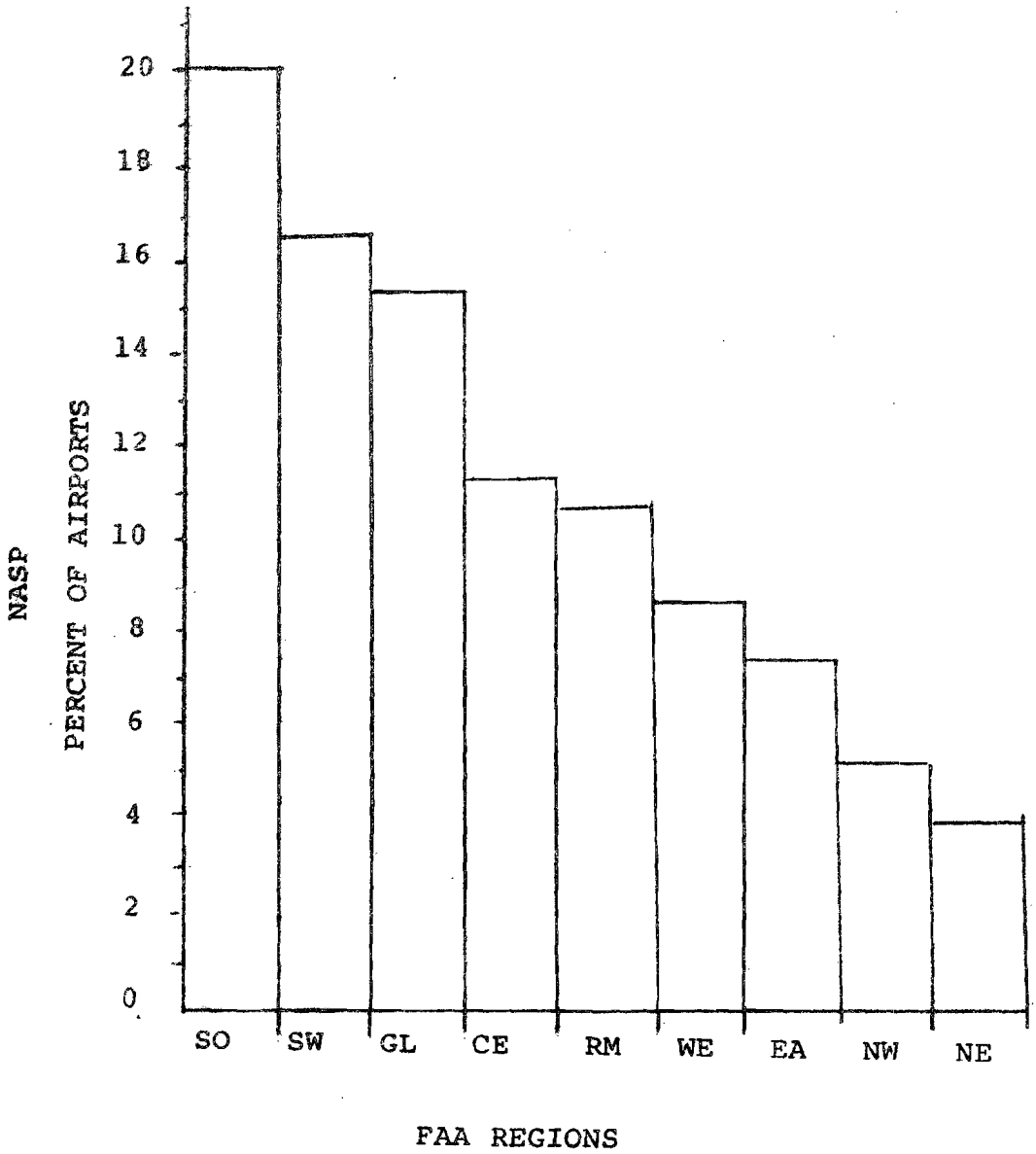


FIGURE 2.2.1-2 GEOGRAPHICAL DISTRIBUTION OF NASP AIRPORTS



A distribution analysis of the 200 randomly selected model candidates was similarly made according to size and geography and not unexpectedly was found to have characteristics dissimilar to NASP. Certain airports causing the distributional dissimilarities were then culled according to their order of random selection until a more appropriate distribution was reached. However this caused a deficiency in the number of candidate airports and prompted a new round of activities wherein the random selection process, the airport categorization and the distributional analysis was repeated.

An additional and equally important consideration was simultaneously applied as criteria for model candidacy. This concerned the type of airport chosen; tower and non-tower classifications were distinguished and the non-tower types were further categorized as tower candidates and non-candidates. Such an examination was due to the quality difference in available data about annual operations that is associated with these three types of airports. Tower airport's operations, recorded daily by the FAA can be assumed totally accurate as well as easily available. Tower candidate airports have operation estimates based on FAA conducted field sample surveys. Though estimating errors may appear at times, on the whole such estimates are relatively accurate. Furthermore a summary file of these estimates is maintained within the Air Traffic Division of the FAA and can be made available. However, operations data about non-towered, non candidate airports is suspect

and can not be used as a reference value. Only if such airports are surveyed (using the tower candidate procedure) can their operation levels be used as a reference; availability for such cases are therefore constrained by the resource limits of the study.

The compromise to be made in selecting airports as possible model airports therefore considered the quality and the availability of operations data for each airport in addition to the desired distributional makeup of the model. On the one hand there was plenty of accurate and readily available information for the large airports that are only a small portion of the NASP population, while on the other hand there was little or no reliable operations data for the bulk of NASP airports which are the ones where the model should be most applicable. As a consequence, priorities were given to tower and tower candidate airports as model candidates; moreover the smaller tower airports and tower candidate airports were made prime candidates because of their better contribution to the distributional simulation. Twenty five non-tower, non-candidate airports were selected to be part of the model and thereby provided modeling coverage for the "small" airports even though they required contractor conducted field surveys.

2.2.2 Model Description

As a result of these various compromises and subsequent iterations an airports model consisting of 162 airports was finally selected.

Of these 62 are towered and 100 are non-towered airports. Table 2.2.2-1 identifies these airports by type and by location. As shown in Figure 2.2.2-1 their locations across the country are proportionally distributed. Figure 2.2.2-2 gives the geographic distribution by FAA region and compares favorably with the actual distribution of NASP airports previously discussed. In terms of individual airport size, the airports model shows the effect of the bias introduced to favor tower airports. Figure 2.2.2-3 presents the models size distribution and comparison with the ideal case, i.e. the NASP's distribution, one can see a shift in the concentration (reduced percentage level) from the small airport size toward the larger airport. With the exception of "under 5,000," there appears to be a reasonable similarity with those airports. normally considered as non-towered airports.

Later in the study, it was found that certain discrepancies that were occurring could be traced to some of the airports selected as part of the airports model. To an extent, this model was intended to be representative of the typical airport, that is those that make up the bulk of the NASP airport population; yet airports within large metropolitan areas, or those principally servicing resort areas could not be classified as typical. Especially those airports in the proximity to military installations appeared to cause an undue influence on the regressions. Furthermore, the original selections still included some large tower airports as well as tower candidate airports whose operations estimates appeared questionable. Consequently, a final purge of the airports model modified it to 124 airports. Table 2.2.2-2 lists the airports and the basis for their deletion.

TABLE 2.2.2-1 AIRPORTS MODEL - TYPE AND LOCATION

AIRPORT	TOWER	NON-TOWER TC	NON-TOWER OTHER
Alabama			
Anniston		x	
Mobile		x	
Tuscaloosa		x	
Muscle Shoals		x	
Arizona			
Goodyear	x		
Flagstaff		x	
Grand Canyon		x	
Prescott		x	
Winslow		x	
Arkansas			
Pine Bluff		x	
El Dorado		x	
Fayetteville		x	
W. Memphis		x	
Hot Springs	x		
Texarkana	x		
Brinkley			x
Harrison			x
California			
Salinas	x		
S. Lake Tahoe	x		
Visalia		x	
Red Bluff		x	
Corona		x	
Sacramento			x
Orland			x
Colorado			
Pitkin Co.	x		
Grand Junction	x		
Julesburg			x
Limon			x
Florida			
Destin		x	
Naples		x	
Titusville		x	
Ocala		x	
Pompano Beach		x	
Lakeland		x	
Vero Beach		x	
Gainesville	x		
Georgia			
Albany	x		
Augusta	x		
Macon	X		
Valdosta	x		
Brunswick		x	

AIRPORT	TOWER	NON-TOWER TC	NON-TOWER OTHER
Georgia (con't.)			
Athens		x	
Rome		x	
Dawson		x	
Butler		x	
Idaho			
Idaho Falls	x		
Pocatello	x		
Illinois			
Decatur	x		
Marion	x		
Mt. Vernon	x		
Danville	x		
E. St. Louis	x		
Greenville			x
Shelbyville			x
Indiana			
Terre Haute	x		
Gary		x	
Elkhart		x	
Paoli			x
Madison			x
Iowa			
Cedar Rapids	x		
Kansas			
Salina	x		
Hutchinson	x		
Liberal	x		
Elkhart			x
Junction City			x
Hugoton			x
Concordia			x
Kentucky			
Owensboro	x		
Bowling Green		x	
London		x	
Middlesboro			x
Morehead			x
Louisianna			
Patterson		x	
Maine			
Bangor	x		
Fryeburg			x
Auburn-Lewiston			x
Maryland			
Gaithersburg		x	
Hagerstown		x	
Massachusetts			
Orange			x
Gardner			x

TABLE 2.2.2-1 (continued)

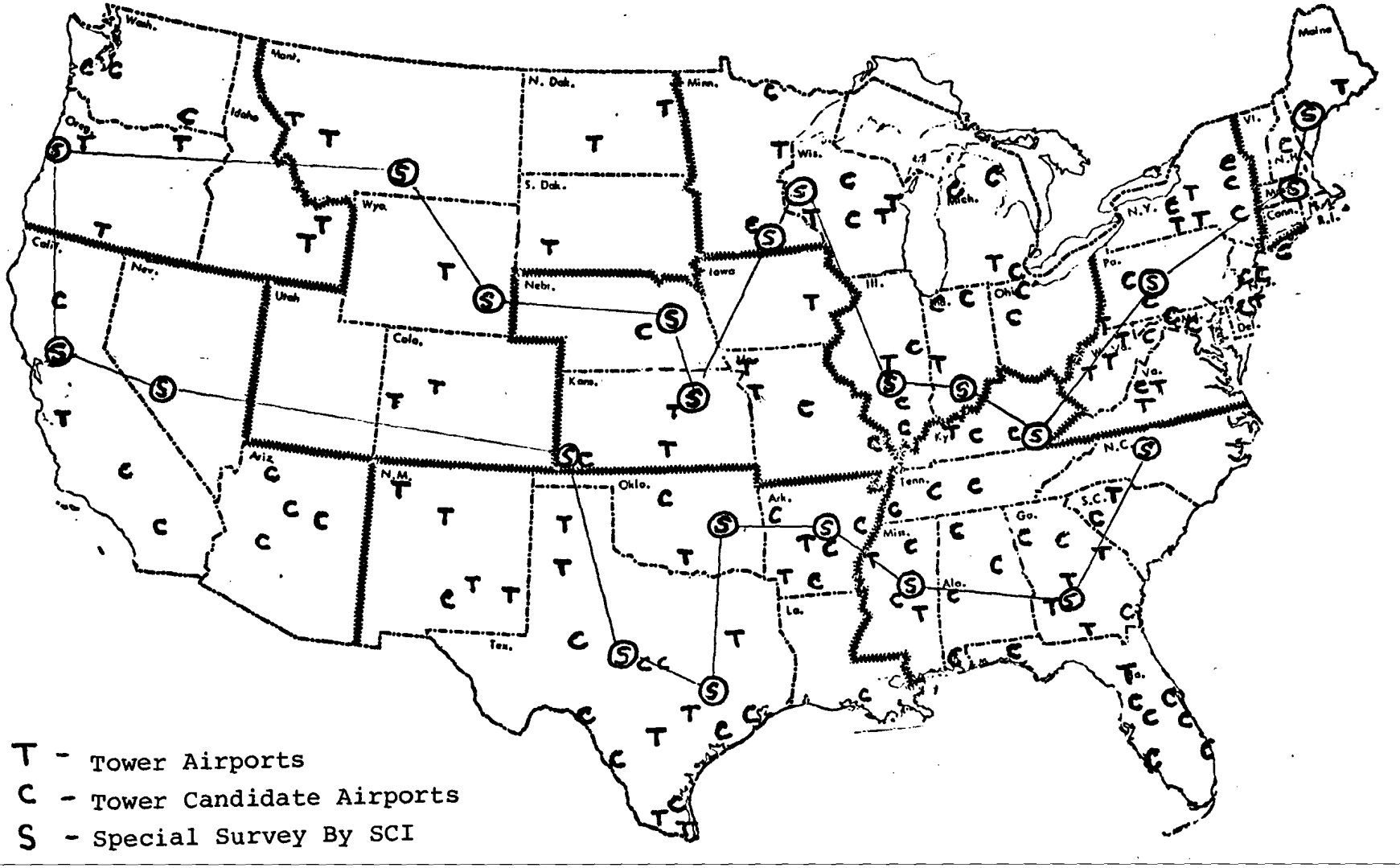
AIRPORT	TOWER	NON-TOWER TC	NON-TOWER OTHER
Michigan			
Jackson	x		
Grosse ILE		x	
Traverse City		x	
Alpena		x	
Minnesota			
Duluth	x		
International Falls		x	
Mankato		x	
Albert-Lea			x
Mississippi			
Meridian	x		
Tupelo		x	
Greenville	x		
Madison		x	
Philadelphia			x
Starkville			x
Missouri			
K.C.International	x		
St. Josephs	x		
C. Girardeau		x	
Columbia		x	
Montana			
Helena	x		
Missoula	x		
Red Lodge			x
Hardin			x
Nebraska			
Grand Island		x	
David City			x
Fremont			x
Nevada			
Tanopah			x
Hawthorne			x
New Hampshire			
Lebanon		x	
New Jersey			
Atlantic City	x		
Readington		x	
Wildwood		x	
Belmar		x	
New Mexico			
Hobbs	x		
Roswell	x		
Farmington	x		
Santa Fe	x		
Alamagordo		x	
Artesia			x
New York			
Utica	x		
Elmira	x		
Binghamton	x		

AIRPORT	TOWER	NON-TOWER TC	NON-TOWER OTHER
New York (cont.)			
Schenectady		x	
Poughkeepsie		x	
Shirley		x	
Glen Falls		x	
Ithica		x	
North Carolina			
Ahoskie			x
Elkin			x
North Dakota			
Bismark	x		
Frand Forks	x		
Ohio			
Toledo	x		
Toledo		x	
Lima		x	
Oklahoma			
Ardmore	x		
Enid		x	
Wilburton			x
Hugo			x
Oregon			
Pendleton	x		
Hillsboro '	x		
Klamath Falls	x		
Tillamook			x
Hermiston			x
Pennsylvania			
Franklin		x	
Johnstown		x	
Punxsutawny			x
Titusville			x
South Carolina			
Anderson		x	
Spartanburg	x		
South Dakota			
Rapid City	x		
Tennesee			
Jackson		x	
Millington		x	
Smyrna		x	
Texas			
Amarillo	x		
Plainview	x		
Tyler	x		
San Antonio	x		
McAllen	x		
College Station	x		
Brownsville	x		
Laredo		x	
Killeen		x	

TABLE 2.2.2-1 (concluded)

AIRPORT	TOWER	NON-TOWER		AIRPORT	TOWER	NON-TOWER	
		TC	OTHER			TC	OTHER
Texas							
Harlingen		x					
Victoria		x					
Big Spring		x					
Del Rio		x					
Galveston		x					
Temple		x					
Hearne			x				
Coleman			x				
Virginia							
Lynchburg	x						
Charlottesville	x						
Staunton		x					
Washington							
Tacoma		x					
Walla Walla		x					
Olympia		x					
West Virginia							
Clarksburg	x						
Morgantown	x						
Parketsburg	x						
Wheeling	x						
Martinsburg		x					
Wisconsin							
Oshkosh	x						
LaCrosse	x						
Appleton	x						
Mosinee		x					
Rhinelander		x					
New Richmond			x				
Eau Claire			x				
Wyoming							
Casper	x						
Wheatland			x				

FIGURE 2.2.2-1 AIRPORT SITES INCLUDED IN MODEL



T - Tower Airports

C - Tower Candidate Airports

S - Special Survey By SCI

FIGURE 2.2.2-2 GEOGRAPHICAL DISTRIBUTION OF AIRPORTS MODEL

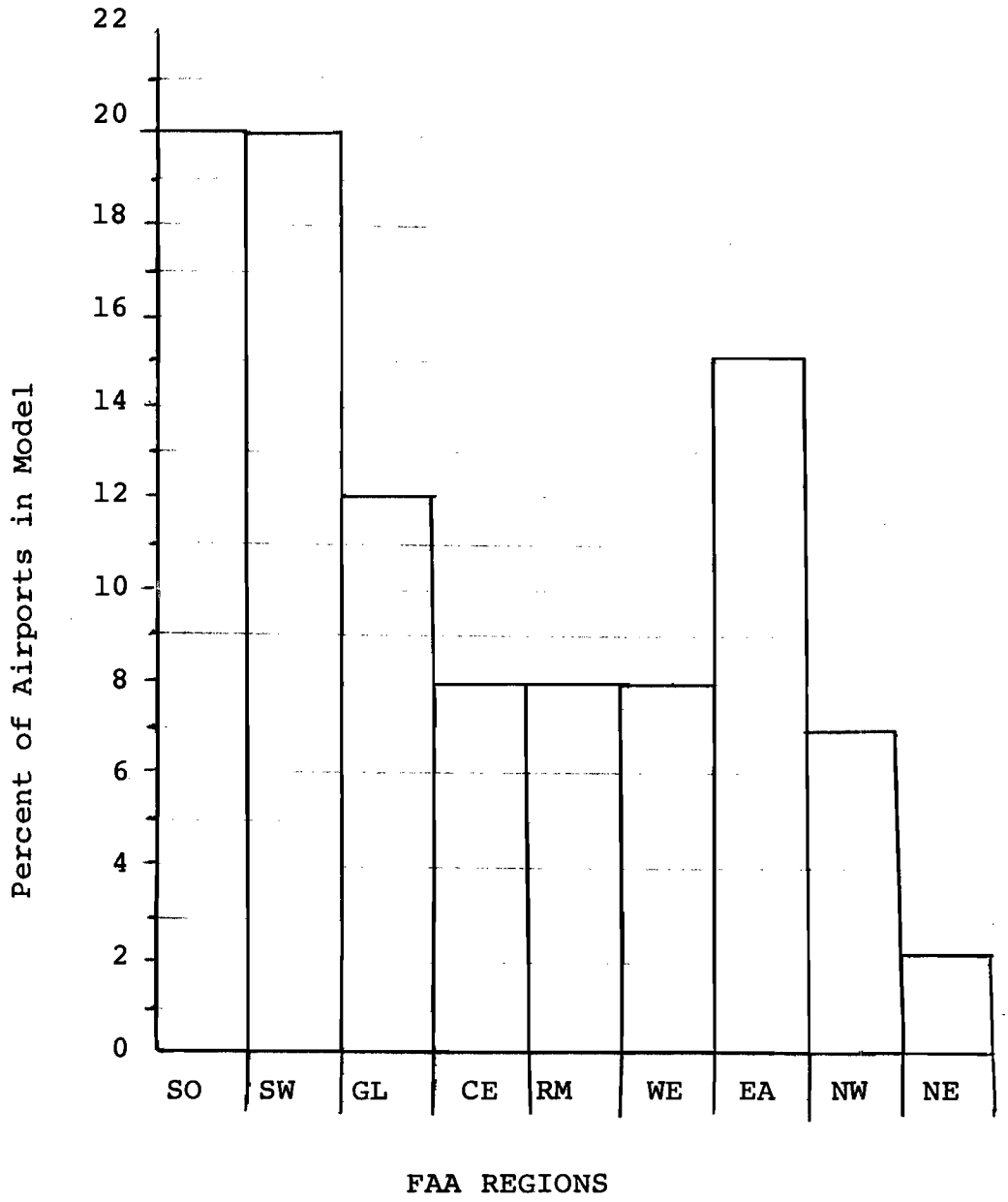


FIGURE 2.2.2-3 SIZE DISTRIBUTION OF AIRPORTS MODEL

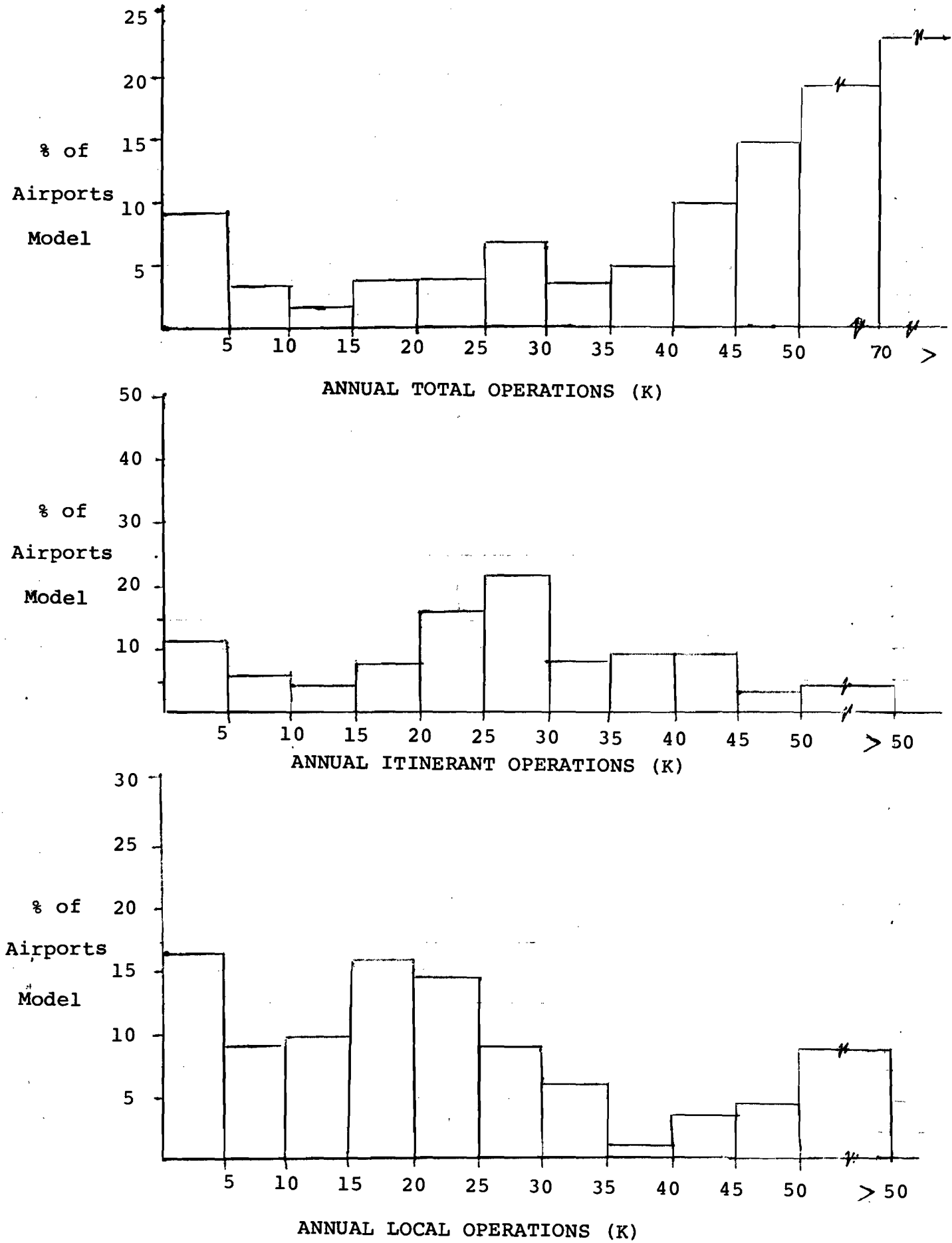


TABLE 2.2.2-2 DELETIONS FROM AIRPORTS MODEL

AIRPORT	I.D. No.	CAUSE FOR DELETION
Anniston, Alabama	470	Only one T.C. Survey
Mobile, Alabama	480	63,000 Itinerant Operations - Too large
Goodyear Arizona	10	160,000 Total Ops - too large
South Lake Tahoe, California	250	Too few local Ops - Resort area
Destin, Florida	580	Only one T.C. Survey - 26 mo. from data
Valdosta, Georgia	1000	Significant military operations
East St. Louis, Illinois	490	71,000 Total Ops - too large
Liberal, Kansas	1520	Disparity in T.C. Surveys
Patterson, Louisiana	360	Only one T.C. Survey - data discrepancy
Bangor, Maine	1040	Significant military Ops
Alpena, Michigan	1590	Only one T.C. Survey - Military Ops
Grose Isle, Michigan	1570	Wide disparity in two T.C. Surveys
Traverse City, Michigan	1580	Outdated 5010 data; Military Ops
Duluth, Minnesota	1060	Significant military Ops
International Falls, Minnesota	370	Wide disparity in two T.C. Surveys
Greenville, Mississippi	80	One T.C. date point - Late '72 tower
Madison, Mississippi	390	Only one T.C. Survey
Meridian, Mississippi	1070	Significant military Ops
Kansas City Int'l., Missouri	1080	125,000 Total Ops - too large
Atlantic City, New Jersey	1110	Significant military Ops
Belmar, New Jersey	1650	Only one T.C. Survey - data discrepancy
Readington, New Jersey	400	Only one T.C.Survey; 22 mos. from data
Lima, Ohio	420	Only one T.C. Survey - 19 mos. from data
Toledo, Ohio	1720	Disparity in T.C.Surveys
Enid, Oklahoma	1730	Significant military Ops
Klamath Falls, Oregon	1200	Significant military Ops
Franklin, Pennsylvania	1740	Only one T.C. Survey; 12 mos. from data
Johnstown, Pennsylvania	1750	Only one T.C. Survey; 12 mos. from data
Millington, Tennessee	1760	Wide disparity in two T.C.Surveys
Smyrna, Tennessee	1770	Significant military Ops
Amarillo, Texas	1210	Significant military Ops
Big Spring, Texas	1810	Significant military Ops
Del Rio, Texas	1820	Significant military Ops
Laredo, Texas	1780	Significant military Ops
San Antonio, Texas	1230	Significant military Ops
Martinsburg, West Virginia	1880	Significant military Ops
Rhinelander, Wisconsin	1900	Only one T.C. Survey; 15 mos. from data

2.3 AIRPORT OPERATIONS - REFERENCE LEVELS

The next major task of the study was the collection of appropriate data for each of the airports that were selected to be part of the airports model. One of the necessary data items concerned the airports' actual numbers of annual operations. Though itinerant, local and total operations were of principal concern due to their direct bearing on the study objectives, attention was also directed to the collection of information about airports' air carrier, air taxi and military operations. The data collection process was dependent on the type of airport being examined and required either of two different procedures. For tower airports and tower candidate airports,a routine literature-search type effort sufficed. On the other hand, an extensive estimating process requiring field inspection and surveys at the airport was required for the small non-towered airports.

Tower airport operations are recorded daily by the FAA on Form 7230 and such information summarized and published on a fiscal and calendar year basis in the report "FAA Air Traffic Activity." This source was used in the study to define the reference operations levels for the tower airports in the model. An extraction from this source is shown below and illustrates the categories of data.

TABLE 4 CALENDAR YEAR 1972

AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA-OPERATED TRAFFIC CONTROL TOWERS BY STATE

STATE AND LOCATION NAME	LOCATION IDENTIFIER	HUB	TOTAL	AIR CARRIER	AIR TAXI	GENERAL AVIATION	MILITARY
MICHIGAN		(CONTINUED)					
GRAND RAPIDS		(CONTINUED)					
ITINERANT OPERATIONS			93260	24154	2607	66203	296
LOCAL OPERATIONS			42558			42413	145
TOTAL OPERATIONS			135818	24154	2607	108616	441
JACKSON REYNOLDS MUNIC	(JXN)	N					
ITINERANT OPERATIONS			43361	3273	673	39060	355
LOCAL OPERATIONS			31694			31354	340
TOTAL OPERATIONS			75055	3273	673	70414	695
KALAMAZOO	(AZO)	S					
ITINERANT OPERATIONS			71252	10777	479	59973	283
LOCAL OPERATIONS			66536			66342	194
TOTAL OPERATIONS			137788	10777	479	126055	477

The operation levels used as reference values for the model's tower candidate airports were extracted from airports surveys conducted by the FAA Regions. These surveys require a seven day count of operations and are periodically made as a step in a formal procedure to estimate airport operations; the estimates are used to assess an airport's qualification for tower installation. Summary records of these surveys/estimates are maintained within the Air Traffic Division of the FAA. A typical record is shown below. It should be noted that the data is slightly different from tower data in that general aviation and military itinerant traffic is combined in a single entry.

Harlingen, Texas				Industrial Airpark				A/C TT
LOCATION				AIRPORT			TYPE AIRPORT	
SURVEY DATES	TOTAL ITINERANT	SCH A/C	G/A AND MILITARY	AIR TAXI COMMUTER	LOCAL OPS	TOTAL OPS	BASED AIRCRAFT	PASS.
6/21-27/69	23,242	7,072	16,172	-	22,672	45,914	38	-
11/4-10/70	24,268	7,176	17,092	-	13,672	37,940	53	195,000
5/2-8/71	24,466	6,448	18,018	-	10,538	35,004	64	
11/6-12/71	30,000	6,500	23,500	-	15,800	45,800	64	
5/22-28/72	31,040	6,344	24,696	-	27,976	59,016	64	

When more than one survey was recorded, a smoothing process was applied to the difference in operation levels and the reference value selected was a composite of the recorded values modified if necessary, to be applicable to the date of the airport's most recent 5010 inspection. For those cases where wide disparities in operations made it impossible to reasonably smooth the difference from one survey to another, it was assumed that at least one estimate was improper

and the airport was deleted from the model.

Data collection of operations at the small non-towered airports represented a significant portion of the effort. For these airports in the model it was necessary to conduct, as part of the study, the same procedures that are normally done in the FAA's tower candidate surveys, i.e., schedule the field survey, perform the actual count of operations, correlate this count with operations at neighboring tower airports to determine its normalcy and then project the count from the sample period to an annual basis.

The itinerary that was prepared to give coverage to small airports indicated the need for a six month period. As a precaution, an alternate airport was selected as a backup for each basic airport in the event that uncontrollable conditions might prohibit a successful survey. Table 2.3-1 lists the itinerary for surveying the primary and alternate airports. As these airport locations were spread throughout the United States, this order was chosen to minimize the effect of expected seasonal conditions. Airport surveys commenced on March 1, 1973.

The composite method as described in Report No. FAA-RD-73-18, Statistical Methods for Measuring Aeronautical Activity at Non-Towered Airports, was the technique followed in estimating these operations. Abrams Counters were used as a supplement to the surveyor's on-site count and were provided to the contractor by the Michigan Aeronautics Commission. A summary of the results of these surveys with the estimated levels of annual operations is given in Table 2.3-2.

As scheduled, 24 airports were surveyed. However, two airports,

TABLE 2.3-1 ITINERARY OF AIRPORT SURVEYS

WEEK NO.	AIRPORT	ALTERNATE AIRPORT
1.	Aloskie, N. Carolina	Elkin, N. Carolina
2.	Dawson, Georgia	Butler, Georgia
3.	Philadelphia, Mississippi	Starkville, Mississippi
4.	Brinkley, Arkansas	Harrison, Arkansas
5.	Wilburton, Oklahoma	Hugo, Oklahoma
6.	Hearne, Texas	Coleman, Texas
7.	Coleman, Texas	Artesia, N. Mexico
8.	Tanopah, Nevada	Hawthorne, Nevada
9.	Sacramento, California	Orland, California
10.	Tillamook, Oregon	Hermiston, Oregon
11.	Red Lodge, Montana	Hardin, Montana
12.	Wheatland, Wyoming	Julesburg, Colorado
13.	Julesburg, Colorado	Limon, Colorado
14.	Elkhart, Kansas	Hugoton, Kansas
15.	Junction City, Kansas	Concordia, Kansas
16.	David City, Nebraska	Freemont, Nebraska
17.	Albert Lea, Minnesota	New Richmond, Wisconsin
18	New Richmond, Wisconsin	Eau Claire, Wisconsin
19.	Greenville, Illinois	Shelbyville, Illinois
20.	Paoli, Indiana	Madison, Indiana
21.	Middlesboro, Kentucky	Morehead, Kentucky
22.	Punxsutawnay, Penn.	Titusville, Penn.
23.	Orange, Massachusetts	Gardner, Massachusetts
24.	Fryeburg, Maine	Auburn-Lewiston, Maine

Table 2.3-2 SMALL AIRPORT OPERATION ESTIMATES BY SURVEY METHOD

SURVEY AIRPORT	ITINERANT OPERATIONS					LOCAL OPS.	TOTAL OPS.
	AIR CARRIER	AIR TAXI	MILITARY	GENERAL AVIATION	TOTAL		
• Punxsutawney, Mun. Pennsylvania	0	0	0	2,720	2,720	500	3,220
• Orange, Massachusetts	0	0	0	7,000	7,000	8,580	15,580
• Fryeburg, Maine	0	0	0	6,120	6,120	12,780	18,900
• Elkin, North Carolina	0	0	0	5,710	5,710	5,040	10,750
• Dawson, Georgia	0	0	0	4,310	4,310	9,200	13,510
• Phila.Mun., Mississippi	0	0	0	3,240	3,240	4,850	8,090
• Brinkley, Arkansas	0	0	0	150	150	0	150
• Wilburton, Oklahoma	0	0	0	2,110	2,110	2,780	4,890
• Hearne, Texas	0	0	0	2,800	2,800	160	2,960
• Coleman, Texas	0	0	0	960	960	0	960
• Elkhart, Kansas	0	0	0	440	440	160	600
• Tonopah, Nevada	0	180	0	4,900	5,080	5,980	11,060
• Orland Haigh, California	0	0	0	7,270	7,270	6,190	13,460
• Tillamook, Oregon	0	180	0	1,880	2,060	730	2,790
• Red Lodge, Montana	0	0	0	3,310	3,310	980	4,290
• Wheatland, Wyoming	1,280	0	0	3,190	4,470	2,190	6,660
• Junction City, Kansas	0	0	3,720	4,090	7,810	10,420	18,230
• David City, Nebraska	0	0	0	2,040	2,040	1,330	3.370
• Albert-Lea, Minnesota	0	0	0	9,180	9,180	6,020	15,200
• New Richmond, Wisconsin	0	0	0	2,380	2,380	1,090	3,470
• Greenville, Illinois	0	0	0	4,860	4,860	1,460	6,320
• Middleboro, Kentucky	0	0	0	5,190	5,190	2,920	8,110
• Paoli, Indiana	0	0	0	2,210	2,210	0	2,210

Ahoskie, North Carolina, and Brinkley, Arkansas were scrubbed due to bad weather. Elkin, North Carolina was selected as an alternate to Ahoskie, North Carolina and Orland, California was substituted for Tenco Tractor Airport outside of Sacramento, California because this airport had recently been closed to all outside operations. Bad weather plagued much of the early part of the survey although near the end the weather was quite good.

Table 2.3-3 lists all of the airports in the model, tower, tower candidates, and small airports, and identifies the level of itinerant, local and total operations that has been associated with each as a result of the various data collection efforts. The file sequence number given with each airport is simply an identifier used to simplify the computer processing of the data.

TABLE 2.3-3 REFERENCE OPERATION LEVELS FOR AIRPORTS MODEL

FILE SEQUENCE NUMBER	AIRPORT NAME	ANNUAL OPERATIONS (THOUSANDS)			
		ITINERANT	LOCAL	TOTAL	
10	Goodyear, Arizona	43.4	117.6	161.0	*
20	Gainsville, Florida	50.0	30.4	80.4	
30	Idaho Falls, Idaho	26.1	10.0	36.1	
40	Pocatello, Idaho	30.4	17.5	47.9	
50	Terre Haute, Indiana	40.2	31.5	71.7	
60	Hutchinson, Kansas	40.3	24.1	64.4	
70	Owensboro, Kentucky	29.6	18.9	48.5	
80	Greenville, Mississippi	20.6	6.1	26.7	*
90	Helena, Montana	23.5	23.9	47.4	
100	Hobbs, New Mexico	21.7	9.4	31.1	
110	Farmington, New Mexico	30.3	5.6	35.9	
120	Elmira, New York	39.4	47.9	87.3	
130	Grand Forks, North Dakota	24.0	65.0	89.0	
140	Ardmore, Oklahoma	26.6	31.9	58.5	
150	Spartanburg, South Carolina	29.6	26.8	56.4	
160	Rapid City, South Dakota	44.0	43.8	87.8	
170	Plainview, Texas	27.9	15.8	43.7	
180	Charlottesville, Virginia	30.5	15.8	46.3	
190	Morgantown, West Virginia	37.1	28.6	65.7	
200	Appleton, Wisconsin	28.5	23.5	52.0	
210	Oshkosh, Wisconsin	48.8	48.4	97.2	
220	Hot Springs, Arkansas	43.2	21.2	64.4	
230	Texarkana, Arkansas	46.2	25.1	71.3	
240	Salina, Kansas	30.3	24.5	54.8	
250	S. Lake Tahoe, California	26.9	7.0	33.9	*
260	Pitkin Co., Colorado	20.6	4.1	24.7	
270	Grand Junction, Colorado	37.1	18.1	55.2	
280	Albany, Georgia	54.9	30.6	85.5	
290	Augusta, Georgia	56.2	46.6	102.8	
300	Macon, Georgia	43.6	41.8	85.4	
310	Tuscaloosa, Alabama	23.0	28.0	51.0	
320	Muscle Shoals, Alabama	20.5	15.0	35.5	
330	El Dorado, Arkansas	15.9	14.0	29.9	
340	Visalia, California	25.8	22.4	48.2	
350	Marion, Illinois	28.1	12.1	40.2	
360	Patterson, Louisiana	19.9	15.0	34.9	*
370	Int'l. Falls, Minnesota	6.3	19.8	26.1	*
380	Mankato, Minnesota	9.0	18.8	27.8	
390	Madison, Mississippi	21.8	28.9	50.7	*
400	Readington, New Jersey	17.6	37.2	54.8	*
410	Alamagordo, New Mexico	10.5	23.8	34.3	
420	Lima, Ohio	11.1	3.7	14.8	*
430	Anderson, South Carolina	13.9	9.2	23.1	
440	Jackson, Tennessee	17.4	17.1	34.5	
450	Harlingan, Texas	27.5	16.0	43.5	
460	Tacoma, Washington	23.0	50.0	73.0	

Table 2.3-3 (continued)

FILE SEQUENCE NUMBER	AIRPORT NAME	ANNUAL OPERATIONS (THOUSANDS)			
		ITINERANT	LOCAL	TOTAL	
470	Anniston, Alabama	9.5	12.1	21.6	*
480	Mobile, Alabama	28.6	35.1	63.7	*
490	Flagstaff, Arizona	26.5	23.5	50.0	
500	Grand Canyon, Arizona	23.0	16.5	39.5	
510	Prescott, Arizona	28.5	24.0	52.5	
520	Winslow, Arizona	21.5	3.5	25.0	
530	Pine Bluff, Arkansas	29.5	11.0	40.5	
540	Fayetteville, Arkansas	29.8	17.0	46.8	
550	W. Memphis, Arkansas	39.5	77.0	116.5	
560	Red Bluff, California	19.2	9.4	28.6	
570	Corona, California	21.8	86.0	107.8	
580	Destin, Florida	21.1	31.1	52.2	*
590	Naples, Florida	26.0	10.0	36.0	
600	Titusville, Florida	30.0	39.2	69.2	
1000	Valdosta, Georgia	21.1	70.2	91.3	*
1010	Decatur , Illinois	33.5	25.2	58.7	
1020	Cedar Rapids, Iowa	49.3	34.8	84.1	
1030	Salinas, California	48.7	56.6	105.3	
1040	Bangor, Maine	51.0	27.7	78.7	*
1050	Jackson, Michigan	41.4	26.4	67.8	
1060	Deluth, Minnesota	51.4	26.1	77.5	*
1070	Meridian, Mississippi	34.6	7.3	41.9	*
1080	Kansas City Int'l, Missouri	19.2	82.6	101.8	*
1090	St. Joseph's, Missouri	41.6	82.5	124.1	
1100	Missoula, Montana	42.9	41.4	84.3	
1110	Atlantic City, New Jersey	41.9	63.2	105.1	*
1120	Rosewell, New Mexico	29.1	17.3	46.4	
1130	Santa Fe, New Mexico	37.3	24.3	61.6	
1140	Utica, New York	39.4	47.9	87.3	
1150	Binghampton, New York	38.3	20.9	59.2	
1160	Bismarck, North Dakota	40.7	31.4	72.1	
1170	Toledo, Ohio	117.7	76.9	194.6	*
1180	Pendleton, Oregon	22.5	19.4	41.9	
1190	Hillsbora, Oregon	42.2	37.4	79.6	
1200	Klamath Falls, Oregon	37.7	14.4	52.1	*
1210	Amarillo, Texas	56.7	30.5	87.2	*
1230	San Antonio, Texas	30.1	60.8	90.9	*
1240	McAllen, Texas	33.1	14.6	47.7	
1250	College Station, Texas	38.7	40.4	79.1	
1260	Brownsville, Texas	28.5	8.6	37.1	
1270	Lynchburg, Virginia	41.3	24.9	66.2	
1280	Clarksburg, West Virginia	32.8	10.2	43.0	
1290	Parkersburg, West Virginia	29.2	13.8	43.0	
1300	Wheeling, West Virginia	27.2	21.9	49.1	
1310	LaCrosse, Wisconsin	39.8	23.9	63.7	*
1320	Casper, Wyoming	41.9	23.6	65.5	

Table 2.3-3 (continued)

FILE SEQUENCE NUMBER	AIRPORT NAME	ANNUAL OPERATIONS (THOUSANDS)		
		ITINERANT	LOCAL	TOTAL
1400	Ocala, Florida	13.5	5.0	18.5
1410	Pompano Beach, Florida	60.0	86.4	146.4
1420	Lakeland, Florida	30.5	26.0	56.5
1430	Vero Beach, Florida	59.0	75.0	134.0
1440	Brunswick, Georgia	31.4	31.0	62.4
1450	Athens, Georgia	31.0	32.5	63.5
1460	Rome, Georgia	13.5	15.3	28.8
1470	Mt. Vernon, Illinois	22.0	4.0	26.0
1480	Danville, Illinois	25.8	32.0	57.8
1490	E. St. Louis, Illinois	65.8	131.6	197.4 *
1500	Gary, Indiana	29.0	58.3	87.3
1510	Elkhart, Indiana	34.9	29.8	64.7
1520	Liberal, Kansas	17.6	38.3	55.9
1530	Bowling Green, Kentucky	25.4	20.1	45.5
1540	London, Kentucky	16.4	19.0	35.4
1550	Gaithersburg, Maryland	39.9	52.0	91.9
1560	Hagerstown, Maryland	37.8	12.0	49.8
1570	Gross Ile, Michigan	17.2	18.2	35.4 *
1580	Traverse City, Michigan	25.1	34.6	59.7
1590	Alpena, Michigan	18.7	6.0	24.7 *
1600	Tupelo, Mississippi	16.9	17.4	34.3
1610	C. Girardeau, Missouri	23.0	16.2	39.2
1620	Columbia, Missouri	29.5	12.5	42.0
1630	Lebanan, New Hampshire	21.4	6.1	27.5
1640	Wildwood, New Jersey	14.2	14.1	28.3
1650	Belmar, New Jersey	25.2	35.9	61.1 *
1660	Schenectedy, New York	24.3	25.0	49.3
1670	Poughkeepsie, New York	39.8	18.8	58.6
1680	Shirley, New York	40.5	49.9	90.4
1690	Glen Falls, New York	21.5	19.6	41.1
1700	Ithaca, New York	27.0	14.0	41.0
1710	Grand Island, Nebraska	25.5	22.5	48.0
1720	Toledo, Ohio	19.3	60.2	79.2 *
1730	Enid, Oklahoma	33.2	32.5	65.7 *
1740	Franklin, Pennsylvania	12.1	8.9	21.0 *
1750	Johnstown, Pennsylvania	17.4	10.6	28.0 *
1760	Millington, Tennessee	13.2	62.6	75.8 *

Table 2.3-3 (continued)

FILE SEQUENCE NUMBER	AIRPORT NAME	ANNUAL OPERATIONS (THOUSANDS)			
		ITINERANT	LOCAL	TOTAL	
1770	Smyrna, Tennessee	9.4	14.0	23.4	*
1780	Laredo, Texas	52.1	66.0	118.1	*
1790	Killeen, Texas	25.0	90.0	115.0	
1800	Victoria, Texas	17.5	2.0	19.5	
1810	Big Spring, Texas	14.1	24.8	38.9	*
1820	Del Rio, Texas	20.8	47.6	68.4	*
1830	Galveston, Texas	20.7	21.0	41.7	
1840	Temple, Texas	21.5	21.0	42.5	
1850	Staunton, Virginia	16.4	6.2	22.6	
1860	Walla Walla, Washington	25.8	27.2	53.0	
1870	Olympia, Washington	28.5	57.0	85.5	
1880	Martinsburg, West Virginia	16.4	20.5	36.9	*
1890	Mosinee, Wisconsin	16.0	6.0	22.0	
1900	Rhine Lander, Wisconsin	9.2	2.4	11.6	*
2000	Elkin, North Carolina	5.4	4.7	10.1	
2010	Dawson, Georgia	4.3	8.1	12.4	*
2020	Phila., Mississippi	3.2	5.0	8.2	
2030	Wilburton, Oklahoma	2.2	2.4	4.6	
2040	Hearne, Texas	2.7	.7	3.4	
2050	Coleman, Texas	1.1	.5	1.6	
2060	Elkhart, Kansas	.9	1.9	2.8	
2070	Tonopah, Nevada	4.2	.7	5.5	
2080	Orland, California	7.2	6.4	13.6	
2090	Tillamook, Oregon	2.9	.5	3.4	
3000	Red Lodge, Montana	3.1	.5	3.6	
3010	Junction City, Kansas	8.0	10.1	18.1	
3020	David City, Nebraska	2.0	1.6	3.6	
3030	Albert Lea, Minnesota	9.0	6.1	15.1	
3040	New Richmond, Wisconsin	2.6	1.0	3.6	
3050	Greenville, Illinois	4.4	1.2	5.6	*
3060	Wheatland, Wyoming	3.9	1.0	4.9	
3070	Paoli, Indiana	2.1	.5	2.6	
3080	Middelsboro, Kentucky	5.4	.5	2.6	
3090	Punxsutawney, Pennsylvania	2.7	.5	3.2	
4000	Orange, Massachusetts	6.0	4.5	10.5	
4010	Fryeburg, Maine	5.5	12.5	18.0	*

* NOT INCLUDED IN FINAL MODEL

2.4 AIRPORT PARAMETERS

In addition to operation levels, each airport in the airports model must have associated with it certain data that can distinguish one airport from another and hence be useful as an indicator of the airport's operations. Though certain factors have traditionally been considered as prime indicators of airport operations, in this study there was no attempt to give priorities to such factors nor to exclude any possibly related parameter. An attempt was made to consider every characteristic about the airport or its environs as a potential factor of influence, trusting that the subsequent regression analyses would in a most objective way either validate or dispute its merit. The one constraint that was applied to each parameter was that its pertinant data had to be readily available.

2.4.1 Indirectly Related Parameters

A variety of parameters can initially be listed as potential factors of influence but early in the study an attempt was made to expand this list and achieve a more exhaustive coverage. This effort questioned the basic causes for flying which then led to the identification of several categorical reasons. An examination of each reason in turn led to an identification of certain requisite conditions and these could subsequently be associated with a measurement parameter. As a consequence, a number of socio-economic factors about the community were found to be indirectly relatable to airport operations and were therefore candidate parameters together with the more obvious directly related factors.

2.4.2 Parameter Listings

Approximately 70 different parameters were considered and later evaluated as possible indicators of airport operations. Table 2.4.2-1 contains a listing of these parameters. Each of the parameters identified in the listing together with their data source have at various times been employed in the model and evaluated for their contributions to airport operations. It should be noted that the FAA Airport Master Record (5010-1) and the Census Bureau's City County Data Book were the primary data sources.

For every one of the 162 airports in the model, appropriate statistics for every listed parameter was then gathered as a part of the data collection process. Table 2.4.2-2 is presented to illustrate the extent of information that was associated with each airport. The mean values of each parameter at typical tower, tower candidate, and small non-towered airport are shown.

2.4.3 Multi-County Analysis

A principal decision-problem that was encountered during the study concerned the question of the geographical boundary of the community wherein the airport was located. Such boundaries are not obvious, yet must be known if the community is to be evaluated properly. Socio-economic characteristics are principally identified by states and by counties and with the exception of major SMSA's, no smaller regional areas are recorded. Consequently a problem arises when an airport's hypothetical community boundaries do not coincide with county lines. For instance when more than one airport is located within the same county, only a fraction of the county's resources

Table 2.4.2-1 AIRPORT PARAMETERS LISTING

	PARAMETER	SOURCE
1.	Reference Annual Itinerant Operations	
	Tower Airports	FAA Air Traffic Activity
	Tower Candidate Airports	FAA-AT Internal Records
	Non Candidate Airports	SCI Surveys between March & Sept., 1973
2.	Reference Annual Local Operations	Same as above
3.	Reference Annual Total Operations	Same as above
4.	Total AVGAS Storage Capacity	Form 5010-1 Item #114
5.	Less than 100 Octane AVGAS Stor. Cap.	Form 5010-1 Item #114
6.	Greater than 100 Octane AVGAS Stor.Cap.	Form 5010-1 Item #114
7.	Jet Fuel Storage Capacity	Form 5010-1 Item #114
8.	Total Based Aircraft	5010-1 #124,125,126
9.	Multi-engine Based Aircraft	5010-1 #126
10.	Single Engine ($\geq$ 4 place) Aircraft	5010-1 #124
11.	Single Engine ($<$ 4 place) Aircraft	5010-1 #125
12.	Hours Flown	
13.	Number of FBO's	5010-1 #112
14.	FBO Services: Instructional	5010-1 #113
15.	FBO Services: Sales	5010-1 #113
16.	FBO Services: Rental/Charter	5010-1 #113
17.	FBO Services: Agriculture	5010-1 #113
18.	FBO Services: Other	5010-1 #113
19.	Repairs - Airframe - Major	5010-1 #102
20.	Repairs - Airframe - Minor	5010-1 #103
21.	Repairs - Engine - Major	5010-1 #104
22.	Repairs - Engine - Minor	5010-1 #105
23.	Hours of Attendance	5010-1 #74
24.	Normal Maximum Temperature	5010-1 #29
25.	Number of Runways: Paved	5010-1 #36
26.	Corrected Runway length	5010-1; page 2; 5010-2
27.	No. of T-Type Hangars	5010-1 #98
28.	No. of Conventional Hangars	5010-1 #99
29.	Runway Lights	5010-1 #44
30.	Airport Acreage	5010-1; page 2; 5010-2
31.	Military Operations - Towers	FAA Air Traffic Activity
32.	Military Operations - Non-towers	5010-1 #119, Mil. AT Activity Report
33.	Air Taxi Operations - Towers	FAA Air Traffic Activity
34.	Air Taxi Operations - Non-towers	5010-1 #120
35.	Airport Landing Fees	5010-1 #77
36.	Fire/Rescue Index	5010-1 #84
37.	Taxiway Lights	5010-1 #81
38.	Military Landing Rights	5010-1 #116
39.	Joint Use Agreements	5010-1 #115
40.	Military Based Aircraft	5010-1 #118

Table 2.4.2-1 (continued)

	PARAMETER	SOURCE
41.	FBO Index	5010-1
42.	FACILITIES INDEX	5010-1
43.	No. of Student Pilots	8070-37 U.S.Airmen
44.	No. of Private Pilots	8070-37 U.S.Airmen
45.	No. of Instructors	8070-37 U.S.Airmen
46.	No. of Commercial Pilots	8070-37 U.S.Airmen
47.	No. of Total Pilots	8070-37 U.S.Airmen
48.	No. of Registered Aircraft (GA) in County	Census of U.S. Civil Aircraft
49.	Population	City/County Data Book
50.	Population per square mile	City/County Data Book
51.	Median Income	City/County Data Book
52.	Number of Families	City/County Data Book
53.	Percentage of families > 10^K Income	City/County Data Book
54.	Number of Employed Persons	City/County Data Book
55.	Percentage of White Collar Workers	City/County Data Book
56.	Bank Deposits	City/County Data Book
57.	No. of Retail Establishments	City/County Data Book
58.	Manufacturers with > 100 employees	City/County Data Book
59.	Manufacturers with > 20 employees	City/County Data Book
60.	Service Establishments Payroll	City/County Data Book
61.	Service Establishments Gross Rec'pts.	City/County Data Book
62.	Paved Miles of Highways in State	Highway Statistics - DOT
63.	Paved Highway miles per sq. mile	Highway Statistics
64.	Number of Hotel/Motel Rooms	Hotel Red Book
65.	GA Aircraft per 100,000 Population	Census of U.S.Civil Aircraft
66.	Air Carrier Scheduled Departures	Airport Static-Certified Route Air Carriers
67.	Air Carrier and Air Taxi Operations	FAA Air Traffic Activity
68.	Population Index	5010-2

Table 2.4.2-2 TYPICAL VALUES OF AIRPORT PARAMETERS USED IN MODEL

VARIABLES EMPLOYED IN THE MODEL	OWENSBORO, KY	LEBANON, N. HAMP	DAVID CITY, NEB.
ACTUAL OPERATIONS: DEPENDENT VARIABLES			
Total Annual Itinerant Operations	29,600	21,400	2,000
Total Annual Local Operations	48,500	27,500	3,600
Total Annual Operations	78,100	48,900	5,600
5010-1 VARIABLES - (AIRPORT DEPENDENT)			
Total Non-Jet Fuel [< 100 + > 100 Octane] (100 gal.)	216	195	5
Non Jet Fuel [< 100 Octane] (100 gal.)	106	85	5
Non Jet Fuel [> 100 Octane] (100 gal.)	110	110	0
Jet Fuel (100 gal.)	226	170	0
Total Based Aircraft	61	15	8
Based Aircraft: Multi-Engine	17	0	1
Based Aircraft: Single Engine - ≥ 4 place	35	15	6
Based Aircraft: Single Engine - < 4 place	9	0	1
Hours Flown	12,192	9,900	1,655
Number of FBO's	2	1	75
Scheduled Air Carrier Departures	1,385	561	0
Population Index	4	4	2

Table 2.4.2-2 TYPICAL VALUES OF AIRPORT PARAMETERS USED IN MODEL (CONTINUED)

VARIABLES EMPLOYED IN THE MODEL	OWENSBORO, KY	LEBANON, N. HAMP	DAVID CITY, NEB.
5010-1 VARIABLES - (AIRPORT DEPENDENT) (Cont.)			
FBO Services: Instructional	1	1	0
(yes = 1) Sales	1	1	0
(no = 0) Rental/Charter	1	1	0
Agricultural	0	0	0
Miscellaneous	1	1	0
Repair Services:			
Airframe Major	1	1	0
" Minor	1	1	0
Engine Major	1	1	0
" Minor	1	1	0
Hours of Attendance per Day	18	14	0
Airport Temperature: Normal Maximum (°F)	90	82	88
Number of Runways: Paved	2	2	0
Corrected Runway Length (ft)	5,372	4,409	2,100
Number of T-Type Hangars	0	7	8
Number of Conventional Hangars	6	1	1

Table 2.4.2-2 TYPICAL VALUES OF AIRPORT PARAMETERS USED IN MODEL (CONTINUED)

VARIABLES EMPLOYED IN THE MODEL	OWENSBORO, KY	LEBANON, N. HAMP	DAVID CITY NEB.
5010-1 VARIABLES - (AIRPORT DEPENDENT) (Cont.)			
Runway Lights (Yes = 1 No = 0)	1	1	1
Airport Acreage	363.5	617.0	160.0
5010-1 Operations: Annual Military	490	150	0
" " Annual Air Taxi	797	5,000	100
" " Annual Local	19,409	10,000	4,410
" " Annual Itinerant	30,099	15,000	1,890
Airport Landing Fees (Yes = 1 No = 0)	0	0	0
FBO Index #1	82	67	5
FBO Index # 2	-6	-10	0
Facilities Index	63	72	24
UNI-COUNTY VARIABLES (AIRPORTS AREA OF INFLUENCE)			
Student Pilots	58	40	13
Number of GA Aircraft Registered	44	23	13
MULTI-COUNTY VARIABLES (AIRPORTS AREA OF INFLUENCE)			
Pilots: Student	68	18	5
Private	139	24	24
Total	266	58	35

Table 2.4.2-2 TYPICAL VALUES OF AIRPORT PARAMETERS USED IN MODEL (CONTINUED)

VARIABLES EMPLOYED IN THE MODEL	OWENSBORO, KY	LEBANON, N. HAMP	DAVID CITY NEB.
MULTI-COUNTY VARIABLES (AIRPORTS AREA OF INFLUENCE) (Cont.)			
Population	87,688	18,268	8,250
Population per Square Mile	87	34	18
Median Income ($/year)	4,382	5,125	3,231
Number of Families	22,056	4,537	2,226
% of Families with Income > $10K	8.2	10.3	3.2
Number of Persons Employed	29,536	6,824	2,894
% of White Collar Workers	33.8	37.8	25.5
Bank Deposits ($1,000)	80,184	28,480	12,888
Retail Establishments	578	165	58
Manufacturers with > 100 Employees	15	5	0
Payroll of Service Establishments ($1,000)	212	79	10
Gross Receipts of Service Establishments ($1,000)	11,466	3,980	483
Number of GA Aircraft Registered	51	9	10
AIRCRAFT AND MISCELLANEOUS			
Number of GA Aircraft per 100,000 Population in State	30	62	122
Air Carrier Plus Air Taxi Operations	3,400	8,000	0

should be associated with either airport. On the other hand, when an airport is located near a county line, it should be expected that this airport would draw on the resources of the adjacent county as well as its own.

It was concluded that a multi-county approach to the problem would first require an identification, in some manner, of the community's boundaries. Then county lines could be superimposed and finally a comparison of these outlines would allow the appropriate airport vs. county relationship to be made. The most reasonable approach to identifying an airport's hypothetical boundary was to locate on a map, the airport in question as well as each of the nearest airports that surround it. Points on the boundary were then determined by dividing the radial distance (from the central airport to the surrounding airport) in proportion to the number of aircraft based at either airport. The entire boundary was then plotted by circling the central airport according to these premeasured points. This area was then compared with the very well-defined county lines and an estimate was made of the portion of the county or counties that were included in the airport's influence.

This procedure was employed in evaluating all of the reference airports. The results show quite a variety of relationships. Some of the airports are influenced by only 20 percent of the county in which it is located; other airports may be influenced by as many as 10 neighboring counties. A total of 405 counties were identified as affecting the reference airports. This information is presented in Table 2.4.3-1. In that review, each airport within the model is

TABLE 2.4.3-1 AIRPORT INFLUENCE-REGION BY COUNTY

CITY	COUNTY	COUNTY	COUNTY
ALABAMA			
Anniston	Calhoun 50%	Cleburne 50%	Talladega 20%
Mobile	Mobile 40%	Baldwin 20%	
Tuscaloosa	Tuscaloosa 100%		
Muscle Shoals	Colbert 80%	Lauderdale 80%	
ARIZONA			
Goodyear	Maricopa 20%		
Flagstaff	Coconino 40%		
Grand Canyon	Coconino 40%		
Prescott	Yavapai 50%		
Winslow	Navajo 30%	Coconino 20%	
ARKANSAS			
Pine Bluff	Grant 60%	Cleveland 50%	Lincoln 60%
	Jefferson 100%		
El Dorado	Union 100%	Calhoun 50%	Bradley 20%
Fayetteville	Washington 100%	Madison 50%	
West Memphis	Crittenden 90%		
Hot Springs	Garland 100%	Hot Springs 20%	
Texarkana	Miller 80%	Bowie-Texas 40%	
Brinkley	Monroe 50%	Lee 30%; St. Francis 20%	Woodruff 30%
Harrison	Boone 100%	Marion 40%; Newton 40%	Carroll 30%
CALIFORNIA			
Salinas	Monterey County 40%		
So. Lake Tahoe	Alpine 50%	El Dorado 20%	Douglas-Nevada 80%
Visalia	Tulare 20%	Kings 15%	
Red Bluff	Tehama 80%		
Corona	Riverside 20%		
Sacramento	Sutter County 10%	Sacramento 10%	
Orland	Tehama 10%	Glenn 20%	
COLORADO			
Pitkin County	Pitkin County 100%		
Grand Junction	Mesa 100%		
Julesburg	Sedgwick 100%	Dueul-Nebraska 100%	
Limon	Lincoln 70%	Elbert 40%	
FLORIDA			
Destin	Okaloosa 30%	Walton 20%	
Naples	Collier 50%		
Titusville	Brevard 30%		
Ocala	Marion 80%		
Pompano Beach	Broward 20%		
Lakeland	Polk 30%		
Vero Beach	Indian River 70%		
Gainesville	Alachua 100%		
GEORGIA			
Albany	Baker 80%; Lee 100%	Dougherty 100%	Terrell 20%
	Mitchell 30%	Worth 40%	Edgefield, S. C. 80%
Augusta	Rchmnd, Colmbia 100%	Jffrsn, Burke, McAffl 30%	Aiken, S. C. 40%

TABLE 2.4.3-1 AIRPORT INFLUENCE-REGION BY COUNTY

CITY	COUNTY	COUNTY	COUNTY
GEORGIA (cont)			
Macon	Bibb, Monroe 100%	Jones, Crawford 100%	Jasper, Wilkinson 80
	Peach, Twiggs 50%	Putnam 40%	Hauston, Baldwin 20
Valdosta	Laundes, Echols 100%	Lanier, Lynn 100%	Brooker, Clinch 30%
	Cook 20%	Madison-Florida 50%	Hamilton-Fl. 80%
Brunswick	Camden 80%	Charlton 20%;	Wayne, McIntosh 30%
	Brantley 90%		
Athens	Oconee, Clarke 100%	Oglethorpe 80%; Bankr 40%	Jackson, Franklin 50
	Hart 50%		
Rome	Cherokee-Alabama 20%	Floyd 100%; Bartow 20%	Chattooga 80%
Dawson	Terrell 80% Smter 10%	Wbstr, Stwart 30%	Randolph 50%
Butler	Taylor 100%	Marion 20%	
IDAHO			
Idaho Falls	Bonneville 90%	Jefferson 50%	Bingham 20%
Pocatello	Bannack 90%	Carribou 70%	Power 30%
ILLINOIS			
Decatur	Macon 100%; Piatt 40%	Moultere 60%	Shelby 10%
Marion	Williamson 100%	Johnson 50%	
Mt. Vernon	Jefferson 100%	Wayne 20%	Hamilton 20%
Danville	Vermillion 80%	Vermillion-Ind. 40%	Warren-Ind. 30%
E. St. Louis	St. Clair 100%		
Greenville	Bond 80%	Fayette 20%	
Shelbyville	Shelby 70%	Christian 20%	
INDIANA			
Terrehaute	Vigo 100%	Clark-Illinois 20%	
Gary	Porter 20%	Lake 50%	
Elkhart	Elkhart 40%	Cass-Michigan 20%	
Paoli	Orange 70%		
Madison	Jefferson 100%	Trimble-Ky. 100%	
IOWA			
Cedar Rapids	Linn 100%	Benton 60%	Johnson, Iowa 20%
KANSAS			
Salina	Salina 100%	Ottawa 80%	Lincoln, Elswrth 20%
Hutchinson	Reno 100%	Harvey 20%	
Liberal	Seward 90%	Beaver-Okla. 20%	
Elkhart	Morton 50%	Texas-Okla. 10%	Cimarron-Okla. 10%
Junction City	Geary 60%	Riley 30%	
Hugoton	Stevens 80%	Morton 20%	
Concordia	Cloud 100%		
KENTUCKY			
Owensboro	Daviess, Hancock 100%	Ohio 40%	McLean 50%
Bowling Green	Warren 100%	Butler 80%	Edmonson 80%
London	Laurel 100%	Jackson 50%	Rockcastle 50%
Middlesboro	Bell 100%	Knox 50%	Claiborne-Tenn. 50
Moreland	Rowan 100%	Fleming 30%	

TABLE 2.4.3-1 **AIRPORT INFLUENCE-REGION BY COUNTY**

CITY	COUNTY	COUNTY	COUNTY
LOUISIANA			
Patterson	St. Mary 80%	Port St. Martin 100%	Terrebonn 20%
MAINE			
Bangor	Penobscot 20%	Hancock 10%	
Fryeburg	Cumberland Co. 10%	Oxford Co. 15%	
Auburn-Leus	Andrascoggin 100%	Oxford 10%; Cmbrlnd 20%	Sagadahoe 90%
MARYLAND			
Gaithersburg	Montgomery 80%		
Hagerstown	Washington 80%	Frederick 30%	Franklin-Pa. 20%
MASSACHUSTS			
Orange	Franklin 30%	Worcester 10%	
Gardner	Worcester 20%		
MICHIGAN			
Jackson	Jackson 80%		
Grosse Ile	Wayne 10%	Monroe 10%	
Traverse City	Grand Traverse 100%		
Alpena	Alpena 100%	Presque Isle 20%	
MINNESOTA			
Deluth	St. Louis 40%	Carlton 20%	
Int'l. Falls	Koochiching 80%		
Mankato	Blue Earth 80%	Nicollet 40%; Waseca 20%	Le Sueur 60%
Albert-Lea	Freeborn 80%		
MISSISSIPPI			
Meridian	Lauderdale 100%	Kemper 40%	Sumter-Ala. 30%
Tupelo	Lee 100%	Itawamba 60%	
Greenville	Washington 60%	Bolivar 20%	
Madison	Madison 80%	Yazoo 20%	Rankin 20%
Philadelphia	Neshoba 100%	Kemper 30%	Winston 20%
Starkville	Oktibbeha 100%	Clay 50%	
MISSOURI			
K. C. Int'l.	Clay 40%	Platte 50%	
St. Joseph	Andrew 20%	Buchanan 40%	Doniphan-Kan. 50%
C. Girardeau	Cape Girardeau 50%	Scott 40%; Bollinger 60%	Union-Ill. 20%
Columbia	Boone 70%	Callaway 10%	
MONTANA			
Helena	Lewis & Clark 60%	Jefferson 50%	Broadwater 50%
Missoula	Missoula 70%	Mineral 30%	
Red Lodge	Carbo 80%		
Hardin			
NEBRASKA			
Grand Island	Hall 70%	Howard 30%	Hamilton, Merrick 20%
David City	Butler 80%		
Fremont	Dodge 40%	Saunder 30%	Washington 30%

TABLE 2.4.3-1 **AIRPORT INFLUENCE-REGION BY COUNTY**

CITY	COUNTY	COUNTY	COUNTY
NEVADA			
Tanopah	Nye 50%	Esmeraldo 30%	
Hawthorne	Mineral 70%		
NEW HAMPSHR			
Lebanon	Grafton 20%	Windsor 20%	
NEW JERSEY			
Atlantic City	Atlantic 40%		
Readington	Hunterdon 20%	Somerset 20%	
Wildwood	Cape May 70%		
Belmar	Monmouth 30%		
NEW MEXICO			
Hobbs	Lea 60%	Gaines-Tex. 30%	
Roswell	Chaves 100%		
Farmington	San Juan 100%		
Santa Fe	Santa Fe 100%		
Alamagordo	Otero 100%		
Artesia	Eddy 20%	Chaves 20%	
NEW YORK			
Utica	Oneida 40%		
Elmira	Chemung 90%	Steuben 30%	
Binghamton	Broome 60%		
Schenectady	Schenectady 100%	Saratoga 20%	Montgomery 20%
Poughkeepsie	Dutchess 50%		
Shirley	Suffolk 30%		
Glen Falls	Warren 70%	Saratoga 10%	Washington 50%
Ithaca	Tompkins 100%		
NO. CAROLINA			
Aloskie	Hertford 100%	Bertie 20%	Gates 30%
Elkin	Yadkin 60%	Wilkes 20%	Surry 20%
NO. DAKOTA			
Bismarck	Burleigh 100%	Kidder, Emmons 100%	Shridn 70%; Logar
Grand Forks	Grand Forks 70%	Pock-Minn. 20%	
OHIO			
Toledo-T.	Lucas 100%	Fulton 20%	
Toledo-TC.	Wood 40%		
Lima	Allen 50%		
OKLAHOMA			
Ardmore	Carter 70%	Love 30%	Johnston 20%
Enid	Garfield 100%	Major 20%	
Wilburton	Latimer 100%	Haskell 50%	Pushmataha 20%
Hugo	Choctaw 100%	Pushmataha 70%	

TABLE 2.4.3-1 AIRPORT INFLUENCE-REGION BY COUNTY

CITY	COUNTY	COUNTY	COUNTY
OREGON			
Pendleton	Umatilla 50%		
Hillsboro	Washington 70%	Multnomah 30%	
Klamath Falls	Klamath 70%		
Tillamook	Tillamook 70%		
Hermiston	Umatilla 20%	Benton-Wash. 10%	
PENNSYLVNIA			
Franklin	Venango 80%		
Johnstown	Cambria 40%	Somerset 30%	Westmoreland 10%
Punxsutawny	Jefferson 40%	Indiana 10%	Clearfield 10%
Titusville	Crawford 30%	Warren 20%	Venango 20%
SO. CAROLINA			
Anderson	Anderson 100%	Abbeville 20%	
Spartanburg	Spartanburg 80%	Cherokee 20%	
SO.DAKOTA			
Rapid City	Pennington 50%	Meade 30%	
TENNESSEE			
Jackson	Madison 100%	Chester 60%	Henderson 20%
Millington	Shelby 30%	Tipton 60%	
Smyrna	Rutherford 40%	Williamson 20%	Davidson 20%
TEXAS			
Amarillo	Potter 50%	Randall 50%	
Plainview	Hale 80%	Floyd 20%	Swisher 20%
Tyler	Smith 100%	Henderson 20%	Van Zandt 20%
San Antonio	Bexar 100%		
McAllen	Hidalgo 60%		
College Station	Brazos 100%	Grimes 30%	
Brownsville	Cameron 50%		
Laredo	Webb 80%		
Killeen	Bell 50%	Coryell 40%	
Harlingen	Cameron 50%	Willacy 20%	Hidalgo 20%
Victoria	Victoria 100%	Goliad 30%	
Big Spring	Howard 100%	Martin 20%	Glasscock 20%
Del Rio	ValVerde 50%	Kinney 20%	
Galveston	Galveston 100%		
Temple	Bell 50%	Falls 30%	
Hearne	Robertson 20%	Milam 20%	
Coleman	Coleman 60%		
VIRGINIA			
Lynchburg	Campbell 60%	Appomatx, Amherst 100%	Nelson 20%
Charlottesville	Albemarle 70%		
Staunton	Augusta 70%		

TABLE 2.4.3-1

AIRPORT INFLUENCE-REGION BY COUNTY

CITY	COUNTY	COUNTY	COUNTY
WASHINGTON			
Tacoma	Pierce 20%		
Walla Walla	Walla Walla 80%	Umatilla-Ore. 20%	
Olympia	Thurston 100%		
W. VIRGINIA			
Clarksburg	Harisn, Dodrdg 100%	Taylor 50%; Lewis 20%	Barbour 40%
Morgantown	Monongalia 100%	Preston 20%	
Parkersburg	Wood, Wirt 100%	Pleasants 100%	Washington-O. 100%
Wheeling	Ohio 100%	Brooke 50%	
Martinsburg	Berkeley 100%	Jefferson 40%	Washington,-Md. 20%
WISCONSIN			
Appleton	Outgamie 60%	Winnebago 30%	
La Crosse	La Crosse 100%	Houston-Minn. 40%	Winona-Minn. 20%
	Trempealeau 20%		
Oshkosh	Winnebago 70%		
Mosinee	Marathon 30%		
Rhinelander	Oneida 80%		
New Richmond	St. Croix 40%		
Eau Claire	Eau Claire 40%	Chippeau 30%	Dunn 20%
WYOMING			
Casper	Natrana 100%	Converse 40%	Johnson 20%
Wheatland	Platte 60%	Gurnsey 20%	

associated with all of its influencing counties, i.e. its surrounding counties (if applicable) as well as the resident county. The percentage of each county's resources that should be attributed to the respective airport is noted.

To illustrate, from Table 2.4.3-1, it can be noted that the airport at Anniston, Alabama, has been found to be influenced by 50% of Cleburne County, 20% of Talladega and 50% of its own Calhoun County. (The remaining portions of these counties are assummed to contribute to other airports). Then if the parameter 'population' is being considered, using the multi-county approach, the population statistics for these three counties would be collected and appropriately factored (50%, 20% and 50%) and then added together as the number of people to be associated with this airport. All other parameters with county-defined statistics would be treated similarly.

2.4.4 Index Measurements

A feature that drew special attention during the study has since been referred to as the airport's Facility Index and the FBO (fixed base operator) Index. These indices were developed to get some sort of composite measure about the airport's physical makeup or the available airport services, both of which were thought to be influential to airport operations. By combining a number of airport parameters (which by themselves were ineffectual as operations indicators) into a hypothetical index, such measures could be made and additional airport distinguishing characteristics could be accounted for.

FBO Index - It had been recognized that the services provided at an airport, primarily as a result of the FBO's efforts, are

probably of major significance in the level of activity that will occur at the airport. More comprehensive and better provision of services probably results in a higher level of operations; poor services or the lack of services should result in lower than otherwise expected activity levels. It was therefore necessary in this study to include in its evaluation process some kind of characteristic that would serve as a measurement of services provided at the local aiport.

The problem encountered was that no single characteristic existed to provide a measure that would relate airport services with airport operations. On the one hand, though it is certain that the efforts of a personable and energetic fixed-based operator will promote activity at his airport, it was impractical to find a means to measure his personableness or his energy. On the other hand, rather than a single characteristic that could be useful in measuring overall airport services, which was unavailable, there were a number of characteristics that were available but they only addressed a portion of the subject. For example, information was available about the number of FBO's and their principal services, i.e., instruction, charters, crop dusting, etc., at an airport. The airports operating period, types of fuel available, and the presence of repair facilities were other indicators of airport services but each of these bits of information by themselves could not provide an answer to the problem. With each airport having different varieties of services it was difficult to see a pattern that associated airport activity with airport services.

To enable such an evaluation and hopefully to find an additional

predictor of operational levels, a scheme was developed that attempted to evaluate total airport services, at any airport, on a common basis. For study purposes, this was referred to as an FBO Index. Several different procedures were used throughout the study with varying degrees of success; however each scheme had in common,the attempt to scale airport services. The following description is typical of the manner in which the FBO Index was derived.

The FBO Index is assummed dependent on five factors: the number of FBO's, his services, type of fuel, availability of repairs and the airport's attendance schedule. Arbitrary values are assigned to each factor, according to a preset priority assessment of their relative importance, in such a manner that the best possible Index value would equal 100. The following rationale applies to development of the Index:

> Number of FBO's: Though unable to measure personality of individual operators, it is assummed that competition encourages better service. Therefore two FBO's at the same airport should enhance services more than if there is only one FBO. Three is better than two but to a lesser degree than two is to one. More than four FBO's at any one airport provides no improvement over the services that four FBO's could provide. The absence of an FBO at an airport should imply a negative effect on services.
>
> FBO Services: These services can be categorized into five areas: instruction, sales, charter or rentals,

agriculture and miscellaneous (i.e., mapping, sightseeing, etc.). The number of these services available at an airport is deemed important as is the type of service. In other words, an airport providing all five is superior to one that provides only four or three of these services. However, the availability of instruction is indicative of better service than the provision of miscellaneous services or agriculture, etc.

Fuel Availability: Fuel has been divided into three groups: jet fuel, under 100 octane and over 100 octane. The capacity of storage facilities is not considered. The availability of the jet fuel is considered less important than the others. Airports without fuels of any type should be penalized when services are assessed.

Repair Facilities: Readily available information about repair facilities differentiate the airport's ability to accomplish major or minor repairs as well as engine or airframe repair capabilities. Minor repair capability is deemed most essential when assessing airport services.

Attendance Schedule: Data is available concerning the daily operating hours, days of the week and seasonal variations. All day and night attendance throughout the year would be the best possible service. Unattended airports should indicate a negative effect on services.

Using the rationale described above, hypothetical airports with varying services available were considered and appropriate ratings

assigned to cover the range between the best and worst extremes. Then each airport in the selected set of airports used in the model were compared against this hypothetical rating and an apporpriate FBO Index was assigned.

The most effective FBO Index was finally derived after it was noted that certain individual service related parameters had an opposing effect on each other in terms of indicating operations, i.e., they would tend to cancel each other. To negate this effect, those parameters were segregated into two sets, one with a strong positive itinerant effect or strong negative local effect and another which had the opposite effect. The natural logarithm of the ratio of these variables, where the numerator contains strong local operations variables and the denominator contains strong itinerant operations variables, then defined the FBO Index.

The expression which leads to the FBO Index is:

$$\text{FBO Index} = 100\left(\text{Log}\ \frac{X(25) + X(20) + 9.X(27) + 3\ X(21) + 2\ X(24) + 16}{X(22) + 6\ X(29) + 5\ X(2) + 2\ X(28) + 2\ X(30) + 16}\right)$$

where the following table identifies the variables:

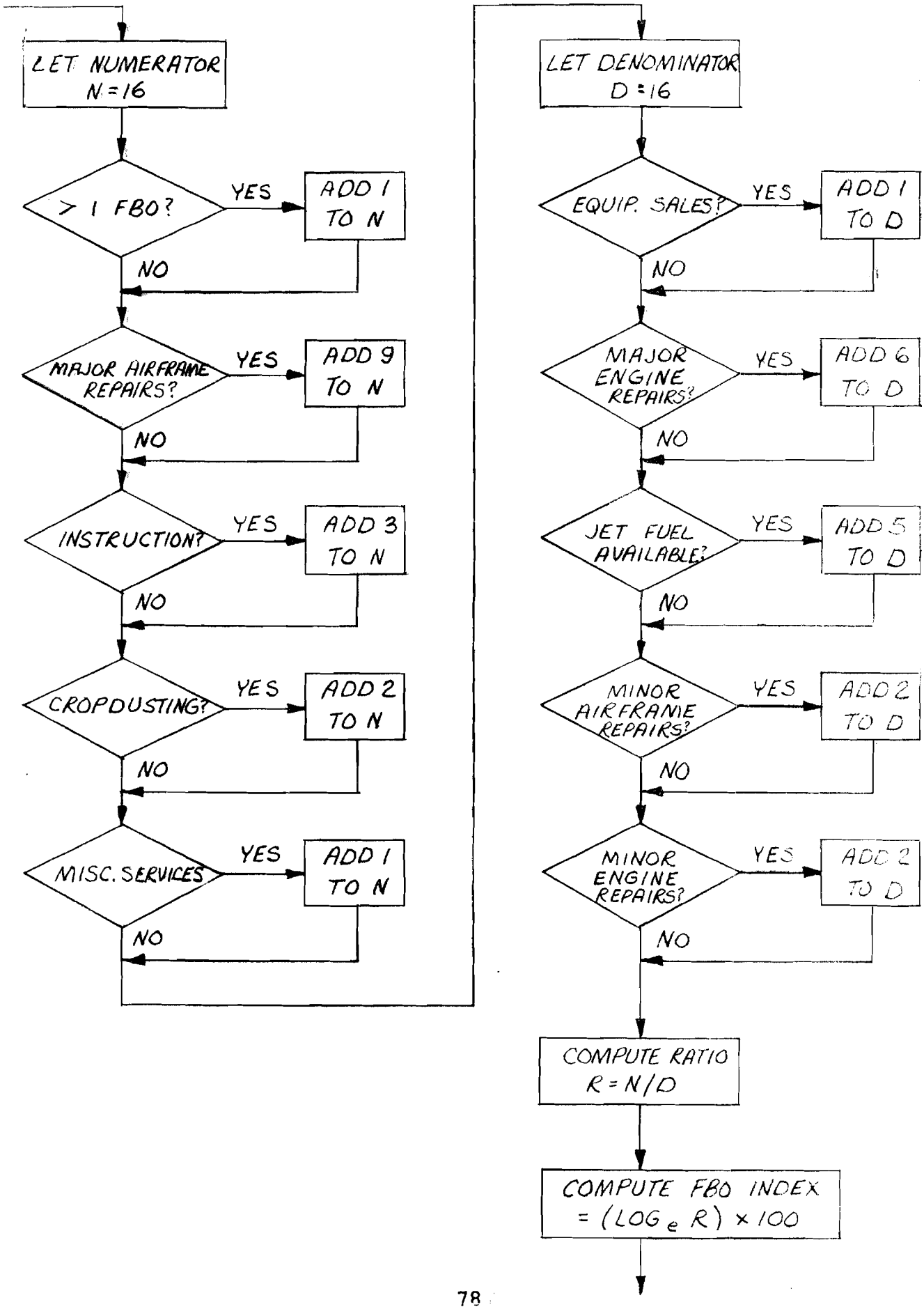
Variable	Description
X(2)	Jet Fuel Storage
X(20)	More than one FBO
X(21)	Instructional Service
X(22)	Equipment Sales
X(24)	Agricultural Service
X(25)	Other FBO Services
X(27)	Airframe Repairs (major)
X(28)	Airframe Repairs (minor)
X(29)	Powerplant Repairs (major)
X(30)	Powerplant Repairs (minor)

These variables are all of yes or no type, meaning that if a particualr service is available at an airport that variable is assigned a value of 1, while the lack of service means that a zero value is assigned to it. The constants in the ratio are chosen proportionally to the variable's relative influence as an operations indicator and in this way an index is obtained which is 0 when all variables are 1; the index is +69 (natural logarithm multiplied by 100) when the variables in the numerator are all 1 and those in the denominator are all zeros. The index is -69 when all variables in the numerator are zero and those in the denominator are 1. Figure 2.4.4-1 depicts a systematic procedure for computing the FBO Index.

Facility Index - Another probable determinant of aircraft operations is the facilities at an airport, i.e., those items physically located at the airport to accomodate aircraft activity. These facilities differ from airport services since services are mostly airport personnel oriented. However, there is a similarity in that neither services nor facilities can easily be measured.

Airport facilities consist of such things as runways, hangars, restaurants, lighting, fuel tanks, etc. Airports with facilities in good condition are assummed to attract aircraft operations and conversely the lack of facilities usually results in loss of aircraft operations. All facilities must be considered before any conclusions can be made as to their impact on operations. Unfortunately, data on all existing airport facilities is not readily available. For example, data about the existance of a restaurant at an airport is not easily available. Consequently, it is necessary to restrict attention to those items for which data is available.

FIGURE 2.4.4-1 DETERMINATION OF THE FBO INDEX



Data on many facilities is reported on FAA 5010-1 form and the Airports Facility Records Statistical Report (RIS AS 5010-2). Most of the facilities reported on these two documents have some correlation with aircraft operations but there is no single characteristic which can effectively relate aircraft operations. Consequently, to develop a statistic which will serve as a measure of the facilities at the local airport its facilities have to be combined in such a fashion that they can be represented by a single numerical value.

In a manner similar to the development of the FBO Index, a computational procedure was developed to yield a Facilities Index which quantifies a number of facility related parameters into a single airport measurement. The variables of importance in determining an airport's Facilities Index are:

1. Number and types of runways
2. Corrected Runway length
3. Fuel capacity
   a. Underground
   b. Above ground
4. Conventioanl Hangars
5. T-type Hangars
6. Weather Station on Airport
7. Administration/Terminal Building
8. Airport acreage

Each data element included in the Index receives a specific point value according to the criteria listed in Table 2.4.4-1. The point value of each variable is determined by the airport's actual physical makeup and their cumulative total is the Facilities Index for that airport. An example which shows the derivation of the Facilities Index at the Municipal Airport, Gainesville, Florida, is presented in Table 2.4.4-2.

TABLE 2.4.4-1 **FACILITY INDEX DETERMINANTS**

DETERMINANT	VARIABLE	POINTS
Number of Runways	1 2 ≥3	5 7 11
Runway Surface Composition	Asphalt-Concrete Gravel Dirt-Turf	8 per Rwy. 2 per Rwy. 0 per Rwy.
In the case where an airport has more than 3 runways, use those that give the highest possible point value.		
Corrected Runway Length. (ft.)	1000-4000 4001-8000 >8000	3 6 10
Consider only the longest runway.		
Fuel Storage -Underground-	Type F12-15 Type F18-22 Type ≥F30 (Jet)	3 4 7
Fuel Storage -Above ground-	Type F12-15 Type F18-22 Type ≥F30 (Jet)	1 2 2
No. of Hangars -Conventional-	1 to 5 6 to 10 >10	3 5 6
No. of Hangars -T-Type-	1 to 20 21 to 60 >60	1 3 10
Weather Station on Airport	Yes No	10 0
Administration/ Terminal Bldg. on Airport	Yes No	5 0
Airport Acreage	<300 Acres 300-1000 Acres 1001-3000 Acres >3000 Acres	2 5 9 11

FIGURE 2.4.4-2 EXAMPLE OF FACILITY INDEX DETERMINATION

MUNICIPAL AIRPORT - GAINESVILLE, FLORIDA

Facility Index Variable	5010 Data	Points Received
No. of Runaways	3	11
Types of Runaways	Asphalt	24
Runaway Length	5480	6
Fuel Capacity		
Underground F-12-15	120	3
F-18-22	120	4
F $\geq$ 30	80	7
Above ground		
F-12-15	24	1
F-18-22	28	2
F $\geq$ 30	40	2
Hangars (Conventional)	3	3
Hangars (T-Type)	20	1
Weather Station	Yes	10
Administration/Terminal Bldg.	Yes	5
Acreage	940	5
	Total	89

Facility Index = 89

2.4.5 Evaluation

In general, the data collection activity was straightforward and though an extensive effort was involved there were no major difficulties encountered. In the interest of objectivity there was little or no attempt made in the study to question the accuracy of the referenced parameter's statistics; rather they were simply accepted, just as such data would need be accepted when the estimating formula would be implemented in the field. There was one condition however that should be reported in that it had some bearing on the outcome of the study. It concerns the timeliness of the data. The basis of the study relied on the hypothesis that airport data could be correlated with airports' operations and it is necessarily required that both sets of data are applicable to the same time period. In most cases the annual publication of the reference documents used as data sources enabled the extraction of data that was appropriate with the date of the operations estimate. However the Census Bureau's City and County Data Book was an exception in that the most recent and applicable publication was unavailable in time to be of use to this study. Necessarily then in drawing the conclusions that it has, this study presumes that differences in statistics for county data that appears in one publication or the next is of a minor nature. The other exception, that is, the FAA Airport Master Record, FAA Form 5010-1, was not due to an inablility of acquiring the most recent edition but rather the fact that the latest edition was at times outdated. In those cases an attempt was made to acquire operations data for that airport appropriate with the inspection date of the 5010. Failing that the airport was deleted from the model.

2.5 COMPUTER ANALYSIS PREPARATION

After the process of collecting requisite data is complete but prior to the analysis period certain preparatory steps were required to 1) convert the data into a usable format and 2) provide the necessary computer programs that would facilitate analysis. As an integral part of the study, these efforts also required considerable care in their development; additional attention was subsequently given to rechecking their correctness.

Development of the data base required the conversion of data from source documents into computer usable format. Each airport in the airports model was assigned a file sequence number and with that number, the appropriate statistics about the airport's parameters were entered via the computer terminal's keyboard. The basic data base was a matrix of 20 variables (airport parameters) and 162 observations (airports). Several of these data bases were therefore required to accommodate all of the variables. These different sets of data were identified as MODATA 1, MODATA 2, etc. The ability of conversationally entering or deleting data from the basic data bases enabled the analyses of numerous sets of parameters. Later in the study an expanded data base accommodating 50 variables was also developed which permitted computer analysis of more parameters simultaneously.

The development of computer programs were necessary to facilitate the analysis, perform the regression routines and enable evaluations to be made of the estimators. This effort relied on a standard library multiple regression FORTRAN program, MULREGX, and two other programs, SHIVA and NEWCOMP, specifically designed to meet the needs

of this study.

MULREGX performs a multiple linear regression analysis on up to 20 variables, with an unlimited number of observations. Input for the regression analysis may be raw data consisting of the values of the variables at each observation, or it may be the means,standard deviation, and correlation matrix of the variables. Any number of regressions may be performed on the same input data. MULREGX computes the following statistics:

- Beta weights (regression coefficients of standardized variables)
- Standard errors of the beta weights
- T-test of each beta weight against zero
- B coefficients (regression coefficients of raw variables)
- Intercept (constant term of raw variable regression equation)
- Standard errors of the B coefficients
- Partial correlation of each predictor variable with the criterion variable (holding all other variables in the regression constant)
- Multiple correlation coefficient
- F-test of the multiple correlation coefficient against zero
- Standard error of estimate
- Proportion of unexplained variance

MULREGX can also calculate the means, standard deviations, and correlation matrix before performing the regression. Data for the regression was located in a data file (MODATA) although in certain cases it was also entered conversationally in response to program-generated questions. During the course of program execution MULREGX requests the following information from the user:

- Type of data being used as input (raw data or means, standard deviations, and correlation matrix)
- Total number of variables and observations
- Location of data (data file or conversational input)
- Number of variables to be used in the forthcoming regression
- For the forthcoming regression, which is the dependent variable and which are the independent variables

SHIVA is basically a standard Multiple Regression FORTRAN program which in effect was a modification of MULREGX to suit the needs of this study. The modifications included 1) a capability at the user's option, of temporarily modifying file variables within SHIVA without affecting the data file, MODATA; 2) also at the user's option, a capability of listing for each file airport the actual number of aircraft operations, the model's estimate of operations, and their absolute and percentage difference; 3) an expansion of program to permit 50 variables; 4) changes to speed execution time. A listing of the SHIVA program is shown in the Appendix.

NEWCOMP is a special FORTRAN program developed for this study to permit the analyst to examine in detail, model performance, variable by variable, for any particular airport. NEWCOMP was developed to detect the reasons for individual estimates having large percentage error; however it is also helpful in detecting errors in the data file. The program lists the product of each variable multiplied by its constant term. Any product term which stands out is investigated. Three categories of estimates are chosen for each particular run of NEWCOMP; namely, gross overestimates, very good estimates, and underestimates. Their comparison then enables the exposure of certain variables that may be responsible for causing bad estimates.

2.6 ANALYSIS

The analysis phase of the study was initiated with the supposition that 1) the data base contained an exhaustive listing of parameters that were possible indicators of airport operations and 2) computer programs had been developed and were available to determine, via regression analysis, a best fit mathematical formula that could relate airport parameters (as independent variables) with airport operations (as the dependent variable). The analysis effort therefore set out to find which particular parameters were of more importance than others so that a concise and easily implemented formula could be derived. In setting an arbitrary goal of "a formula with less than 10 variables," the problem became one of systematically reducing the list of 70 parameters to a much smaller group which contained only those parameters that were most effective in estimating operations.

The analytical tools available did not permit an examination of all parameters simultaneously and though it was possible to identify the more effective indicators within a group of parameters, each group could contain no more than 20 variables. The numerous list of variables and the even more numerous permutations and combinations of variable subsets therefore introduced complexity into the process of selectively discriminating good predictor parameters from poor ones. Consequently the initial procedure was to justify the elimination of certain parameters as potential indicators of airport operations and thereby get a more workable listing wherein all parameters could be examined at the same time.

2.6.1 Iteration Process

An iterative process was followed as the means for reducing the parameters list. Each iteration consisted of a number of regression analysis computer runs whereby an arbitrary set of parameters (usually 20 to begin with) was whittled down in successive increments to a smaller group (five to ten) that contained only parameters with a high degree of confidence in their predictive ability.

With each regression, a statistical measurement of its success in estimating airport operations was made together with a conclusion of each parameter's probability as a predictor. This information was used as criteria for eliminating parameters from the subsequent regressions and therefore useful in assessing the parameter's candidacy as a variable in the final version of the relationship defining airport operations. Those parameters that remained for the next regression were still considered as candidates while those excluded became suspect as candidates. Then when subsequent iterations made on different sets of parameters also resulted in similar suspicions about a parameter's candidacy, that parameter was deleted from any further consideration. However a judicious approach was sometimes necessary because of the intercorrelation between parameters; certain parameters appeared important when grouped with one set of parameters but unimportant when grouped with another set.

To aid in this elimination process, correlation coefficients were derived for each parameter according to the parameter's individual relationship with airport operations (itinerant and local) as well as with each other parameter. A summary of the correlation analysis

is shown in Table 2.6.1-1. A more complete correlation matrix with all the parameters is attached in the Appendix. Parameters having high correlations with airport operations automatically became highly rated candidates although those that were also highly correlated with other parameters were often superceded by these other parameters. On the other hand, certain parameters not highly correlated with operations sometimes ended up as useful indicators, even in the final version. The correlation matrix was useful in suggesting parameter sets to be tested; however the complexity introduced with parameter intercorrelations when multiple parameters were considered, limited its further usefulness in the study.

Each regression analysis computer run was initiated by activating the computer with a few instructions that identified which variables (airport parameters) were to be investigated. A multiple linear regression was then performed on this data and a description of its results were output on hard copy. For any iteration, three items were paid the foremost attention out of all output that was generated. These were the T-value, the multiple correlation coefficients and the standard error of estimate. The decisions made as to the acceptance or rejection of a particular set or combination of variables depended heavily on these factors. A description of an iteration will perhaps best demonstrate both the importance of these factors and the procedure used in developing the analysis.

The computer run starts with the set of independent variables selected for observation, operating on either of the three dependent variables that is itinerant, local or total operations. The computer output lists the T-values and the coefficients for each independent variable

TABLE 2.6.1-1 PARAMETER CORRELATIONS - SUMMARY

NO.	PARAMETER	CORRELATION WITH ITINERANT OPS	CORRELATION WITH LOCAL OPS	OTHER PARAMETERS WITH INTERCORRELATIONS > .50
1	Total AVGAS Storage	.48	.18	2, 21
2	Jet Fuel Storage	.47	.10	1, 21
3	Multi Engine Aircraft	.53	.28	4, 41
4	Total Based Aircraft	.43	.39	3,8,9,13,21,23,41,44,49
5	Actual Itinerant Ops	1.00	.51	3,6,49
6	AC and Air Taxi Ops	.53	.05	
7	Actual Local Ops	.51	1.00	8,48,49
8	Student Pilots	.47	.50	4,9,11,15,16,17,19,20,22, 24,25,26,41,49
9	Total Pilots	.43	.46	4,8,11,15,17,19,20,22,24,25, 26,41,49
10	FBO Index	.49	.28	28,29,30,31,35,36,37,38
11	Population	.32	.27	8,9,12,15,17,18,19,20,24,26, 28,41
12	Population/Mile^2	.06	.14	4,15,17,19,20,25,26
13	% Families > $10^K Income	.22	.22	14,16,22,24,26
14	Median Income	.14	.21	13,16
15	Employed Persons	.32	.24	8,9,11,12,17,18,19,20,24,25, 26,41
16	% White Collar Workers	.40	.34	8,13,14,24
17	Bank Deposits	.27	.23	8,9,11,12,15,18,19,20,24,25, 26,41
18	Manufacturers > 100 People	.25	.14	11,15,17,19,20,25,26
19	No. Retail Establishments	.39	.30	8,9,11,12,15,17,18,20,24,25, 26,41
20	No. Selected Service Establishments	.37	.29	8,9,11,12,15,17,18,19,24,25, 26,41
21	> 100 Octane AVGAS	.46	.15	1,2
22	≥ 4 place single engine aircraft	.35	.33	4,8,9,13,24,26,41,44
23	Airport Acreage	.24	.18	42,43
24	Private Pilots	.46	.42	4,8,9,11,13,15,16,17,19,20, 22,25,26,41,49
25	No. Families	.34	.26	8,9,11,12,15,17,18,19,20,24, 26,41
26	Selected Services Gross	.26	.24	8,9,11,12,13,15,17,18,19,20, 22,24,25,41
27	Hours of Attendance	.35	.16	
28	No. of FBO's	.32	.29	10
29	FBO Service - Instruction	.10	.10	10,41
30	FBO Service - Sales	.25	.15	10

TABLE 2.6.1-1 PARAMETER CORRELATIONS SUMMARY (continued)

NO.	PARAMETER	CORRELATION WITH		OTHER PARAMETERS WITH INTERCORRELATIONS > .50
		ITINERANT OPS	LOCAL OPS	
31	FBO Service - Rent/Charter	.26	.16	10,29,36,38
32	FBO Service - AGRI	.11	.09	
33	FBO Service - Other	.08	.00	
34	Landing Fees	.06	.08	
35	Repairs - AF, Major	.35	.23	10,36,37,38
36	Repairs - AF, Minor	.24	.10	10,31,35,37,38
37	Repairs - Engine, Major	.35	.18	10,35,36,38
38	Repairs - Engine, Minor	.24	.10	10,31,35,36,37
39	Max. Temperature	-.01	.06	
40	Aircraft per 100,000	-.08	-.05	
41	Aircraft in County	.45	.39	3,4,8,9,11,15,17,19,20,22, 24,25,26,49
42	Corrected Runway Ft.	.32	.16	23
43	No. Runways	.34	.12	23
44	No. T Hangars	.21	.14	4,22
45	No. Conventional Hangars	.26	.12	
46	Military Operations - 5010	.18	.29	
47	Air Taxi Operations - 5010	.15	.06	
48	Local Operations - 5010	.47	.70	49
49	Itinerant Operations-5010	.76	.53	3,4,8,9,24,48
50	Hours Flown	.70	.71	3,4,8,22,41

under observation in that particular regression. The output also shows the multiple correlation as well as the standard error (same as the standard deviation about a mean of σ) associated with that set of variables. Each variable is then examined independently according to its T-value. The T statistic is most important since it is a determinant of the coefficient for that variable. The higher the T-value (positive or negative), the more confidence that the actual value of coefficient is not zero and hence a predictor of aircraft activity.

After the first regression, all variables having a value of less than 0.7 are eliminated and the remaining variables are now subject to closer scrutiny in the next regression. Whenever the number of variables is reduced, there is a drop in the multiple correlation coefficient and an increase in the standard error. However, there is a trade-off involved in this process. The variables which are statistically less valid according to the T statistic are eliminated to get a more stable and statistically valid model; and certainly, it is easier to implement an estimating model with five variables than one which has 20 or more. So, in effect, a little accuracy is sacrificed for ease of implementation of the model. In successive regressions, variables are eliminated when their T-values are less than 1.0 and 1.5. Finally a set of variables is obtained in which all variables have T-values of 2.0 and greater. This particular regression is then judged against other models from other iterations according to its multiple correlation coefficient and its standard error estimate.

Once the user is satisfied with a particular set of variables that

may possibly be effective in estimating annual aircraft activity, a listing is obtained of actual and estimated airport operations (computed according to the variables currently in the regression model at that time) along with their absolute and percentage difference for each airport in the data file. The listing informs the user as to how effective the model really is in estimating annual aircraft activity.

2.6.2 Iteration Illustration

The study's final iteration process, i.e., the derivation of the recommended formula for estimating itinerant operations, occurred only after the parameters list had been reduced to 15 independent variables. However that iteration is typical of all other iterations and is presented in Figure 2.6.2-1 to illustrate the process. Its first regression was made by instructing the computer that sixteen variables were applicable (one dependent variable) and the I.D.'s of those variables were input. The computer results of the regression then listed, for each dependent variable shown in the first column, the appropriate statistical measures. This regression's overall measure shows a multiple correlation coefficient of .8610 and a standard error of 7019 (absolute units of operations are in hudreds). It can be noted that according to the T-test, variables five and twelve are most suspect.

Consequently the next regression does not include these two independent variables; rather it operates only on the other 13 variables. The results of this second regression shows four variables (8,10,11 and 19) that are most suspect because of their T-values less than 1.0,

FIGURE 2.6.2-1 DERIVATION OF ESTIMATING RELATIONSHIP

FIRST REGRESSION

INPUT

OUTPUT

```
TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?16
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,5,
? 6,7,8,9,10,11,12,13,14,15,19,20
```

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.3006	.0532	5.650	.226766E-01	.401353E-02	.4584
4	.4026	.0824	4.888	3.33861	.683069	.4075
5	-.0190	.0869	-.218	-.410120E-01	.188042	-.0199
6	-.0764	.0563	-1.358	-1.18345	.871263	-.1231
7	-.1713	.0687	-2.493	-.309550E-01	.124162E-01	-.2219
8	.0457	.0584	.782	5.53076	7.07401	.0712
9	.0989	.0781	1.266	1.58293	1.25029	.1148
10	-.1538	.1874	-.821	-.739037	.900349	-.0747
11	.0577	.0806	.716	.703968E-01	.983630E-01	.0652
12	.0248	.0778	.319	.245300E-01	.769010E-01	.0291
13	.3418	.2241	1.525	1.12464	.737597	.1379
14	.2411	.0715	3.370	.364912	.108290	.2940
15	.0998	.0963	1.037	.111858	.107846	.0943
19	-.0570	.0667	-.855	-5.88222	6.88264	-.0778
20	-.0829	.0603	-1.375	-.268423	.195202	-.1246

NDF =108 INT = -27.1916

MULTIPLE R= .8610, STD.ERR.EST.= 70.191 , UNEXPLAINED= .2587

F= 20.6287 , NDF= 15.0, 108.0

SECOND REGRESSION

INPUT

OUTPUT

```
TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?14
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,6,
? 7,8,9,10,11,13,14,15,19,20
```

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.3032	.0526	5.766	.228730E-01	.396666E-02	.4658
4	.4073	.0800	5.089	3.37704	.663617	.4213
6	-.0758	.0529	-1.432	-1.17412	.819728	-.1296
7	-.1713	.0685	-2.501	-.309485E-01	.123766E-01	-.2225
8	.0436	.0577	.755	5.28237	6.99526	.0688
9	.1008	.0774	1.303	1.61297	1.23828	.1181
10	-.1604	.1867	-.859	-.770777	.897099	-.0782
11	.0558	.0798	.699	.680234E-01	.973019E-01	.0637
13	.3375	.2173	1.554	1.11075	.714933	.1404
14	.2340	.0669	3.500	.354224	.101215	.3043
15	.1187	.0776	1.531	.133003	.868994E-01	.1384
19	-.0593	.0650	-.912	-6.11458	6.70780	-.0829
20	-.0837	.0594	-1.409	-.271017	.192329	-.1276

NDF =110 INT = -27.5339

MULTIPLE R= .8608, STD.ERR.EST.= 70.234 , UNEXPLAINED= .2590

F= 24.2029 , NDF= 13.0, 110.0

FIGURE 2.6.2-1 (continued)

THIRD REGRESSION

```
TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?10
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,6,7,9,13,14
?15,20
```

MULTIPLE REGRESSION RESULTS

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.3091	.0526	5.878	.233152E-01	.396630E-02	.4728
4	.3962	.0738	5.372	3.28536	.611620	.4403
6	-.0605	.0516	-1.173	-.937355	.799409	-.1064
7	-.1568	.0664	-2.363	-.283308E-01	.119890E-01	-.2109
9	.1433	.0666	2.152	2.29255	1.06520	.1928
13	.1736	.0739	2.350	.571340	.243100	.2098
14	.2205	.0636	3.467	.333770	.962832E-01	.3017
15	.1532	.0552	2.773	.171629	.619013E-01	.2454
20	-.0534	.0537	-.994	-.172983	.173957	-.0904
		NDF =114	INT =	-46.2802		

MULTIPLE R= .8570, STD.ERR.EST.= 71.106 , UNEXPLAINED= .2655

F= 35.0388 , NDF= 9.0, 114.0

FOURTH REGRESSION

```
TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?8
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,7,9,13,14,15
```

MULTIPLE REGRESSION RESULTS

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.3141	.0531	5.915	.236925E-01	.400579E-02	.4751
4	.4328	.0713	6.073	3.58834	.590879	.4849
7	-.1974	.0606	-3.260	-.356759E-01	.109429E-01	-.2852
9	.1555	.0669	2.324	2.48747	1.07022	.2076
13	.1623	.0744	2.180	.534071	.244977	.1952
14	.2194	.0643	3.413	.332149	.973153E-01	.2975
15	.1528	.0558	2.736	.171175	.625581E-01	.2423
		NDF =116	INT =	-70.8800		

MULTIPLE R= .8533, STD.ERR.EST.= 71.953 , UNEXPLAINED= .2719

F= 44.3794 , NDF= 7.0, 116.0

so the next regression operates only on the remaining nine variable. The third regression indicates that variables six and 20 are less than 1.5 and should be deleted. With the fourth regression it is concluded that no further regressions are necessary in that all variables have T-values greater than 2.0.

It should be noted that the stepwise elimination of parameters is an important process and the most effective way, from the study's viewpoint, is using the successive criteria 0.7,1.0, 1.5, and 2.0 as permissible T-values. When a different procedure is followed, different conclusions will be derived for the end product. For example, if the final criterion, T-value $\geq$ 2.0, had been applied to the first regression, only variables three, four, seven, and 14 would have been retained.

With all variables in the regression exceeding the T-value criteria, this regression is considered as the final version and its characteristics are then defined as the iteration's characteristics. In other words, this iteration (and not just this regression)has seven independent variables, with each variable having the coefficient as indicated in the B COEF column, and the intercept term is -70.88. As an estimating model it has a standard error of 7195 and a predictability coefficient (MULTIPLE R) of .8533. These values are a basis for comparison with similar values from other iterations.

Another basis for comparison is the effectiveness of the final regression's estimating formula when applied to individual airports. This evaluation is made by directing the computer to assign the appropriate coefficients, as defined in the B COEF. column, with

each variable remaining in the regression and thereby compute the estimated operations at each airport in the airports model. Table 2.6.2-1 presents such information. For each airport whose I D is given in the first column, actual operations and estimated operations are shown in the next two columns and their difference in absolute terms (fourth column) and percentages (fifth column) are also shown. Absolute operations are shown in units of hundreds.

The iteration process was identically performed when total operations and local operations were considered. The final version of the process which identifies the recommended estimating relationships has been included in the Appendix. Individual airport estimates for total and local operations are also included.

2.6.3 Model Evaluation

The next step in the development of an operations estimating model was to examine all the bad estimates that appear on the listing of actual versus the estimates currently under observation. Two techniques were tried to improve the bad estimates. The first was a graphical approach where the residuals (difference between estimated and actual operations) was plotted against actual operations and other independent variables. This process suggested consideration of certain other mathematical techniques such as a logarithmic model but such schemes proved unsuccessfull. However the graphical data was helpful in categorizing the error ranges of the estimator; such as 10 - 20% or 5 - 10^K absolute error. It also pointed out trouble spots where the model was having its greatest difficulty in estimating aircraft operations. For instance, the model's difficulty in estimating operations at very large airports (towers) was visually

TABLE 2.6.2-1 FINAL ITERATION'S AIRPORT ESTIMATES

AIRPORT's FILE SEQUENCE NUMBER	ACTUAL OPERATIONS (HUNDREDS)	ESTIMATED OPERATIONS (HUNDREDS)	ABSOLUTE DIFFERENCE (HUNDREDS)	PERCENTAGE DIFFERENCE
20	500.000	339.447	-160.553	-32.111
30	261.000	362.289	101.289	38.808
40	304.000	281.612	-22.388	-7.364
50	402.000	303.847	-98.153	-24.416
60	403.000	407.927	4.927	1.223
70	296.000	283.358	-12.642	-4.271
90	235.000	327.831	92.831	39.503
100	217.000	311.613	94.613	43.600
110	303.000	330.797	27.797	9.174
120	394.000	380.706	-13.294	-3.374
130	240.000	334.525	94.525	39.385
140	266.000	152.918	-113.082	-42.512
150	296.000	431.073	135.073	45.633
160	440.000	414.085	-25.915	-5.890
170	279.000	295.431	16.431	5.889
180	305.000	266.431	-38.569	-12.645
190	371.000	268.176	-102.824	-27.715
200	285.000	232.033	-52.967	-18.585
210	488.000	441.308	-46.692	-9.568
220	432.000	305.399	-126.601	-29.306
230	462.000	299.018	-162.982	-35.277
240	303.000	296.529	-6.471	-2.136
260	206.000	209.777	3.777	1.833
270	371.000	393.344	22.344	6.023
280	549.000	374.488	-174.512	-31.787
290	562.000	535.829	-26.171	-4.657
300	436.000	438.741	2.741	.629
310	230.000	308.573	78.573	34.162
320	205.000	320.253	115.253	56.221
330	159.000	155.295	-3.705	-2.330
340	258.000	223.820	-34.180	-13.248
350	281.000	230.482	-50.518	-17.978
380	90.000	139.174	49.174	54.638
410	105.000	200.890	95.890	91.324
430	139.000	177.750	38.750	27.878
440	174.000	240.879	66.879	38.436
450	275.000	373.132	98.132	35.684
460	230.000	279.569	49.569	21.552
490	265.000	201.851	-63.149	-23.830
500	230.000	216.017	-13.983	-6.080
510	285.000	170.596	-114.404	-40.142
520	215.000	171.259	-43.741	-20.345
530	295.000	264.354	-30.646	-10.388
540	298.000	266.818	-31.182	-10.464
550	395.000	204.443	-190.557	-48.242

TABLE 2.6.2-1 (continued)

AIRPORT'S FILE SEQUENCE NUMBER	ACTUAL OPERATIONS (HUNDREDS)	ESTIMATED OPERATIONS (HUNDREDS)	ABSOLUTE DIFFERENCE (HUNDREDS)	PERCENTAGE DIFFERENCE
560	192.000	262.957	70.957	36.957
570	218.000	322.507	104.507	47.939
590	260.000	214.964	-45.036	-17.322
600	300.000	260.255	-39.745	-13.248
1010	335.000	388.382	53.382	15.935
1020	493.000	390.600	-102.400	-20.771
1030	487.000	554.623	67.623	13.886
1050	414.000	395.329	-18.671	-4.510
1090	416.000	233.211	-182.789	-43.940
1100	429.000	433.277	4.277	.997
1120	291.000	270.254	-20.746	-7.129
1130	373.000	318.042	-54.958	-14.734
1140	394.000	330.841	-63.159	-16.030
1150	383.000	376.336	-6.664	-1.740
1160	407.000	392.070	-14.930	-3.668
1180	225.000	277.450	52.450	23.311
1190	422.000	414.885	-7.115	-1.686
1220	361.000	333.835	-27.165	-7.525
1240	331.000	404.308	73.308	22.147
1250	387.000	309.451	-77.549	-20.038
1260	285.000	445.732	160.732	56.397
1270	413.000	426.431	13.431	3.252
1280	328.000	316.914	-11.086	-3.380
1290	292.000	333.152	41.152	14.093
1300	272.000	241.848	-30.152	-11.085
1320	419.000	385.388	-33.612	-8.022
1400	135.000	203.493	68.493	50.735
1410	600.000	590.103	-9.897	-1.650
1420	305.000	296.389	-8.611	-2.823
1430	590.000	326.575	-263.425	-44.648
1440	314.000	250.782	-63.218	-20.133
1450	310.000	271.935	-38.065	-12.279
1460	135.000	254.239	119.239	88.325
1470	220.000	238.491	18.491	8.405
1480	258.000	378.972	120.972	46.888
1500	290.000	295.120	5.120	1.766
1510	349.000	373.461	24.461	7.009
1530	254.000	213.903	-40.097	-15.786
1540	164.000	145.638	-18.362	-11.196
1550	399.000	409.125	10.125	2.537
1560	378.000	329.507	-48.493	-12.829
1600	169.000	225.999	56.999	33.727
1610	230.000	270.824	40.824	17.749
1620	295.000	282.289	-12.711	-4.309
1630	214.000	213.240	-.760	-.355
1640	142.000	217.869	75.869	53.429
1660	243.000	279.100	36.100	14.856

TABLE 2.6.2-1 (continued)

AIRPORT'S FILE SEQUENCE NUMBER	ACTUAL OPERATIONS (HUNDREDS)	ESTIMATED OPERATIONS (HUNDREDS)	ABSOLUTE DIFFERENCE (HUNDREDS)	PERCENTAGE DIFFERENCE
1670	398.000	344.061	-53.939	-13.552
1680	405.000	321.703	-83.297	-20.567
1690	215.000	191.164	-23.836	-11.086
1700	270.000	208.656	-61.344	-22.720
1710	255.000	265.039	10.039	3.937
1790	250.000	180.140	-69.860	-27.944
1800	175.000	274.507	99.507	56.861
1830	207.000	349.520	142.520	68.850
1840	215.000	245.769	30.769	14.311
1850	164.000	187.585	23.585	14.381
1860	258.000	325.529	67.529	26.174
1870	285.000	280.841	-4.159	-1.459
1890	160.000	96.757	-63.243	-39.527
2000	54.000	79.192	25.192	46.651
2020	32.000	47.263	15.263	47.698
2030	22.000	50.926	28.926	131.481
2040	27.000	74.712	47.712	176.710
2050	11.000	48.469	37.469	340.626
2060	9.000	75.453	66.453	738.368
2070	42.000	90.261	48.261	114.908
2080	72.000	85.657	13.657	18.969
2090	29.000	98.119	69.119	238.340
3000	31.000	64.725	33.725	108.790
3010	80.000	102.954	22.954	28.692
3020	20.000	18.122	-1.878	-9.388
3030	90.000	115.142	25.142	27.935
3040	26.000	51.400	25.400	97.692
3060	39.000	29.389	-9.611	-24.642
3070	21.000	43.390	22.390	106.618
3080	54.000	66.759	12.759	23.628
3090	27.000	76.316	49.316	182.653
4000	60.000	105.700	45.700	76.167

apparent from these plots. Another examination of data plots outside a 30% error, revealed that the bulk of those airports had significantly high levels of military operations. Such information then suggested areas of investigation where improvements were necessary. Otherwise it pointed out the inherent limitations of the estimating relationship. Examples of graphical evaluations used to compare iterations are presented in Figures 2.6.3-1 and -2.

The second approach involved an examination of the individual components that contribute to the estimate of airport operations, i.e., the regressions's variable and its coefficient. Their product was examined at each airport where overestimates or underestimates had been made and were used to possibly explain why the poor estimates had been made.

The net effect of these two approaches was the reevaluation of certain variables as potential indicators of airport operations which then served as input considerations for selecting the variables to be used in the next iteration. Numerous iterations finally resulted in the elimination of a sufficient number of parameters to permit regression analyses to be performed on all remaining parameters simultaneously. This ultimately led to the regression described in Figure 2.6.2-1. The process for developing an estimating relationship for total operations, local operations or itinerant operations was the same.

Statistical Evaluation - Certain values output by the computer program were particularly important in making a statistical evaluation of the multiple regression model. These values and their

FIGURE 2.6.3-1 ESTIMATE ERROR VS. ACTUAL OPERATIONS AT MODEL'S AIRPORTS

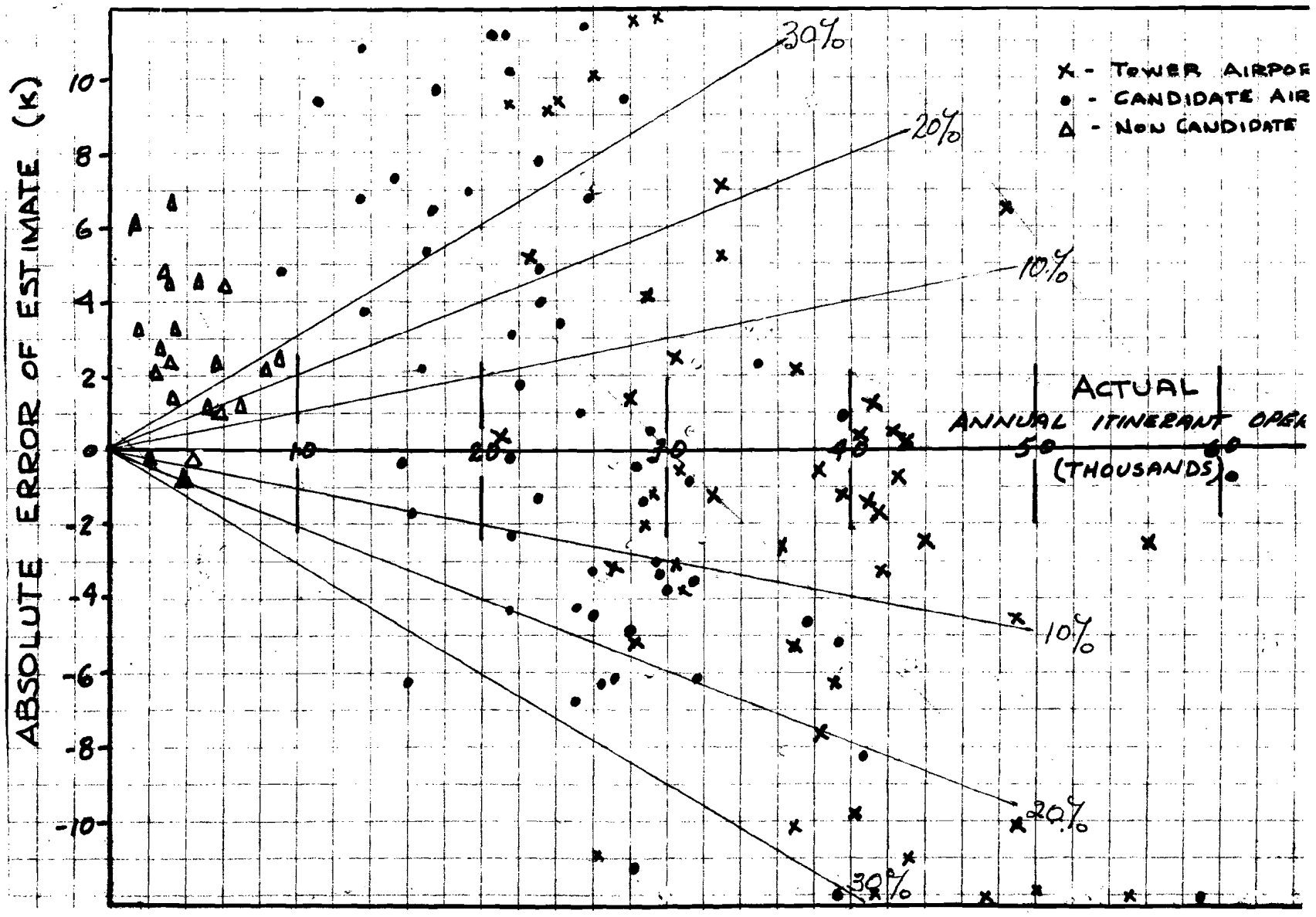
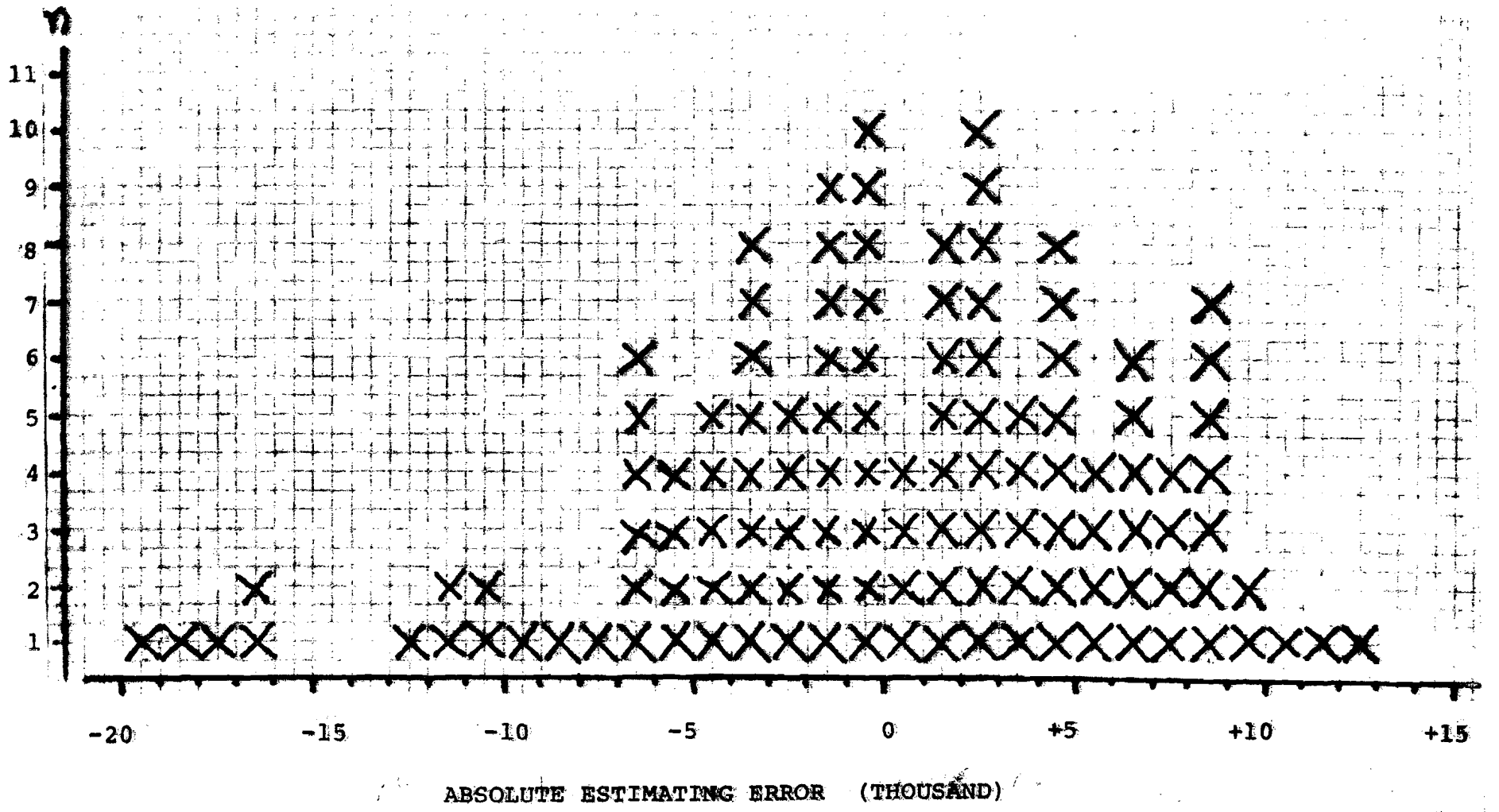


FIGURE 2.6.3-2 DISTRIBUTION OF ESTIMATING ERROR RESIDUALS - ITINERANT OPERATIONS



output identification are: the t value ("T"), multiple regression coefficient ("MULTIPLE R"), standard error of estimate ("STD,ERR. EST."), and the F value ("F").

The t-value ("T") is particularly significant in a statistical evaluation of the multiple regression model. The t-value is the ratio of a model coefficient called the Beta Coefficient ("B COEF.") and its standard error called the Standard Error of the Beta ("S.E.B."). Under the basic assumption of normality, the ratio is referred to as the "t-value" because it is statistically distributed as the well known t distribution with n-k degrees of freedom, where n is the number of airports (observations) in the data file and k is the number of variables in the model. Whenever the number of observations exceeds 30, the t distribution can be usually approximated by the standard normal distribution.

In the computer program, the initial null hypothesis made is that the regression variable's coefficients are zero and then the t test is applied to each variable. Therefore, the larger the t-value, the lower the probability that the true value of the coefficient could be zero and hence, the more confident one is that the variable associated with the coefficient does contribute to the model which estimates operations accurately. In the model, the degrees of freedom have been greater than 105, hence for t-values of 1.96 or more there is a probability of less than .05 that the coefficient could in fact be zero. In other words, we can say that we are 95% confident that the actual value of the constant is not zero. The different levels of confidence as well as their corresponding t-values are displayed in the following table.

Confidence Level	t-value
99.8%	3.090
99.0%	2.576
98.0%	2.326
95.0%	1.960
90.0%	1.645
85.0%	1.439
80.0%	1.282
75.0%	1.151
70.0%	1.036
68.0%	1.000

In the iteration process, the procedure involved rejecting or accepting variables depending upon their t-values; those with lower t-values being rejected so that the final regression variables were only those which had statistically demonstrated their validity.

The multiple regression coefficient-R-measures how well operations are predicted at all airports in the model, here a value of zero would mean no predictability and one would mean complete predictability. The Z transformation of R,

$$z = \text{arctanh } R$$

has a normal distribution with a standard deviation $1/\sqrt{n} = .09$. Therefore, if R = .853, Z = 1.268 and the 95% confidence interval in terms of the z transformation is $1.268 \pm .18$; or in terms of R, .808 to .898. In such a case, only 2.5% of the time could the R value be as low as .808.

The distribution of the difference between actual operations and model estimates is normal with a mean of zero and a standard deviation given by the standard error of estimate. Therefore, only 1/3 of the estimates of the model will be in error by more than the standard error of estimate.

The F value is given by,

$$F = \frac{R^2/(k-1)}{(1-R^2) \ / \ (n-k)}$$

It has an F distribution with k-1 and n-k degrees of freedom under the hypothesis that the population R (multiple regression coefficient) is actually zero. For this model the value of F is 44 with 7, 116 degrees of freedom. This means that there is only a negligible chance that the true R in this case could be zero. In fact, an F of this magnitude and degrees of freedom represents a smaller probability than any that can be found on any of the standard F tables.

2.7 TESTING

Statistical characteristics of the estimating model are useful indicators of estimating efficiency; however they should not be considered as the last word in evaluating the model. The very good estimates made for those airports that were part of the airports model can not legitimately be used to justify the estimating process because it was those very airports that influenced the regression analyses. Good estimates, in this case, simply prove that the regressions were performed effectively. It remains to be proven whether the airports model, i.e., the data on which the regression was based, was truly representative of all airports.

A method for determining the applicability of the estimating procedure was by testing it on a number of airports, independently selected and not part of the airports model. Implementation of the estimating process at these airports yielded annual estimates for total and itinerant operations which then could be compared with actual operations known to have occurred at those sites. In this way an independent assessment could be made of the estimating model.

The assessment however was also subject to the same possible biases that the model had been subject to and similar precautions had to be taken in selecting which airports were to be tested. For example, if only airports with more than 40,000 operations were tested, then the estimating model could only be evaluated on that limited basis. Consequently it was important to select a range of airport sizes that might demonstrate the model's ability

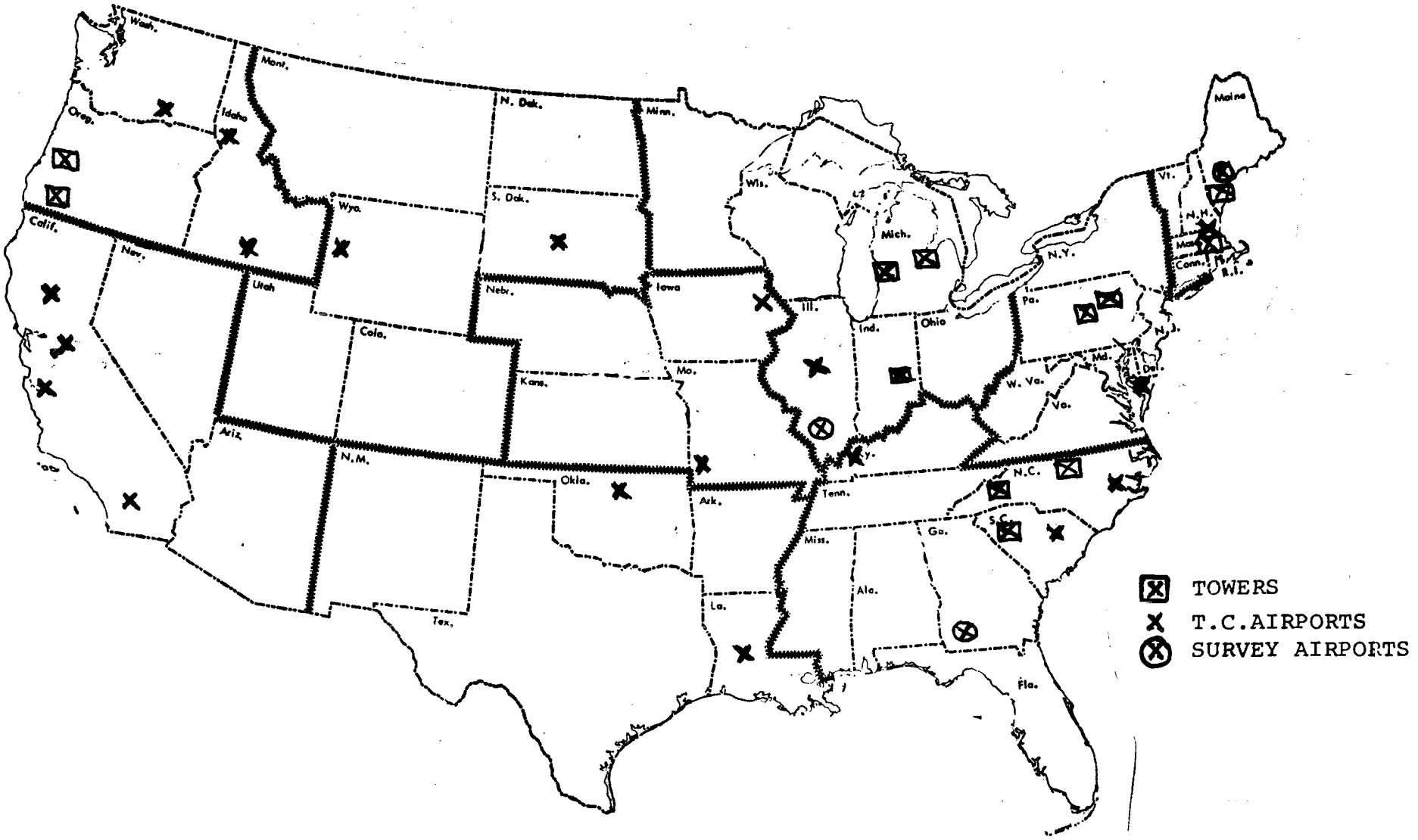
across a broad spectrum.

In a manner similar to the airports model selection, it was also considered important to select airports on a geographical basis so that coverage for all FAA Regions would be demonstrated. Considerations of statistical sufficiency and intended application were also made in the selection process but ultimately all of these factors had to be compromised by practical conditions.

Practicalities caused limitations in the selection of test airports. The choice of airports was minimized due to the basic requirement for knowing the actual number of operations at each airport selected for testing. The same requirement previously imposed in the selection of the airports model had, to an extent, exhausted the list of airports where such data was available. Many of the remaining airports, whether towered or not had previously been considered as candidates for the airports model and rejected for one reason or another. The limited number of airports, and especially the limited "typical" airports therefore prohibited a statistical validation of the tests. Moreover, the difficulty in approaching the desired size and geographical distribution in the set of test airports causes some concern for its applicability. However, these airports should be indicative of the models range of effectiveness. Figure 2.7-1 shows the geographical locations of the airports selected for testing. A total of 34 airports were selected for testing.

Data pertaining to each of the estimating model's parameters then had to be collected for each of the test airports. However since the number of parameters had been reduced to 20, this effort was

FIGURE 2.7-1 AIRPORT SITES SELECTED FOR TESTING



not as extensive as the original data base development. Computation of the tentative estimating formula as defined by each iteration then yielded estimates of operations and their accuracy with regard to the airport's actual operations gave an indication of that method's effectiveness. Such procedures were duplicated for each of the estimating methods reaching final consideration. They provided further comparative data to use in determining which of the tentative estimating methods was best. Table 2.7-1 lists the applicable data that was required for implementing the final version (recommended) estimating process at each of the test airports. The resultant estimates of itinerant operations and their comparison with actuals are shown in Table 2.7-2. Estimates for total operations are shown in Table 2.7-3.

TABLE 2.7-1 DATA STATISTICS FOR TEST AIRPORTS

TEST AIRPORT	FUEL STORAGE	BASED AIRCRAFT ≥ 4 PL.	MULTI ENGINE AIRCRAFT	COUNTY AIRCRAFT	STUDENT PILOTS	TOTAL BASED AIRCRAFT	SCHED. A.C. DEPARTS.	FACILITY INDEX	ACRES
Dawson, Ga.	10	6	0	8	11	22	0	26	61
Greenville, Ill.	100	7	2	12	7	15	0	38	480
Fryeburg, Me.	0	8	0	57	33	14	0	37	533
Chico, Ca.	250	31	13	169	162	52	1380	44	1073
Paso Robles, Ca.	250	19	7	181	112	53	1184	64	1200
Twin Falls, Idaho	360	29	13	61	93	89	1718	61	585
Dubuque, Iowa	29	42	12	91	43	60	2746	78	1087
Paducah, Ky.	150	12	9	32	24	25	4030		592
Alexandria, La.	150	14	11	127	72	27	3771	63	206
Salisbury, Md.	80	12	8	37	34	40	0	79	660
Ponca City, Ok.	60	21	7	59	47	46	1278	43	690
Pierre, S.D.	15	32	6	53	54	60	3016	73	1735
Jackson Hole, Wy.	160	16	4	19	23	29	1411	44	764
Imperial, Ca.	35	35	7	112	173	71	1448	59	279
Marysville, Ca.	100	23	6	123	55	52	244	69	833
Lewiston, Idaho	200	46	9	50	75	94	4016	69	708
Carbondale, Ill.	100	32	15	67	47	78	0	69	441
Lawrence, Mass.	60	90	9	394	190	114	0	57	430
Joplin, Mo.	150	41	11	70	89	70	4084	72	641
New Bern, N.C.	112	25	0	111	29	35	4505	71	400
Florence, S.C.	210	23	11	56	65	44	2105	70	1115
Pasco, Wash.	140	39	3	45	47	58	4594	73	1762
Worcester, Mass.	130	51	11	369	283	68	1441	84	720
Muskegon, Mich.	220	57	33	104	63	99	3854	81	780
Ashville, N.C.	205	26	18	85	7	50	7725	62	440
Eugene, Ore.	370	80	20	279	237	128	4067	69	680
Medford, Ore.	170	58	38	148	194	136	2738	69	750
Williamsport, Pa.	290	26	10	50	63	46	2430	81	735
Muncie, Ind.	110	71	28	83	49	102	0	75	150
Portland, Me.	216	35	5	165	63	50	3406	66	598
Saginaw, Mich.	290	21	25	121	67	54	5554	73	1600
Winston-Salem,N.C.	324	117	33	238	107	167	5990	76	702
Wilkes Barre,Pa.	165	20	18	138	92	44	3024	85	980
Greenville, S.C.	489	62	21	151	122	97	0	72	410

TABLE 2.7-2 TEST RESULTS FOR ITINERANT OPERATIONS ESTIMATES

TEST AIRPORT	TOWER	TYPE	ITINERANT OPS		ERROR	
			ACTUAL	ESTIMATED	ABSOLUTE	%
Dawson, Georgia	No	GA	4,100	3,700	- 400	- 9
Greenville, Illinois	No	GA	4,400	8,100	3,700	83
Fryeburg, Maine	No	GA	5,500	6,600	1,100	20
Chico, California	No	AC	26,800	23,800	- 3,000	-11
Paso Robles, California	No	AC	27,400	27,000	- 400	- 2
Twin Falls, Idaho	No	AC	31,500	34,000	2,500	8
Dubuque, Iowa	No	AC	29,000	31,700	2,700	9
Paducah, Kentucky	No	AC	33,000	29,600	- 3,400	-10
Alexandria, Louisianna	No	AC	26,000	33,000	7,000	27
Salisbury, Maryland	No	GA	28,000	25,500	- 2,500	- 9
Ponca City, Oklahoma	No	AC	30,000	15,700	-14,300	-48
Pierre, South Dakota	No	AC	18,700	26,800	8,100	44
Jackson Hole, Wyoming	No	AC	8,900	15,400	6,500	73
Imperial, California	No	GA	36,500	28,400	- 8,100	-22
Marysville, California	No	GA	29,100	23,100	- 6,000	-21
Lewiston, Idaho	No	AC	34,500	37,900	3,400	10
Carbondale, Illinois	No	GA	39,500	27,200	-12,300	-31
Lawrence, Massachusetts	No	GA	43,000	27,500	-15,500	-36
Joplin, Missouri	No	AC	35,200	38,200	3,000	9
New Bern, North Carolina	No	AC	24,900	32,500	7,600	31
Florence, South Carolina	No	AC	32,300	29,900	- 2,400	- 7
Pasco, Washington	No	AC	31,200	31,600	400	1
Worcester, Massachusetts	Yes	AC	48,200	41,900	- 6,300	-13
Muskegon, Michigan	Yes	AC	38,500	47,800	9,300	24
Ashville, North Carolina	Yes	AC	51,300	43,000	- 8,300	-16
Eugene, Oregon	Yes	AC	68,000	51,000	-17,000	-25
Medford, Oregon	Yes	AC	72,100	47,600	-24,500	-34
Williamsport,Pennsylvania	Yes	AC	43,000	37,200	- 5,800	-14
Muncie, Indiana	Yes	GA	52,800	35,200	-17,600	-33
Portland, Maine	Yes	AC	61,500	32,300	-29,200	-47
Saginaw, Michigan	Yes	AC	49,400	43,000	- 6,400	-13
Winston Salem, N. Carolina	Yes	AC	63,400	58,200	- 5,200	- 8
Wilkes Barre, Pennsylvania	Yes	AC	51,800	39,800	-12,000	-23
Greenville, S. Carolina	Yes	GA	51,000	40,100	-10,900	-21

TABLE 2.7-3 TEST RESULTS FOR TOTAL OPERATIONS ESTIMATES

TEST AIRPORT	TOWER	TYPE	TOTAL OPERATIONS		ERROR	
			ACTUAL	ESTIMATED	ABSOLUTE	%
Dawson, Georgia	No	GA	12,200	11,800	- 400	- 3
Greenville, Illinois	No	GA	5,600	15,300	9,700	174
Fryeburg, Maine	No	GA	18,000	18,700	700	4
Chico, California	No	AC	59,800	47,400	-12,400	-21
Paso Robles, California	No	AC	52,600	60,900	8,300	16
Twin Falls, Idaho	No	AC	46,500	62,400	15,900	34
Dubuque, Iowa	No	AC	40,400	59,800	19,400	48
Paducah, Kentucky	No	AC	43,500	46,700	3,200	7
Alexandria, Louisianna	No	AC	58,800	53,500	- 5,300	- 9
Salisbury, Maryland	No	GA	42,700	47,700	5,000	12
Ponca City, Oklahoma	No	AC	48,600	37,100	-11,500	-24
Pierre, South Dakota	No	AC	36,200	57,800	21,600	60
Jackson Hole, Wyoming	No	AC	13,100	26,500	13,400	103
Imperial, California	No	GA	56,100	59,200	3,100	6
Marysville, California	No	GA	71,600	43,200	-28,400	-40
Lewiston, Idaho	No	AC	72,000	65,900	- 6,100	- 8
Carbondale, Illinois	No	GA	96,500	52,400	-44,100	-46
Lawrence, Massachusetts	No	GA	120,500	74,800	-45,700	-38
Joplin, Missouri	No	AC	46,000	64,400	18,400	40
New Bern, North Carolina	No	AC	48,900	62,800	13,900	29
Florence, South Carolina	No	AC	46,400	50,800	4,400	9
Pasco, Washington	No	AC	58,800	57,900	- 900	- 2
Worcester, Massachusetts	Yes	AC	76,500	82,200	5,700	7
Muskegon, Michigan	Yes	AC	81,300	75,200	- 6,100	- 8
Ashville, North Carolina	Yes	AC	71,500	67,400	- 4,100	- 6
Eugene, Oregon	Yes	AC	119,800	95,000	-24,800	-21
Medford, Oregon	Yes	AC	122,300	90,100	-32,200	-26
Williamsport,Pennsylvania	Yes	AC	65,800	56,300	- 9,500	-14
Muncie, Indiana	Yes	GA	77,900	50,000	-27,900	-36
Portland, Maine	Yes	AC	88,200	63,800	-24,400	-28
Saginaw, Michigan	Yes	AC	74,600	76,800	2,200	3
Winston Salem, N. Carolina	Yes	AC	95,800	101,700	5,900	6
Wilkes Barre, Pennsylvania	Yes	AC	70,300	69,400	- 900	- 1
Greenville, S. Carolina	Yes	GA	91,400	63,600	-27,800	-30

3.0 DEVELOPMENT OF PEAK TRAFFIC CHARACTERISTICS

Procedures for analyzing peak traffic characteristics were primarily of a much more academic nature due to the limited data applicable to this part of the study. Peak traffic by its very definition requires a measure of the maximum daily operations that occur in a one year period; consequently every day's actual number of operations must be known before the true peak day operations can be known. Though it is justifiable for a sample of daily operations from a survey to be projected to an annual basis, it would be improper to use a similar approach to estimating peak day traffic unless an extremely long survey was conducted. Because of this inpracticality there is little or no true data about peak traffic at non-tower airports; clearly there is insufficient data on which to base a statistical analysis.

However, there is a considerable amount of peak operations data at tower airports where operations are recorded by the FAA on a daily basis as well as during busy hours. This information is not only available but can be considered accurate as well. Its one drawback is that it applies to tower rather than non-towered airports. Such a limitation represents a failing but in light of the absence of more appropriate data its use appears reasonable. Furthermore there is no evidence to indicate peak conditions at a tower airport differs from that at a similar but non-towered airport. Theoretically it may be presumed that the determinants of peak traffic are independent of the airport being towered or not.

This rationale formed the basis for the subsequent analysis of peak

traffic characteristics. One precaution used to minimize possible concern for using tower data was that only airports within the continental boundaries and with less than 300,000 total operations were considered. Certain other airports were also eliminated from the data base when it was discerned that their peaks were due to special or unusual (e.g. flyins) conditions.

3.1 Peak Day

Data from the reference document "FAA Air Traffic Activity" for FY 1972 and from Terminal Area Air Traffic Relationships for FY 1971 was analyzed to determine peak characteristics. An extract of such data is shown below.

GROUP II

TABLE 3 - TOTAL AIRCRAFT OPERATION AT AIR COMMERCE AIRPORT, FY 1972

LOCAL IDENT	LOCATION	HUB	DAILY HOURS OF OPNS	AIRCRAFT OPERATIONS ANNUAL	AVERAGE DAY	AVERAGE HOUR	PEAK DAY	RATIO OF PEAK/AVG DAY	BUSY HOUR OPNS	BUSY HOUR O/O OF AVG DAY	RATIO OF BUSY/AVG HOUR
MLB	MELBOURNE	S	18	158784	435	24	1082	2.487	126	29.0	5.250
GSN	GR S W INTERNATIONA	N	24	155329	426	18	736	1.728	116	27.2	6.444
BUF	BUFFALO	M	24	153315	420	18	669	1.593	68	16.2	3.778
HYA	HYANNIS	N	16	153254	420	26	1468	3.495	87	20.7	3.346
FWA	FORT WAYNE	S	24	153249	420	18	744	1.771	147	35.0	8.167
BDR	BRIDGEPORT	N	24	152933	419	17	1053	2.513	130	31.0	7.647
PHF	NEWPORT NEWS	S	24	151786	416	17	814	1.957	116	27.9	6.824
ILG	WILMINGTON GR WILM	N	24	151602	415	17	992	2.390	60	14.5	3.529
SYR	SYRACUSE	M	24	150350	412	17	761	1.847	71	17.2	4.176
	VOLUMES										
43	150000 - 199999		978	7469590	20464	920	42039	2.054	5091	24.9	5.534

In particular, analysis of the peak day to average day ratio was most useful for it was determined that this ratio was a direct function of total operations. Further inspection revealed that different relationships were necessary to distinguish general aviation type airports and air carrier airports. Figure 3.1-1 and 3.1-2 graphically

FIGURE 3.1-1 DATA BASE-PEAK OPS AT AIR CARRIER AIRPORTS

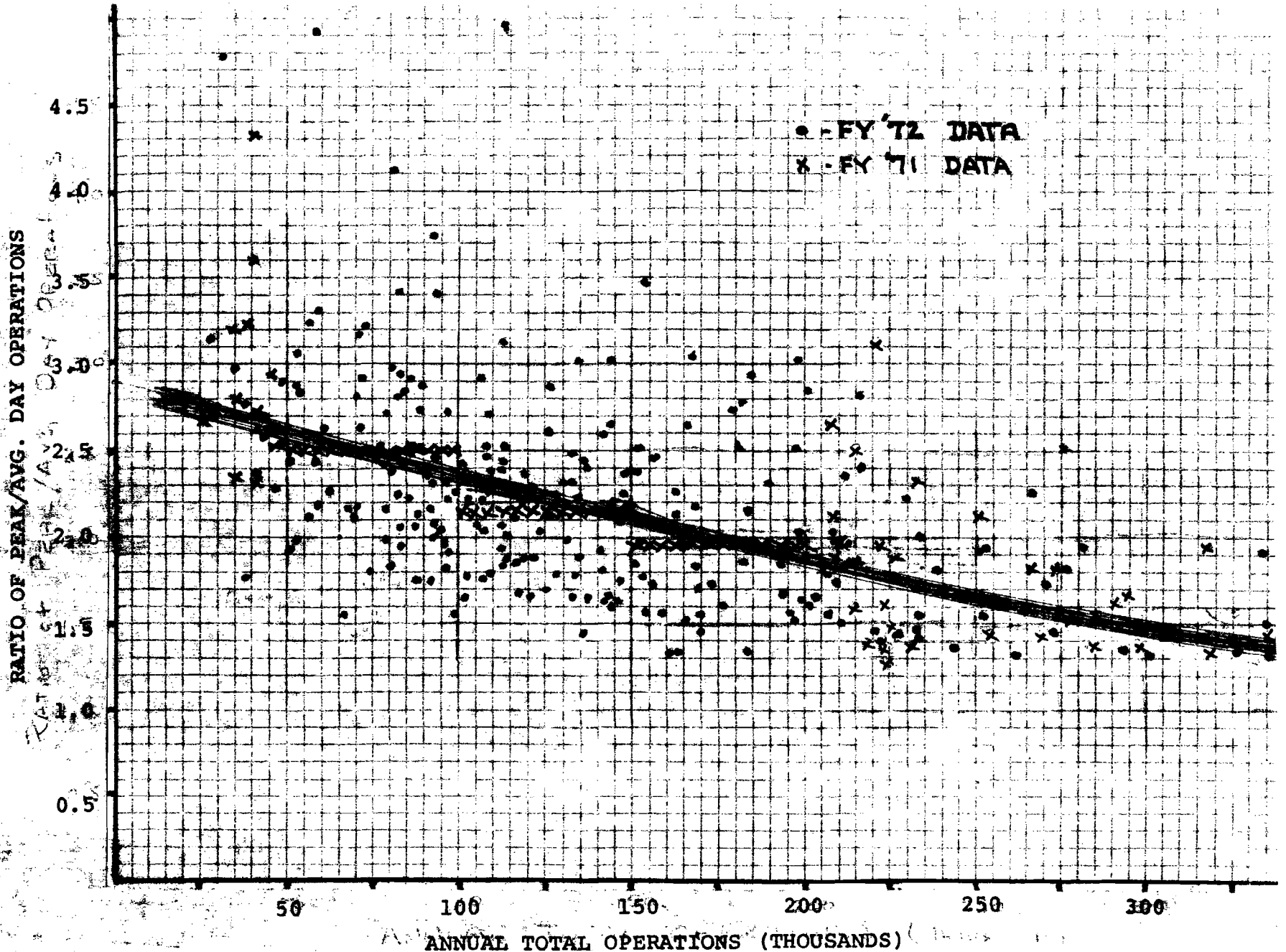
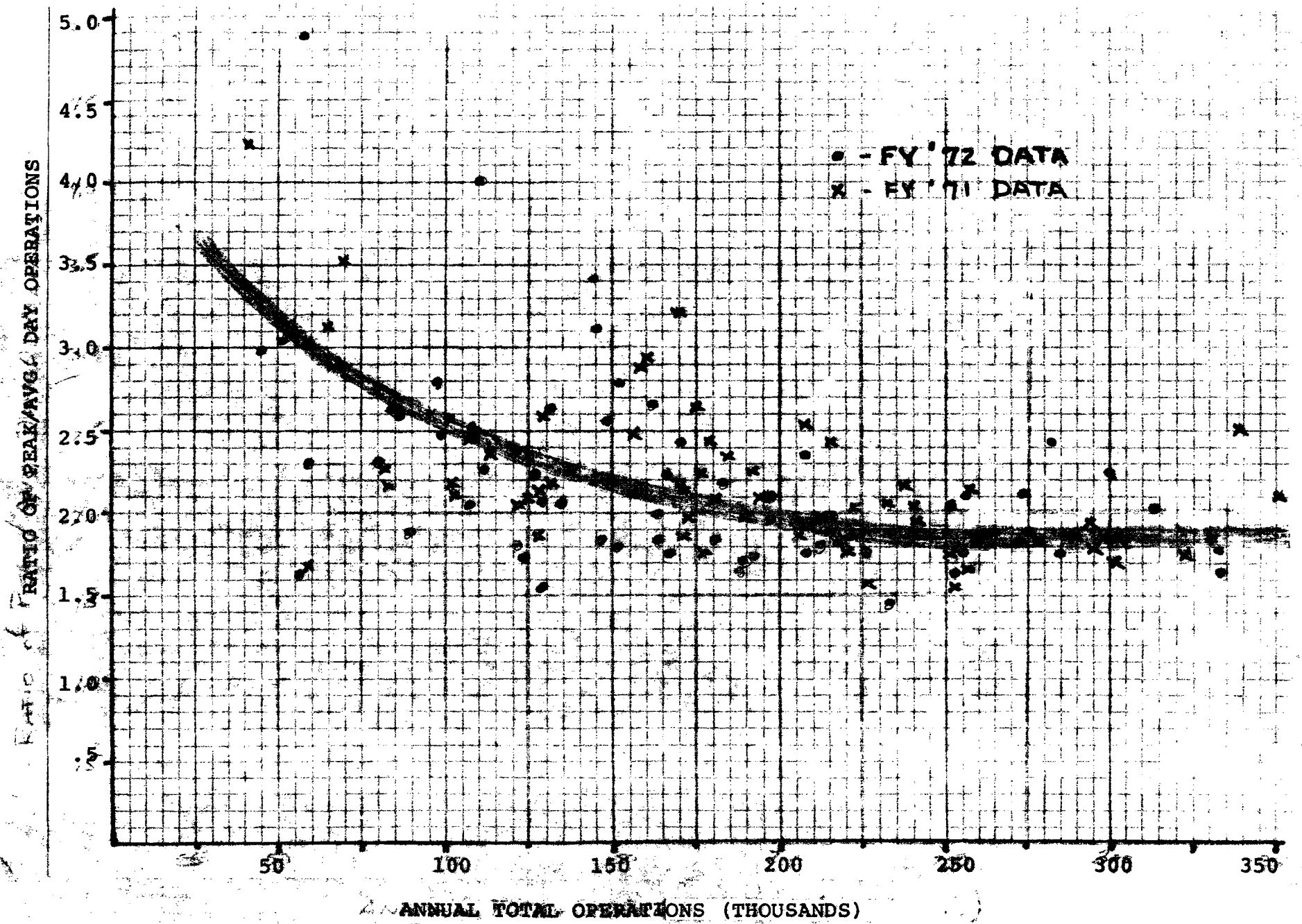


FIGURE 3.1-2 DATA BASE-PEAK OPS AT GENERAL AVIATION AIRPORTS



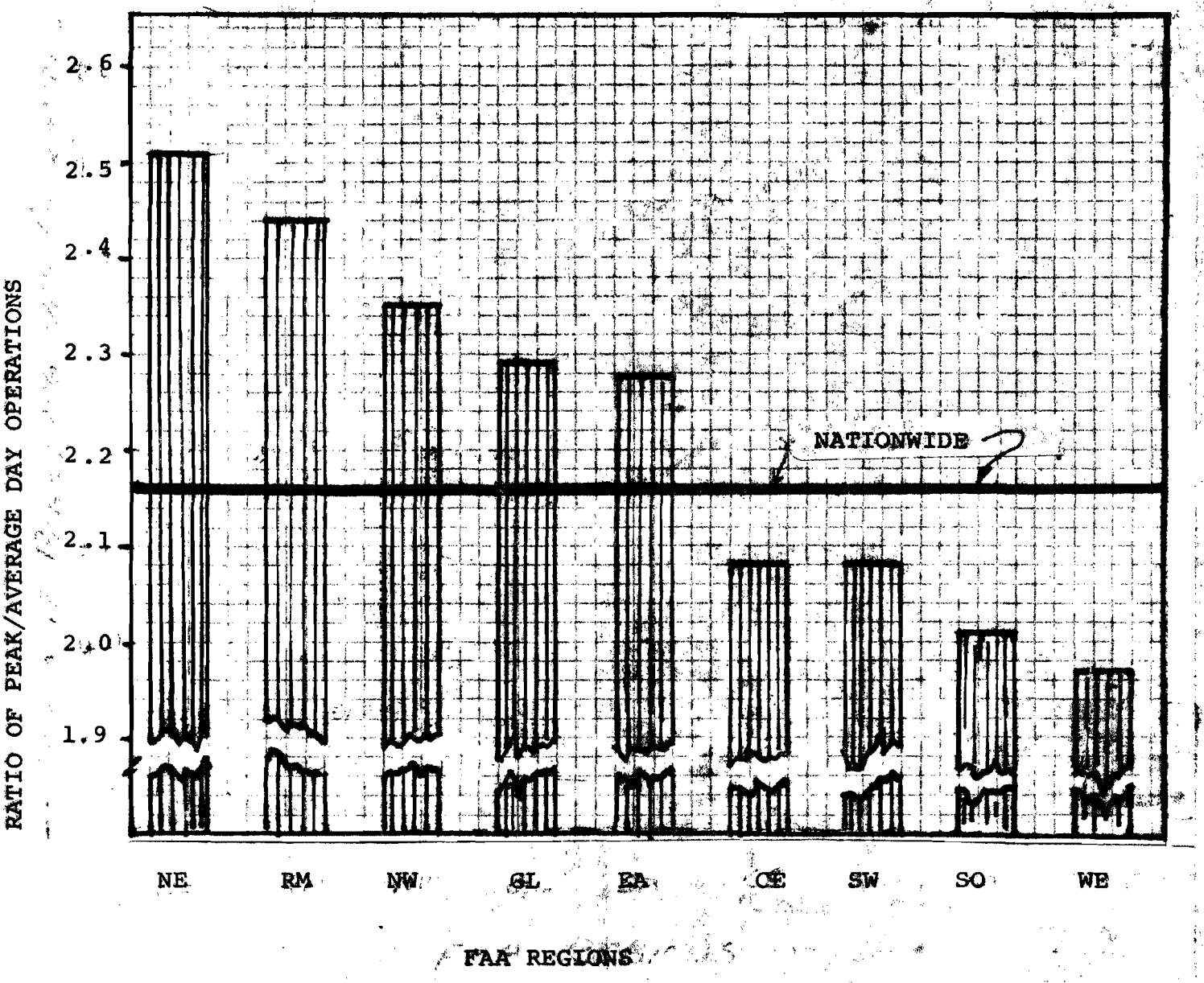
depict these relationships along with the plots of the actual data.

An additional feature was found when the airports were categorized according to FAA regional boundaries. Regardless of the total annual operations, airports within each region were predominantly either above or below the national average. It was subsequently recognized that the different weather experienced within the different regions accounted for this consistancy. Peak day to average day ratios were above average for airports in the northern latitudes and below average in the south. Figure 3.1-3 indicates relative comparisons for each of the FAA Regions.

This analysis about tower airports' peak traffic characteristics has led to a procedure for estimating peak traffic at non-tower airports. The method presumes that with an estimate of an airport's total operations, the airport's theoretical ratio of peak day operations to average day operations is determinable according to the relationship given in Figure 3.1-1 or Figure 3.1-2; hence, the airport's theoretical peak day operations may be computed. Furthermore by accounting for the airport's geographical location, an improvement to this theoretical estimate can be made. It appears that the latter step can best be accomplished by using neighboring tower airports as indicators; if the tower airport is above or below average, then the non-towered airport should also be above or below average and its theoretical estimate modified accordingly. An average of three trials, i.e., three tower airports, should eliminate possible disparities at a tower airport.

The method for estimating peak day operations has been described in Section 1.4 of this report and need not be repeated here. However this procedure can be performed in a manner that relies on graphical

FIGURE 3.1-3 GEOGRAPHICAL INFLUENCE ON PEAK TRAFFIC



interpretation instead of formal solution of several equations. Its description follows:

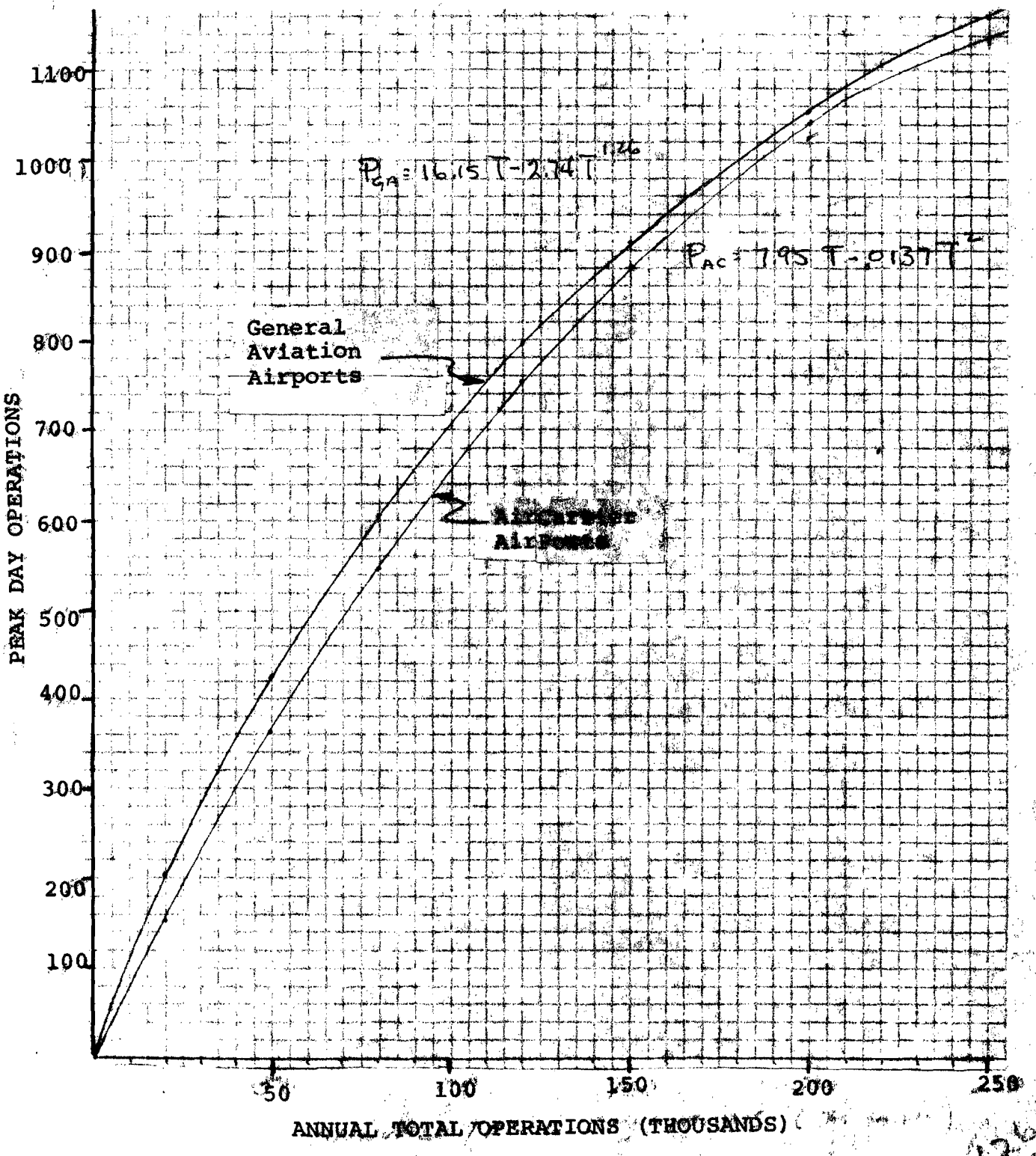
1. On Figure 3.1-4 locate the curve that is applicable to the non-towered airport to be estimated (general aviation or air carrier) and read the value of peak day operations from the ordinate that is appropriate with the airport's estimated total annual operations (abscissa). This is the theoretical peak day operations.
2. For each neighboring tower airport selected (Maximum of three) as a geographical reference, determine in a similar manner, using Figure 3.1-4, its theoretical peak day operations.
3. Divide the value from step 2 by the actual peak day operations for that airport as recorded by the FAA; average the results for the reference airports. This is the average geographical factor.
4. Multiply the theoretical peak day operations by the average geographical factor to get the estimated peak day operations for the non-towered airport.

The use of the graphical method or the procedure described in Section 1.4 is at the discretion of the user. Either procedure will yield the same results for non-towered airports.

3.2 Busy Hour

Busy hour characteristics were similarly evaluated. The same reference documents used to identify peak day traffic were used to give busy hour operations at tower airports. A simpler procedure for estimating this value was possible due to its independence from geographical or climatic conditions. Busy hour operations appear

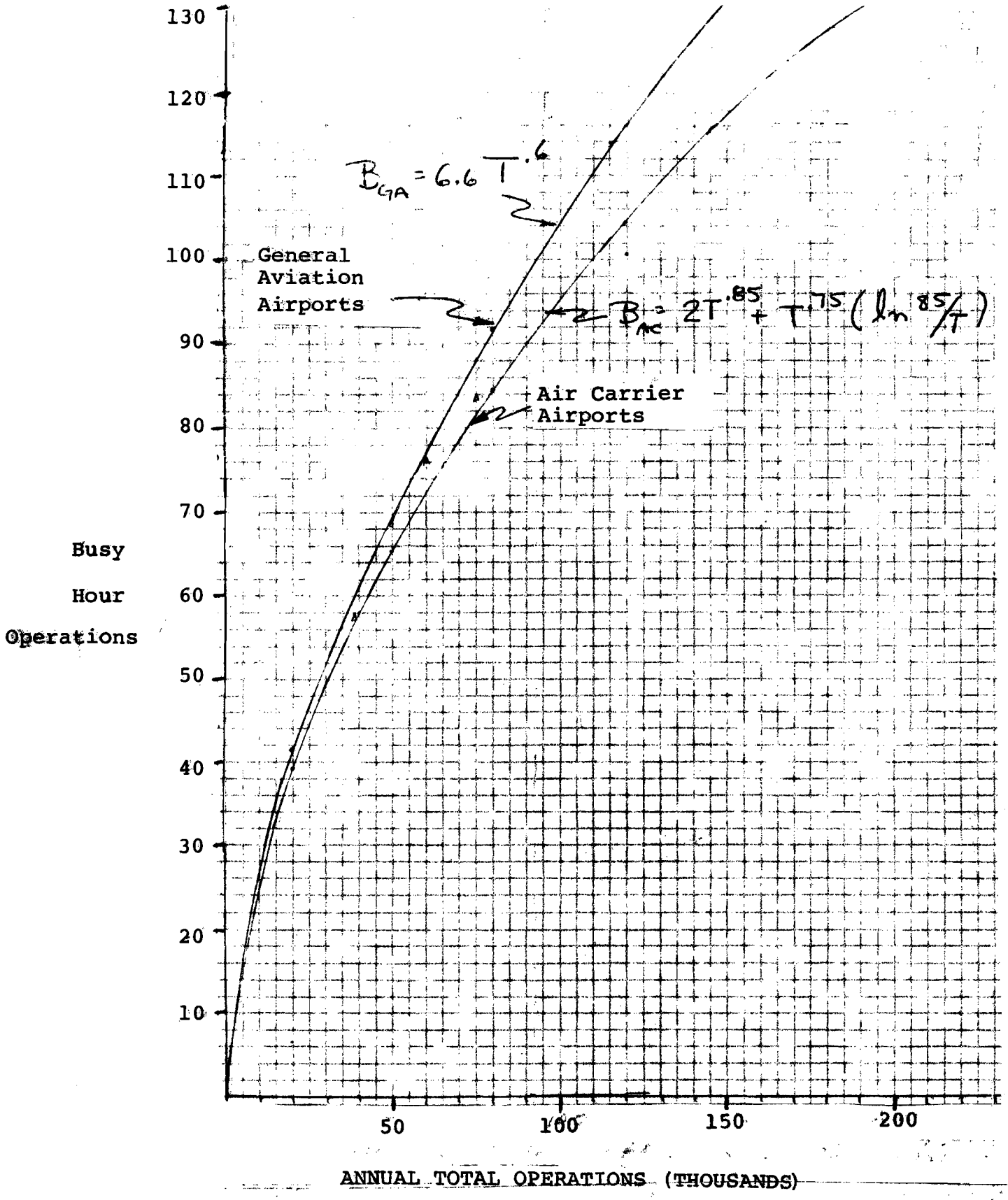
FIGURE 3.1-4 PEAK TRAFFIC ESTIMATORS



to be solely a function of an airport's total annual operations. However, this function differs when the airport is an air carrier or a general aviation airport.

As with peak day operations, a graphical procedure may be used to estimate busy hour operations instead of the procedure previously described in Section 1.4. The graphical procedure requires only the use of Figure 3.2-1. Using the curve applicable to the type of non-towered airport to be estimated (air carrier or general aviation) the busy hour operations can be read from the ordinate for the applicable number of annual total operations.

FIGURE 3.2-1 BUSY HOUR ESTIMATOR



APPENDIX

COMPUTER PROGRAM LISTING

S H I V A

```
LIST SHIVA1
5 PROGRAM STEPMR
15 DIMENSION R(50,50),XM(50),SD(50),IVEC(51),R11(50,50),R12(50),B(50)
25 DIMENSION RG(50,50),Y(50),SEBTSQ(50),SEBT(50),B1(50),TBETA(50)
35 DIMENSION SEB(50),X(50)
45 DIMENSION XXM(50),XSD(50),RP(50)
55 PRINT 65
65 FORMAT(*-TYPE 1 FOR RAW DATA  2 FOR MEAN,STD DEV,CORRELATION INPUT*)
75 INPUT,N
85 IF(N-2) 95,115,95
95 CALL CORREL(NVAR,NOBS,R,XM,SD,N,X,R11)
105 GO TO 535
115 PRINT 125
125 FORMAT(*-TYPE NUMBER OF VARIABLES, OBSERVATIONS*)
135 INPUT,NVAR,NOBS
145 PRINT 155
155 FORMAT(*-TYPE NUMBER OF VARIABLES, OBSERVATIONS*)
165 INPUT,ISTATE
175 IF(ISTATE.EQ.1HY) GO TO 365
185 IF(ISTATE.EQ.1HN) GO TO 205
195 GO TO 155
205 PRINT 215
215 FORMAT(*TYPE IN MEANS*)
225 INPUT,(XM(I),I=1,NVAR)
235 CALL REALIT(XM,NVAR)
245 PRINT 255
255 FORMAT(*TYPE IN STD DEVIATIONS*)
265 INPUT,(SD(I),I=1,NVAR)
275 CALL REALIT(SD,NVAR)
285 PRINT 295
295 FORMAT(*TYPE IN CORRELATION MATRIX*)
305 DO 335 I = 1,NVAR
315 PRINT 325,I
325 FORMAT(*ROW*,I3)
335 INPUT,(R(I,J),J=1,NVAR)
345 CALL REALIT(R,625)
355 GO TO 535
365 READ,(XM(I),I=1,NVAR)
375 CALL REALIT(XM,NVAR)
385 READ,(SD(I),I=1,NVAR)
395 CALL REALIT(SD,NVAR)
405 DO 415 I = 1,NVAR
415 READ,(R(I,J) ,J=1,NVAR)
425 CALL REALIT(R ,625)
435 GO TO 535
445 PRINT 455
455 FORMAT(*MATHEMATICAL ERROR CONDITION-- NO OUTPUT*)
465 PRINT 475
475 FORMAT(*-ANOTHER REGRESSION FROM THIS DATA  Y OR N*)
485 INPUT,IRG
495 IF(IRG.EQ.1HY)GO TO 535
505 IF(IRG.EQ.1HN)GO TO 525
515 GO TO 465
525 CALL EXIT
535 PRINT 545
545 FORMAT(//*-TYPE NUMBER OF VARIABLES FOR THIS REGRESSION*)
```

```
555 INPUT,NV
565 IF(NV.GT.NVAR)PRINT 575
575 FORMAT(/*NUMBER TOO LARGE--TRY AGAIN*)
585 IF(NV.GT.NVAR)GO TO 535
595 PRINT 605
605 FORMAT(*-TYPE INSORDER OF VARIABLES--DEPENDENT FIRST*)
615 INPUT,(IVEC(I),I=1,NV)
625 NVR = NV - 1
635 DO 705 I = 1,NVR
645 K = IVEC(I+1)
655 XXM(I) = XM(K)
665 XSD(I) = SD(K)
675 IF(XSD(I))685,445,685
685 DO 705 J = 1,NVR
695 L = IVEC(J+1)
705 R11(I,J)= R(K,L)
715 K = IVEC(1)
725 DO 755 I = 1,NVR
735 L = IVEC(I+1)
745 R12(I)= R(K,L)
755 B(I)=R12(I)
765 XXM(NV) = XM(K)
775 XSD(NV) = SD(K)
785 IF(XSD(NV)) 795,455,795
795 RQ(1,1) = 1.
805 DO 865 I=1,NVR
815 K = I+1
825 DO 845 J = 1,NVR
835 L = J+1
845 RQ(K,L) = R11(I,J)
855 RQ(1,K) = R12(I)
865 RQ(K,1) = R12(I)
875 GO TO 925
885 FORMAT(//*ACTUAL CORRELATION MATRIX*)
895 DO 905 I = 1,NV
905 PRINT 915,(RQ(I,J),J=1,NV)
915 FORMAT(8F9.3)
925 CALL MATINV(RQ,NV,0,0,DETERM,ERR)
935 PRINT 945,DETERM,ERR
945 FORMAT(/*DETERM =*,F10.5,* ERR =*,F5.1)
955 IF(ERR)445,965,445
965 GO TO 1005
975 FORMAT(//*INVERSE*/)
985 DO 995 I = 1,NV
995 PRINT 915, (RQ(I,J),J=1,NV)
1005 C = 1./RQ(1,1)
1015 RMULT = SQRTF(1.-C)
1025 DO 1065 I = 2,NV
1035 Y(I) = -C*RQ(1,I)
1045 J = I-1
1055 RP(J)=RQ(1,I)/SQRTF(RQ(I,I)*RQ(1,1))
1065 FP(J)=SIGNF(FP(J),Y(I))
1075 CALL MATINV(R11,NVR,B,1,DETERM,ERR)
1085 IF(ERR) 445,1095,445
1095 SESQ=C
1105 SEM = SQRTF(C)*XSD(NV)
```

```
1115 FNC=NOBS-4
1125 DO 1145 I=1,NVR
1135 SEBTSQ(I)=(R11(I,I)*SESQ)/FNC
1145 SEBT(I)=SQRTF(SEBTSQ(I))
1155 DO 1165 I = 1,NVR
1165 TBETA(I)=B(I)/SEBT(I)
1175 NDFT=NOBS-NVR-1
1185 DO 1195 I=1,NVR
1195 B1(I)=(B(I)*XSD(NV))/XSD(I)
1205 BINT = XXM(NV)
1215 DO 1235 I=1,NVR
1225 BINT = BINT-B1(I)*XXM(I)
1235 SEB(I)=(SEBT(I)*XSD(NV))/XSD(I)
1245 XNDF1=NVR
1255 XNDF2=NOBS-NVR-1
1265 F=(1.-C)*XNDF2/(C*XNDF1)
1275 PRINT 1285
1285 FORMAT(//,*MULTIPLE REGRESSION RESULTS*,/)
1295 PRINT 1305
1305 FORMAT(/*VAR      BETA     STD ERR        T      P COEF.          S.E.E.*
1315C *          PART R.*)
1325 DO 1345 I=1,NVR
1335 J = I+1
1345 PRINT 1355,IVEC(J),B(I),SEBT(I),TBETA(I),B1(I),SEB(I),RP(I)
1355 FORMAT(1X,I2,1X,F9.4,1X,F9.4,1X,F9.3,2G14.6,1X,F9.4)
1365 PRINT 1375 ,NDFT,BINT
1375 FORMAT(16X,*NDF =*I3,*     INT =*G14.6//)
1385 PRINT 1395, RMULT,SEM,SESC
1395 FORMAT(*MULTIPLE R=*,F6.4,*, STD.ERR.EST.=*,G13.5,*, UNEXPLAINED=*,
1405C F6.4,/)
1415 PRINT 1425,F,XNDF1,XNDF2
1425 FORMAT(6X,*F=*,F9.4,* , NDF=*,F5.1*,*,F6.1,//)
1435 INPUT,NFLG
1445 IF(NFLG) 465,465,1455
1455 REWIND 60
1465 JJ=IVEC(1)
1475 DO 1555 KX=1,NOBS
1485 READ,(X(I),I=1,NVAR)
1495 GO TO 1575
1505 DO 1525 I=1,NVR
1515 J=IVEC(I+1)
1525 PXNT=PXNT+B1(I)*X(J)
1535 AXY=PXNT-X(JJ)
1545 APC=AXY*100./X(JJ)
1555 PRINT 1595,N12,X(JJ),PXNT,AXY,APC
1565 GO TO 465
1575 PXNT=BINT
1585 CALL REALIT(X,NVAR)
1595 FORMAT(I6,4F10.3)
```

```
1605 CALL REGF(X)
1615 CALL GETSEG(N12)
1625 N12=N12-6
1635 GO TO 1505
1645 END
1655 SUBROUTINE REGF(X)
1665 DIMENSION X(50)
1675 Z=X(4)/X(12)
1685 IF (X(20).EQ.0.) X(20)=.75
1695 IF (Z.GT.1.) Z=1.
1705 IF (X(40).LE.2.1) X(35)=1.
1715 X(42)=0.
1725 IF (X(40).LE.15.1.AND.X(41).LE.8.1) X(42)=1.
1735 X(11)=X(11)*Z
1745 R=0
1755 IF (X(20).GT..8) R=7.
1765 IF (X(20).GT.1.5) R=12.
1775 IF (X(20).GT.2.5) R=15.
1785 IF (X(20).GT.3.5) R=20.
1795 T1=AMIN1*1.,X(1)-X(13))*2.
1805 T2=AMIN1(1.,X(13))*3.
1815 T3=AMIN1(1.,X(2))*2.
1825 S=X(21)*5.+X(22)*10.+X(23)*3.+X(24)*15.+X(25)*10.+X(27)*10.
1835C +X(28)*5.+X(29)*10.+X(30)*5.
1845 X(16)=R+T1+T2+T3+S
1855 DO 1895 I=1,3
1865 FLT=I*15
1875 X(I+43)=0
1885 IF(X(40).GT.FLT.AND.X(40).LE.FLT+15.) X(I+43)=1.
1895 CONTINUE
1905 X(47)=0
1915 IF(X(40).GT.60.) X(47)=1.
1925 X(38)=AMIN1(1.,X(2))
1935 X(18)=ALOG((X(25)+X(27)*8.+X(21)*3.+11.)/(X(28)+X(38)*3.+
1945C X(29)*6.+X(30)*2.+11.))
1955 X(33)=X(5)+X(7)
1965 X(48)=0
1975 IF(X(40).LE.15..AND.X(41).GT.8.) X(48)=1.
1985 X(31)=0
1995 IF(X(41).GT.48.) X(31)=1.
2005 X(6)=0
2015 IF(X(40).GT.15..AND.X(41).LE.8.) X(6)=1.
2025 DO 2065 I=1,5
2035 FLT=I*8
2045 X(I+25)=0
2055 IF(X(41).GT.FLT.AND.X(41).LE.FLT+8.) X(I+25)=1.
2065 CONTINUE
2075 X(39)=X(8)/500.+X(38)+X(39)+X(41)
2085 GO TO 2095
2095 RETURN
2105 END
2115 SUBROUTINE REALIT(AA,NN)
2125 DIMENSION AA(1)
2135 DO 2155 I = 1,NN
2145 AA(I) = ABEAL(AA(I))
2155 CONTINUE
2165 END
```

```
2175↑5 SUBROUTINE CORREL(NV,NG,R,XM,SD,N,X,SS)
2185↑10 DIMENSION X(50),SX(50),SS(50,50),R(50,50),XM(50),SD(50)
2195↑15 PRINT 20
2205↑20 FORMAT(*-TYPE NUMBER OF VARIABLES,OBSERVATIONS*)
2215↑25 INPUT,NV,NG
2225↑30 DO 60 I=1,50
2235↑35 SX(I)=0
2245↑40 XM(I)=0
2255↑45 SD(I)=0
2265↑50 DO 60 J=1,50
2275↑55 R(I,J) = 0
2285↑60 SS(I,J)=0
2295↑65 PRINT 70
2305↑70 FORMAT(*-DATA ALREADY IN A DATA FILE  Y OR N*)
2315↑75 INPUT,ISTATE
2325↑80 FNG = NG
2335↑85 DO 140 K = 1,NG
2345↑90 IF(ISTATE.EQ.1HN) GO TO 95
2355↑91 IF(ISTATE.EQ.1HY) GO TO 115
2365↑92 GO TO 65
2375↑95 PRINT 100,K
2385↑100 FORMAT(*TYPE VARIABLES FOR CASE*,I4)
2395↑105 INPUT,(X(I),I=1,NV)
2405↑110 GO TO 120
2415↑115 READ,(X(I),I=1,NV)
2425↑120 CALL REALIT(X,NV)
2435↑121 CALL REGF(X)
2445↑122 DO 135 I = 1 , NV
2455↑125 SX(I)=SX(I)+X(I)
2465↑130 DO 135 J=1,NV
2475↑135 SS(I,J)=SS(I,J)+X(I)*X(J)
2485↑140 CONTINUE
2495↑145 DO 155 I=1,NV
2505↑150 DO 155 J=1,NV
2515↑155 SS(I,J)=SS(I,J)-SX(I)*SX(J)/FNG
2525↑160 DO 170 I=1,NV
2535↑165 XM(I)=SX(I)/FNG
2545↑170 SD(I) = SQRTF(SS(I,I)/FNG)
2555↑175 DO 215 I=1,NV
2565↑180 IF(SS(I,I))200,185,200
2575↑185 PRINT 190,I
2585↑190 FORMAT(*NO VARIANCE, ROW*,I3,* OMITTED*)
2595↑195 GO TO 215
2605↑200 DO 215 J=1,NV
2615↑205 IF(SS(J,J))210,215,210
2625↑210 R(I,J)=SS(I,J)/SQRTF(SS(I,I)*SS(J,J))
2635↑215 CONTINUE
2645↑216 IF(N) 285,218,218
2655↑218 NVXX = NV
2665↑219 IF(NVXX.GT.5)NVXX=5
2675↑220 PRINT 225,(II,II=1,NVXX)
2685↑225 FORMAT(///1X,5(I10,4X))
2695↑230 PRINT 235,(XM(I),I=1,NV)
2705↑235 FORMAT(*MEANS*/4(2X,5G14.6/))
2715↑240 PRINT 245,(SD(I),I=1,NV)
2725↑245 FORMAT(//*STD DEV*/4(2X,5G14.6/))
2735↑250 PRINT 255
```

```
2745↑255 FORMAT(/*COEF MATRIX*)
2755↑260 DO 265 I=1,NV
2765↑265 PRINT 270,I,(R(I,J),J=1,NV)
2775↑270 FORMAT(1X,I2/,5(2X,10F7.2/))
2785↑275 PRINT 280
2795↑280 FORMAT(/)
2805↑285 RETURN
2815↑290 END
2825↑510 SUBROUTINE MATINV(C,N,B,M,DETERM,ERR)
2835↑520 DIMENSION C(50,50),B(50),TC(50),D(50)
2845↑530 DETERM=1.
2855↑540 ERR=0
2865↑550 L=N-1
2875↑560 DO 15 K=1,N
2885↑570 X=C(1,1)
2895↑580 DETERM=DETERM*X
2905↑590 IF(X)7,495,7
2915↑7 DO 8 I=2,N
2925↑8 TC(I-1)=C(1,I)
2935↑620 X=1./X
2945↑630 DO 14 I=1,L
2955↑640 Y=-TC(I)*X
2965↑650 C(I,N)=Y
2975↑660 DO 14 J=I,L
2985↑14 C(I,J)=C(I+1,J+1)+Y*TC(J)
2995↑15 C(N,N)=-X
3005↑690 DO 19 I=1,N
3015↑700 DO 19 J=I,N
3025↑710 C(I,J)=-C(I,J)
3035↑19 C(J,I)=C(I,J)
3045↑730 IF(M) 105,500,105
3055↑105 DO 115 I=1,N
3065↑750 D(I)=B(I)
3075↑115 B(I)=0
3085↑770 DO 130 I=1,N
3095↑780 DO 130 J=1,N
3105↑130 B(I)=B(I)+C(I,J)*D(J)
3115↑800 GO TO 500
3125↑495 ERR=1.
3135↑496 PRINT,K
3145↑500 RETURN
3155↑830 END
3165↑FUNCTION AREAL(X)
3175↑EQUIVALENCE (XX,N)
3185↑ISIGN=1 $ XX=X $ AREAL=X
3195* CHECK FOR NEGATIVE BIT
3205↑IF(IBYTE(1,X,47,0) .EQ. 1B) GO TO 200
3215↑50 IEX=IBYTE(12,XX,36,0)
3225* CHECK IF ALREADY A REAL
3235↑IF(IEX .GT. 1531B) RETURN
3245↑AREAL=N*ISIGN
3255↑RETURN
3265↑200 XX=-XX $ ISIGN=-1
3275↑GO TO 50
3285↑END
3295↑10000 ENDPROG
```

DERIVATION OF ESTIMATING RELATIONSHIP

TOTAL OPERATIONS

WITH

ESTIMATES OF AIRPORT OPERATIONS

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?16
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?16,3,4,5,6,7,8,9,10
?11,12,13,14,15,19,20

DETERM = .00002 ERR = 0

FIRST REGRESSION

MULTIPLE REGRESSION RESULTS

DEP 16 IND 3 4 5 6 7 8 9 10 11 12 13 14 15 19 20

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1819	.0626	2.903	.301995E-01	.104020E-01	.2562
4	.2338	.0970	2.410	4.26642	1.77033	.2149
5	.2963	.1023	2.895	1.41103	.487354	.2555
6	.0045	.0662	.068	.153214	2.25807	.0062
7	-.1237	.0809	-1.529	-.491863E-01	.321793E-01	-.1382
8	.0503	.0688	.731	13.4058	18.3339	.0666
9	.0180	.0920	.195	.632590	3.24042	.0178
10	-.3086	.2206	-1.399	-3.26416	2.33346	-.1267
11	.1264	.0949	1.331	.339424	.254930	.1207
12	.1259	.0916	1.374	.273917	.199306	.1245
13	.3143	.2639	1.191	2.27701	1.91165	.1081
14	.3012	.0842	3.576	1.00362	.280658	.3103
15	-.0983	.1133	-.867	-.242467	.279507	-.0789
19	.0790	.0786	1.005	17.9256	17.8379	.0914
20	.0156	.0710	.219	.110858	.505911	.0200
		NDF =108	INT =	-117.928		

MULTIPLE R= .8008, STD.ERR.EST.= 181.91 , UNEXPLAINED= .3587

F= 12.8733 , NDF= 15.0, 108.0

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?13
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?16,3,4,5,7,8,10,11
?12,13,14,15,19

DETERM = .00012 ERR = 0

MULTIPLE REGRESSION RESULTS

DEP 16 IND 3 4 5 7 8 10 11 12 13 14 15 19

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1810	.0625	2.895	.300478E-01	.103775E-01	.2555
4	.2365	.0947	2.496	4.31653	1.72922	.2222
5	.2902	.0967	3.002	1.38201	.460295	.2643
7	-.1183	.0751	-1.575	-.470546E-01	.298692E-01	-.1423
8	.0574	.0625	.919	15.3172	16.6588	.0836
10	-.3247	.1975	-1.644	-3.43465	2.08959	-.1484
11	.1232	.0940	1.311	.330977	.252396	.1189
12	.1227	.0896	1.369	.266955	.194929	.1241
13	.3418	.2173	1.573	2.47587	1.57374	.1422
14	.3052	.0825	3.700	1.01694	.274876	.3200
15	-.0939	.1119	-.839	-.231561	.276068	-.0763
19	.0717	.0705	1.018	16.2899	15.9952	.0926
		NDF =111	INT =	-108.017		

MULTIPLE R= .8007, STD.ERR.EST.= 181.97 , UNEXPLAINED= .3589

ANOTHER REGRESSION FROM THIS DATA Y OR N?Y

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?10
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?16,3,4,5,7,10,11
?12,13,14

DETERM = .00104 ERR = 0

MULTIPLE REGRESSION RESULTS

DEP 16 IND 3 4 5 7 10 11 12 13 14

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1848	.0627	2.946	.306845E-01	.104148E-01	.2597
4	.2888	.0836	3.454	5.27099	1.52605	.3007
5	.2948	.0969	3.043	1.40390	.461363	.2676
7	-.1379	.0737	-1.871	-.548590E-01	.293197E-01	-.1684
10	-.3950	.1929	-2.048	-4.17880	2.04035	-.1838
11	.0810	.0732	1.108	.217615	.196463	.1006
12	.0758	.0734	1.032	.164896	.159729	.0938
13	.4159	.2119	1.963	3.01278	1.53463	.1764
14	.3249	.0792	4.105	1.08245	.263720	.3509
		NDF =114	INT =	-83.7248		

MULTIPLE R= .7968, STD.ERR.EST.= 183.55 , UNEXPLAINED= .3651

F= 22.0225 , NDF= 9.0, 114.0

ANOTHER REGRESSION FROM THIS DATA Y OR N?Y

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?8
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?16,3,4,5,7,10,13,14

DETERM = .00280 ERR = 0

MULTIPLE REGRESSION RESULTS

DEP 16 IND 3 4 5 7 10 13 14

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1996	.0623	3.202	.331485E-01	.103514E-01	.2806
4	.3388	.0803	4.220	6.18270	1.46500	.3595
5	.2803	.0978	2.867	1.33499	.465617	.2532
7	-.1149	.0718	-1.599	-.456837E-01	.285746E-01	-.1444
10	-.3908	.1959	-1.995	-4.13401	2.07251	-.1791
13	.4541	.2143	2.119	3.28939	1.55211	.1899
14	.3213	.0795	4.040	1.07063	.265010	.3460
		NDF =116	INT =	-115.334		

MULTIPLE R= .7894, STD.ERR.EST.= 186.45 , UNEXPLAINED= .3768

F= 27.4074 , NDF= 7.0, 116.0

ANOTHER REGRESSION FROM THIS DATA Y OR N?Y

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?7
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?16,3,4,5,10,13,14

DETERM = .00470 ERR = 0

FINAL REGRESSION

MULTIPLE REGRESSION RESULTS

DEP 16 IND 3 4 5 10 13 14

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.2032	.0630	3.227	.337398E-01	.104543E-01	.2826
4	.2696	.0683	3.945	4.92112	1.24740	.3388
5	.3091	.0971	3.183	1.47202	.462509	.2790
10	-.3689	.1975	-1.868	-3.90260	2.08935	-.1681
13	.4221	.2156	1.958	3.05778	1.56171	.1759
14	.3152	.0803	3.926	1.05009	.267503	.3373
		NDF =117	INT =	-77.3599		

MULTIPLE R= .7843, STD.ERR.EST.= 188.43 , UNEXPLAINED= .3848

F= 31.1716 , NDF= 6.0, 117.0

AIRPORT ?1	ACTUAL OPS	ESTIMATED OPS	ABSOLUTE Δ	% Δ
20	804.000	739.102	-64.898	-8.072
30	361.000	545.963	184.963	51.236
40	479.000	488.096	9.096	1.899
50	717.000	546.284	-170.716	-23.810
60	644.000	486.749	-157.251	-24.418
70	485.000	460.915	-24.085	-4.966
90	474.000	506.792	32.792	6.918
100	311.000	623.554	312.554	100.500
110	359.000	519.354	160.354	44.667
120	873.000	613.369	-259.631	-29.740
130	890.000	837.390	-52.610	-5.911
140	585.000	379.225	-205.775	-35.175
150	564.000	768.955	204.955	36.340
160	878.000	780.591	-97.409	-11.094
170	437.000	423.359	-13.641	-3.122
180	463.000	379.126	-83.874	-18.115
190	657.000	449.232	-207.768	-31.624
200	520.000	377.699	-142.301	-27.366
210	972.000	748.031	-223.969	-23.042
220	644.000	520.585	-123.415	-19.164
230	713.000	398.577	-314.423	-44.099
240	548.000	570.578	22.578	4.120
260	247.000	284.802	37.802	15.304
270	552.000	613.822	61.822	11.200
280	855.000	693.796	-161.204	-18.854
290	1028.000	864.426	-163.574	-15.912
300	854.000	778.715	-75.285	-8.816

310	510.000	598.278	88.278	17.309
320	355.000	467.938	112.938	31.814
330	299.000	293.847	-5.153	-1.723
340	482.000	539.074	57.074	11.841
350	402.000	360.024	-41.976	-10.442
380	278.000	316.000	38.000	13.669
410	343.000	444.417	101.417	29.568
430	231.000	322.837	91.837	39.756
440	345.000	443.095	98.095	28.433
450	435.000	775.887	340.887	78.365
460	730.000	665.289	-64.711	-8.864
490	500.000	383.886	-116.114	-23.223
500	395.000	383.707	-11.293	-2.859
510	525.000	367.048	-157.952	-30.086
520	250.000	272.907	22.907	9.163
530	405.000	417.897	12.897	3.184
540	468.000	496.523	28.523	6.095
550	1165.000	374.935	-790.065	-67.817
560	286.000	439.732	153.732	53.752
570	1078.000	982.002	-95.998	-8.905
590	360.000	376.748	16.748	4.652
600	692.000	645.324	-46.676	-6.745
1010	587.000	653.417	66.417	11.315
1020	841.000	776.562	-64.438	-7.662
1030	1053.000	1126.998	73.998	7.027
1050	678.000	750.895	72.895	10.751
1090	1241.000	458.355	-782.645	-63.066
1100	843.000	810.980	-32.020	-3.798
1120	464.000	668.107	204.107	43.989
1130	616.000	623.475	7.475	1.213
1140	873.000	638.851	-234.149	-26.821
1150	592.000	607.720	15.720	2.655
1160	721.000	643.076	-77.924	-10.808
1180	419.000	580.756	161.756	38.605
1190	796.000	716.847	-79.153	-9.944
1220	487.000	582.515	95.515	19.613
1240	477.000	653.913	176.913	37.089
1250	791.000	548.280	-242.720	-30.685
1260	371.000	627.975	256.975	69.266
1270	662.000	638.502	-23.498	-3.549
1280	430.000	446.693	16.693	3.882
1290	430.000	524.122	94.122	21.889
1300	491.000	385.466	-105.534	-21.494
1320	655.000	652.315	-2.685	-.410
1400	185.000	390.553	205.553	111.110
1410	1464.000	1450.235	-13.765	-.940
1420	565.000	748.762	183.762	32.524
1430	1340.000	619.066	-720.934	-53.801
1440	624.000	487.408	-136.592	-21.890
1450	635.000	505.906	-129.094	-20.330
1460	288.000	469.155	181.155	62.901
1470	260.000	463.143	203.143	78.132
1480	578.000	630.432	52.432	9.071
1500	873.000	602.638	-270.362	-30.969
1510	647.000	765.134	118.134	18.259
1530	455.000	384.973	-70.027	-15.391
1540	354.000	220.722	-133.278	-37.649
1550	919.000	1142.736	223.736	24.346

1560	498.000	471.846	-26.154	-5.252
1600	343.000	354.149	11.149	3.251
1610	392.000	415.704	23.704	6.047
1620	420.000	523.411	103.411	24.622
1630	275.000	345.769	70.769	25.734
1640	283.000	384.740	101.740	35.950
1660	493.000	568.923	75.923	15.400
1670	586.000	889.827	303.827	51.848
1680	904.000	1012.788	108.788	12.034
1690	411.000	327.059	-83.941	-20.424
1700	410.000	360.941	-49.059	-11.966
1710	480.000	538.189	58.189	12.123
1790	1150.000	562.095	-587.905	-51.122
1800	195.000	530.246	335.246	171.921
1830	417.000	700.800	283.800	68.057
1840	425.000	520.434	95.434	22.455
1850	226.000	285.383	59.383	26.276
1860	530.000	681.279	151.279	28.543
1870	855.000	557.510	-297.490	-34.794
1890	220.000	243.493	23.493	10.679
2000	101.000	139.354	38.354	37.974
2020	82.000	94.614	12.614	15.383
2030	46.000	108.166	62.166	135.144
2040	34.000	169.031	135.031	397.150
2050	16.000	122.498	106.498	665.615
2060	28.000	148.388	120.388	429.956
2070	55.000	332.344	277.344	504.262
2080	136.000	176.553	40.553	29.818
2090	34.000	185.125	151.125	444.484
3000	36.000	137.177	101.177	281.047
3010	181.000	202.468	21.468	11.861
3020	36.000	61.786	25.786	71.627
3030	151.000	212.549	61.549	40.761
3040	36.000	122.308	86.308	239.744
3060	49.000	82.437	33.437	68.239
3070	26.000	94.342	68.342	262.853
3080	85.000	125.816	40.816	48.019
3090	32.000	148.251	116.251	363.285
4000	105.000	234.043	129.043	122.898

CORRELATION MATRIX

VARIABLE KEY FOR CORRELATION MATRIX

Variable Number	Parameter
1.	Total AVGAS Storage (<100 + >100 Octane)
2.	Jet Fuel
3.	Based Aircraft: Multi-engine
4.	Based Aircraft: Total
5.	Total Annual Itinerant OPS: Actual
6.	Air Carrier + Air Taxi
7.	Total Annual Local OPS: Actual
8.	Student Pilots
9.	Total Pilots
10.	FBO Index
11.	Population
12.	Population per Square Mile
13.	% of families w/income $> 10^k$
14.	Median Income
15.	Employed Persons
16.	% of White Collar Workers
17.	Bank Deposits
18.	Manufacturers w/ >100 Employees.
19.	Retail Establishments
20.	No. of Selective Service Establishments
21.	AVGAS Storage 100 Octane
22.	Based Aircraft: Single Engine - ≥ 4 Place
23.	Airport Acreage
24.	Private Pilots
25.	No. of Families

Variable Number	Parameter
26.	Selective Services
27.	Hours of Attendance
28.	Number of FBO's
29.	Services: Instructional
30.	Services: Sales
31.	Services: Rental/Charter
32.	Services: Agricultural
33.	Services: Other
34.	Landing Fees
35.	Repairs: Airframe Major
36.	Repairs: Airframe Minor
37.	Repairs: Engine Major
38.	Repairs: Engine Minor
39.	Temperature
40.	Number GA Aircraft per 100,000 population in State
41.	Number GA Aircraft Resistence in Multi-County
42.	Corrected Runway Length
43.	Number of Runways
44.	Number of T-Type Hangars
45.	Number of Conventional Hangars
46.	Annual Military OPS)
47.	Annual Air Taxi OPS) 5010 OPS
48.	Annual Local OPS)
49.	Annual Itinerant OPS)

	1	2	3	4	5
MEANS					
	262.159	145.522	9.90446	54.8726	264.000
	37.2994	251.452	69.9936	63.8344	66.9745
	66.2675	130.299	108.803	48.7006	23.5796
	379.879	74.1783	10.1210	451.599	187.127
	142.904	31.5223	911.535	117.924	16.4713
	12.1401	18.1720	1.75796	.929936	.662420
	.917197	.280255	.464968	.700637F-01	.853503
	.929936	.847134	.929936	88.5924	83.0637
	54.3248	49.4968	2.12739	15.2229	3.38854
	6.63057	2.28662	27.7898	23.7452	.980892
STD DEV					
	229.862	145.243	8.21664	40.0280	138.965
	38.8732	199.812	57.8990	60.0558	20.1965
	56.7817	266.615	51.1789	11.7052	19.8549
	69.8523	79.3018	10.8888	317.058	157.655
	139.844	27.3453	921.547	94.9125	13.3929
	15.0390	6.00443	1.21771	.255254	.472884
	.275584	.449124	.498771	.255254	.353604
	.255254	.359859	.255254	6.02009	39.9179
	41.1833	15.0881	.955881	19.0523	2.84560
	19.7955	3.74855	22.4448	13.6321	.136906

CORRELATION MATRIX

1										
	1.00	.55	.31	.27	.48	.25	.18	.22	.32	.39
	.22	.04	.22	.19	.23	.32	.22	.16	.27	.28
	.91	.23	.28	.31	.24	.15	.29	.30	.03	.08
	.18	.12	.16	.04	.25	.21	.24	.21	.02	.11
	.29	.18	.36	.02	.30	.18	.13	.18	.41	.07
2										
	.55	1.00	.26	.15	.47	.36	.10	.10	.11	.41
	.17	-.04	.06	.13	.19	.19	.10	.21	.18	.14
	.51	.10	.27	.19	.17	.10	.29	.15	.20	.11
	.23	.09	.21	.04	.23	.13	.22	.13	-.12	-.01
	.17	.35	.29	.11	.30	.09	.10	.12	.36	.06
3										
	.31	.26	1.00	.64	.53	.07	.28	.40	.41	.41
	.35	.12	.25	.18	.35	.23	.26	.30	.42	.42
	.28	.49	.10	.45	.38	.28	.15	.42	.17	.23
	.25	.08	.10	.09	.37	.21	.36	.21	-.12	-.11
	.51	.17	.31	.39	.37	.04	.12	.36	.62	.06
4										
	.27	.15	.64	1.00	.43	-.03	.39	.61	.61	.37
	.45	.20	.52	.35	.44	.43	.40	.19	.43	.49
	.22	.95	-.05	.70	.46	.47	.10	.37	.16	.25
	.21	.20	.09	.01	.33	.20	.33	.20	.00	-.01
	.72	-.04	.13	.53	.35	-.01	.08	.42	.54	.10

5										
	.48	.47	.53	.43	1.00	.53	.51	.47	.43	.49
	.32	.06	.22	.14	.32	.40	.27	.25	.39	.37
	.46	.35	.24	.46	.34	.26	.35	.32	.10	.25
	.26	.11	.08	.06	.35	.24	.35	.24	-.01	-.08
	.45	.32	.34	.21	.26	.18	.15	.47	.76	.13
6										
	.25	.36	.07	-.03	.53	1.00	.05	.14	.01	.24
	.07	-.19	.01	.05	.12	.19	.07	.12	.13	.06
	.32	-.06	.21	.11	.09	-.04	.30	.05	-.06	.06
	.08	-.00	.18	-.02	.21	.15	.21	.15	-.06	.01
	.09	.26	.12	.01	.09	.04	.16	.03	.19	.06
7										
	.18	.10	.28	.39	.51	.05	1.00	.50	.46	.28
	.27	.14	.22	.21	.24	.34	.23	.14	.30	.29
	.15	.33	.18	.42	.26	.24	.16	.29	.10	.15
	.16	.09	.00	.08	.23	.10	.18	.10	.06	-.05
	.39	.16	.12	.14	.12	.29	.06	.70	.53	.12
8										
	.22	.10	.40	.61	.47	.14	.50	1.00	.84	.22
	.75	.39	.48	.37	.71	.52	.66	.46	.73	.75
	.24	.60	-.03	.91	.75	.71	.15	.21	.03	.14
	.13	-.11	.04	.06	.28	.17	.27	.17	-.00	-.15
	.80	.04	.09	.28	.23	.11	.01	.41	.52	.10
9										
	.32	.11	.41	.61	.43	.01	.46	.84	1.00	.28
	.67	.35	.40	.29	.64	.48	.64	.35	.67	.72
	.34	.59	.05	.82	.69	.61	.18	.32	.05	.17
	.15	-.01	.06	.08	.24	.15	.22	.15	.08	-.09
	.79	.05	.15	.27	.33	.26	-.08	.44	.54	.10
10										
	.39	.41	.41	.37	.49	.24	.28	.22	.28	1.00
	.13	-.00	.09	.09	.14	.31	.09	.07	.20	.19
	.32	.32	.11	.23	.15	.07	.44	.68	.64	.51
	.67	.33	.32	-.04	.58	.55	.56	.55	.09	.51
	.27	.21	.43	.24	.37	.09	.14	.29	.47	.11
11										
	.22	.17	.35	.45	.32	.07	.27	.75	.67	.13
	1.00	.58	.36	.29	.91	.30	.77	.79	.93	.85
	.25	.45	-.05	.76	.97	.87	.13	.07	.05	.14
	.13	-.12	.00	.06	.23	.17	.22	.17	-.05	-.37
	.65	.01	.14	.19	.24	.10	-.09	.29	.41	.09
12	.04	-.04	.12	.20	-.06	-.19	.14	.39	-.35	-.00
	.58	1.00	.34	.27	.55	.19	.61	.43	.56	.53
	.06	.24	-.06	.40	.58	.66	-.04	-.01	.05	.16
	.09	-.15	-.03	.11	.08	.05	.08	.05	-.09	-.24
	.31	-.07	-.08	.08	.07	.03	.07	-.23	.16	.05

13										
	.22	.06	.25	.52	.22	.01	.22	.48	.40	.09
	.36	.34	1.00	.85	.37	.73	.37	.13	.30	.35
	.17	.56	.13	.58	.35	.51	.10	.06	.02	.14
	.14	-.09	.08	.20	.15	.10	.16	.10	-.26	.03
	.45	.02	.03	.33	.19	-.02	.11	.24	.28	-.05
14										
	.19	.13	.18	.35	.14	.05	.21	.37	.29	.09
	.29	.27	.85	1.00	.30	.64	.33	.19	.28	.30
	.13	.35	.21	.47	.29	.40	.16	.01	.05	.18
	.15	-.14	.06	.25	.17	.09	.16	.09	-.41	.04
	.35	.11	.16	.28	.16	-.02	.12	.25	.25	.03
15										
	.23	.19	.35	.44	.32	.12	.24	.71	.64	.14
	.91	.55	.37	.30	1.00	.27	.76	.77	.89	.83
	.26	.43	-.07	.74	.94	.78	.14	.02	.07	.16
	.14	-.14	.02	.05	.24	.18	.23	.18	-.12	-.38
	.67	.00	.11	.24	.20	.06	-.10	.27	.41	.09
16										
	.32	.19	.23	.43	.40	.19	.34	.52	.48	.31
	.30	.19	.73	.64	.27	1.00	.37	.01	.29	.37
	.30	.45	.24	.57	.28	.43	.20	.20	.11	.19
	.28	-.02	.12	.14	.32	.28	.34	.28	-.10	.14
	.44	.16	.14	.28	.26	.12	.17	.25	.40	.07
17	.22	.10	.26	.40	.27	.07	.23	.66	.64	.09
	.77	.61	.37	.33	.76	.37	1.00	.59	.82	.85
	.25	.40	-.02	.73	.81	.78	.16	.06	.03	.13
	.11	-.13	.04	.06	.21	.13	.21	.13	-.09	-.21
	.68	.00	.12	.20	.20	.10	-.05	.23	.41	.09
18										
	.16	.21	.30	.19	.25	.12	.14	.46	.35	.07
	.79	.43	.13	.19	.77	.01	.59	1.00	.79	.66
	.18	.16	-.11	.47	.80	.60	.08	-.04	.05	.09
	.10	-.15	-.05	.03	.13	.15	.12	.15	-.12	-.47
	.43	-.05	.13	.11	.17	-.02	-.07	.18	.33	.04
19										
	.27	.18	.42	.43	.39	.13	.30	.73	.67	.20
	.93	.56	.30	.28	.89	.29	.82	.79	1.00	.92
	.30	.41	.01	.75	.96	.79	.20	.11	.08	.17
	.17	-.09	.03	.11	.27	.20	.26	.20	-.07	-.37
	.70	.07	.24	.23	.25	.12	-.05	.36	.49	.10
20										
	.28	.14	.42	.49	.37	.06	.29	.75	.72	.19
	.85	.53	.35	.30	.83	.37	.85	.66	.92	1.00
	.31	.49	.03	.82	.89	.82	.18	.14	.07	.10
	.17	-.10	.06	.08	.24	.17	.23	.17	-.04	-.24

.91	.51	.28	.22	.46	.32	.15	.24	.34	.32
.25	.06	.17	.13	.26	.30	.25	.18	.30	.31
1.00	.19	.26	.30	.26	.17	.29	.25	-.06	.02
.15	.04	.16	.02	.24	.19	.23	.19	.02	.06
.29	.-1	.29	.03	.24	.17	.06	.15	.37	.06
.23	.10	.49	.95	.35	-.06	.33	.60	.59	.32
.45	.24	.56	.35	.43	.45	.40	.16	.41	.49
.19	1.00	-.11	.69	.45	.51	.07	.31	.17	.25
.21	.14	.09	-.00	.29	.18	.29	.18	.02	.01
.68	-.09	.05	.55	.29	-.02	.05	.36	.44	.08
.28	.27	.10	-.05	.24	.21	.18	-.03	.05	.11
-.05	-.06	.13	.21	-.07	.24	-.02	-.11	.01	.03
.26	-.11	1.00	.03	-.06	-.00	.35	.06	-.03	-.08
.06	.06	.04	.14	-.01	-.08	-.01	-.08	-.06	.23
.04	.62	.53	-.06	.22	.25	.05	.22	.13	.13
.31	.19	.45	.70	.46	.11	.42	.91	.82	.23
.76	.40	.58	.47	.74	.57	.73	.47	.75	.82
.30	.69	.03	1.00	.77	.75	.16	.19	.06	.14
.16	-.04	.12	.05	.29	.17	.29	.17	-.04	-.07
.92	.05	.13	.43	.31	.06	-.02	.40	.54	.10
.24	.17	.38	.46	.34	.09	.26	.75	.69	.15
.97	.58	.35	.29	.94	.28	.81	.80	.96	.89
.26	.45	-.06	.77	1.00	.83	.14	.06	.07	.15
.14	-.12	.03	.06	.23	.18	.23	.18	-.04	-.37
.70	.00	.14	.24	.23	.09	.08	-.30	.43	.09
.15	.10	.28	.47	.26	-.04	.24	.71	.61	.07
.87	.66	.51	.40	.78	.43	.78	.60	.79	.82
.17	.51	-.00	.75	.83	1.00	.07	.04	.06	.10
.12	-.14	-.01	.06	.16	.10	.17	.10	-.09	-.25
.63	-.00	.11	.20	.24	.12	-.06	.25	.36	.09
.29	.29	.15	.10	.35	.30	.16	.15	.18	.44
.13	-.04	.10	.16	.14	.20	.16	.08	.20	.18
.29	.07	.35	.16	.14	.07	1.00	.13	.26	.13
.25	.20	.14	.15	.21	.12	.22	.12	-.10	.03
.18	.34	.33	.01	.18	.04	.09	.21	.27	.14
.30	.15	.42	.37	.32	.05	.29	.21	.32	.68
.07	-.01	.06	.01	.02	.20	.06	-.04	.11	.14
.25	.31	.06	.19	.06	.04	.13	1.00	.27	.22
.30	.36	.13	-.01	.29	.25	.28	.25	.14	.20
.23	.17	.32	.11	.34	.19	.10	.21	.34	.05

29										
	.03	.20	.17	.16	.10	-.06	.10	.03	.05	.64
	.05	.05	.02	.05	.07	.11	.03	.05	.08	.07
	-.06	.17	-.03	.06	.07	.06	.26	.27	1.00	.33
	.73	.12	.16	.08	.31	.41	.30	.41	-.06	-.01
	.06	.09	.19	.17	.14	.03	.05	.13	.18	-.04
30	.08	.11	.23	.25	.25	.06	.15	.14	.17	.51
	.14	.16	.14	.18	.16	.19	.13	.09	.17	.10
	.02	.25	-.08	.14	.15	.10	.13	.22	.33	1.00
	.42	.06	.10	-.07	.43	.33	.41	.33	-.08	-.08
	.15	.02	.22	.23	.12	.02	.04	.24	.32	.10
31										
	.18	.23	.25	.21	.26	.08	.16	.13	.15	.67
	.13	.09	.14	.15	.14	.28	.11	.10	.17	.17
	.15	.21	.06	.16	.14	.12	.25	.30	.73	.42
	1.00	.03	.19	.08	.46	.55	.45	.55	-.13	.01
	.15	.13	.26	.16	.19	.08	.10	.18	.28	.13
32										
	.12	.09	.08	.20	.11	-.00	.09	-.11	-.01	.33
	-.12	-.15	-.09	-.14	-.14	-.02	-.13	-.15	-.09	-.10
	.04	.14	.06	-.04	-.12	-.14	.20	.36	.12	.06
	.03	1.00	.13	-.06	.14	.12	.15	.12	.23	.26
	.06	.15	.18	.10	.23	.07	-.07	.09	.07	.09
33										
	.16	.21	.10	.09	.08	.18	.00	.04	.06	.32
	.00	-.03	.08	.06	.02	.12	.04	-.05	.03	.06
	.16	.09	.04	.12	.03	-.01	.14	.13	.16	.10
	.19	.13	1.00	-.06	.17	.21	.18	.21	-.10	.24
	.12	.19	.14	.09	.18	.02	.01	.08	.03	-.06
34										
	.04	-.04	.09	.01	.06	-.02	.08	.06	.08	-.04
	.06	.11	.20	.25	.05	.14	.06	.03	-.11	.08
	.02	-.00	.14	.05	.06	.05	.15	-.01	.08	-.07
	.08	-.06	-.06	1.00	-.03	-.02	-.02	-.02	-.21	-.18
	.03	.06	.09	.01	.07	.14	.01	.14	.04	.04
35										
	.25	.23	.37	.33	.35	.21	.23	.28	.24	.58
	.23	.08	.15	.17	.24	.32	.21	.13	.27	.24
	.24	.29	-.01	.29	.23	.16	.21	.29	.31	.43
	.46	.14	.17	-.03	1.00	.66	.98	.66	.01	-.09
	.28	.13	.19	.21	.25	-.01	.06	.22	.32	.21
36										
	.21	.13	.21	.20	.24	.15	.10	.17	.15	.55
	.17	.05	.10	.09	.18	.28	.13	.15	.20	.17
	.19	.18	-.08	.17	.18	.10	.12	.25	.41	.33
	.55	.12	.21	-.02	.66	1.00	.65	1.00	.04	-.02
	.18	.03	.19	.11	.17	-.09	.07	.12	.24	.14

.24	.22	.36	.33	.35	.21	.18	.27	.22	.56
.22	.08	.16	.16	.23	.34	.21	.12	.26	.23
.23	.29	-.01	.29	.23	.17	.22	.28	.30	.41
.45	.15	-.01	.29	.23	.17	.22	.28	.30	.41
.28	.14	.17	.22	.26	-.03	.07	.16	.31	.20
.21	.13	.21	.20	.24	.15	.10	.17	.15	.55
.17	.05	.10	.09	.18	.28	.13	.15	.20	.17
.19	.18	-.08	.17	.18	.10	.12	.25	.41	.33
.55	.12	.21	-.02	.66	1.00	.65	1.00	.04	-.02
.18	.03	.19	.11	.17	-.09	.07	.12	.24	.14
.02	-.12	-.12	.00	-.01	-.06	.06	-.00	.08	.09
-.05	-.09	-.26	-.41	-.12	-.10	-.09	-.12	-.07	-.04
.02	.02	-.06	-.04	-.04	-.09	-.10	.14	-.06	-.08
-.13	.23	-.10	-.21	.01	.04	.00	.04	1.00	.08
.01	-.15	.00	-.06	.08	.12	-.01	-.01	-.02	.04
.11	-.01	-.11	-.01	-.08	.01	-.05	-.15	-.09	.14
-.37	-.24	.03	.04	-.38	.14	-.21	-.47	-.37	-.24
.06	.01	.23	-.07	-.37	-.25	.03	.20	-.01	-.08
.01	.26	.24	-.18	-.09	-.02	-.08	-.02	.08	1.00
-.02	.10	.10	.06	.06	-.04	.06	.15	-.08	.02
.29	.17	.51	.72	.45	.09	.39	.80	.79	.27
.65	.31	.45	.35	.67	.44	.68	.43	.70	.80
.29	.68	.04	.92	.70	.63	.18	.23	.06	.15
.15	.06	.12	.03	.28	.18	.28	.18	.01	-.02
1.00	.04	.17	.47	.33	.03	-.04	.38	.58	.08
.18	.35	.17	-.04	.32	.26	.16	.04	.05	.21
.01	-.07	.02	.11	.00	.16	.00	-.05	.07	.03
.11	-.09	.62	.05	.00	-.00	.34	.17	.09	.02
.13	.15	.19	.06	.13	.03	.14	.03	-.15	.10
.04	1.00	.43	-.02	.26	.22	.01	.17	.17	.04
.36	.29	.31	.13	.34	.12	.12	.09	.15	.43
.14	.08	.03	.16	.11	.14	.12	.13	.24	.21
.29	.05	.53	.13	.14	.11	.33	.32	.19	.22
.26	.18	.14	.09	.19	.19	.17	.19	.00	.10
.17	.43	1.00	.02	.37	.14	.06	.26	.35	.12
.02	.11	.39	.53	.21	.01	.14	.28	.27	.24
.19	.08	.33	.28	.24	.28	.20	.11	.23	.28
.03	.55	-.06	.43	.24	.20	.01	.11	.23	.28
.16	.10	.09	.01	.21	.11	.22	.11	-.06	.06
.47	-.02	.02	1.00	.24	-.07	.04	.21	.27	.11

45

.30	.30	.37	.35	.26	.09	.12	.23	.33	.37
.24	.07	.19	.16	.20	.26	.20	.17	.25	.26
.24	.29	.22	.31	.23	.24	.18	.34	.14	.12
.19	.23	.18	.07	.25	.17	.26	.17	.08	.06
.33	.26	.37	.24	1.00	.29	-.03	.22	.25	.02

46

.18	.09	.04	-.01	.18	.04	.29	.11	.26	.09
.10	.03	-.02	-.02	.06	.12	.10	-.02	.12	.15
.17	-.02	.25	.06	.09	.12	.04	.19	.03	.02
.08	.07	.02	.14	-.01	-.09	-.03	-.09	.12	-.04
.03	.22	.14	-.07	.29	1.00	.04	.18	.11	.05

47

.13	.10	.12	.08	.15	.16	.06	.01	-.08	.14
-.09	-.07	.11	.12	-.10	.17	-.05	-.07	-.05	-.04
.06	.05	.05	-.02	-.08	-.06	.09	.10	.05	.04
.10	-.07	.01	.01	.06	.07	.07	.07	-.01	.06
-.04	-.01	.06	.04	-.03	.04	.00	.02	.12	.05

48

.18	.12	.36	.42	.47	.03	.70	.41	.44	.29
.29	.23	.24	.25	.27	.25	.23	.18	.36	.32
.15	.36	.22	.40	.30	.25	.21	.21	.13	.24
.18	.09	.08	.14	.22	.12	.16	.12	-.01	-.15
.38	.17	.26	.21	.22	.18	.02	1.00	.53	.10

49

.41	.36	.62	.54	.76	.19	.53	.52	.54	.47
.41	.16	.28	.25	.41	.40	.41	.33	.49	.49
.37	.44	.13	.54	.43	.36	.27	.34	.18	.32
.28	.07	.03	.04	.32	.24	.31	.24	-.02	-.08
.58	.17	.35	.27	.25	.11	.12	.53	1.00	.08

50

.07	.06	.06	.10	.13	.06	.12	.10	.10	.11
.09	.05	-.05	.03	.09	.07	.09	.04	.10	.09
.06	.08	.13	.10	.09	.09	.14	.05	-.04	.10
.13	.09	-.06	.04	.21	.14	.20	.14	.04	.02
.08	.04	.12	.11	.02	.05	.05	.10	.08	1.00

For the sake of completeness, the hours flown model is included in this Appendix. Included with its correlation matrix is the final iteration which defined the derivation and the final model for estimating itinerant operations and for estimating total operations. In addition, its applicability to the test airports is also included.

VARIABLE KEY FOR CORRELATION MATRIX

VARIABLE	PARAMETER
1.	Actual Itinerant Operations
2.	Actual Total Operations
3.	Scheduled Air Carrier Departures
4.	Facilities Index
5.	Student Pilots
6.	FBO Index
7.	Airport Acreage
8.	No. of FBO's
9.	Based Aircraft - Multi Engine
10.	Single Engine Aircraft ≥ 4 Place
11.	AVGAS Storage Capacity
12.	Jet Fuel Storage Capacity
13.	Total Based Aircraft
14.	Registered Aircraft in County
15.	AVGAS Storage > 100 Octane
16.	Population Index
17.	GA Aircraft per 100,000 people (in State)
18.	Hours Flown

	1	2	3	4	5
MEANS					
	263.453	503.615	1577.49	62.5726	63.5487
	-3.58120	833.453	1.77350	9.93162	32.3846
	111.094	140.744	55.5299	78.2308	129.778
	4.11111	87.2821	9360.75		
STD DEV					
	139.597	309.817	1807.09	17.0235	63.1338
	9.04711	779.117	1.18528	8.74885	29.3318
	113.204	135.840	42.8684	92.7763	109.917
	1.37609	42.9398	6863.07		

Correlation Matrix

1										
	1.00	.86	.50	.61	.49	-.30	.22	.35	.61	.45
	.46	.55	.56	.42	.56	.42	-.13	.70		
2										
	.86	1.00	.32	.45	.63	-.19	.15	.36	.55	.50
	.37	.41	.60	.56	.41	.43	-.09	.71		
3										
	.50	.32	1.00	.44	.08	-.20	.25	.23	.16	.01
	.21	.43	.06	-.07	.35	.11	.02	.18		
4										
	.61	.45	.44	1.00	.11	-.34	.61	.31	.42	.11
	.46	.54	.22	.01	.49	.44	.04	.35		
5										
	.49	.63	.08	.11	1.00	-.16	-.08	.24	.48	.79
	.14	.16	.81	.66	.16	.26	-.14	.71		
6										
	-.30	-.19	-.20	-.34	-.16	1.00	-.08	.12	-.15	-.00
	-.16	-.32	-.03	.05	-.20	-.27	.19	-.18		
7										
	.22	.15	.25	.61	-.08	-.08	1.00	.17	.17	-.02
	.44	.29	.06	-.04	.35	.11	.38	.10		
8										
	.35	.36	.23	.31	.24	.12	.17	1.00	.40	.26
	.24	.14	.33	.19	.16	.11	.22	.33		
9										
	.61	.55	.16	.42	.48	-.15	.17	.40	1.00	.48
	.29	.28	.64	.43	.29	.35	-.08	.70		
10										
	.45	.50	.01	.11	.79	-.00	-.02	.26	.48	1.00
	.21	.18	.95	.61	.26	.18	-.02	.70		
11										
	.46	.37	.21	.46	.14	-.16	.44	.24	.29	.21
	1.00	.51	.28	.14	.80	.16	.14	.33		
12										
	.55	.41	.43	.54	.16	-.32	.29	.14	.28	.18
	.51	1.00	.24	.00	.70	.16	.00	.39		
13										
	.56	.60	.06	.22	.81	-.03	.06	.33	.64	.95
	.28	.24	1.00	.65	.30	.26	-.03	.80		
14										
	.42	.56	-.07	.01	.66	.05	-.04	.19	.43	.61
	.14	.00	.65	1.00	.13	.32	-.05	.51		
15										
	.56	.41	.35	.49	.16	-.20	.35	.16	.29	.26
	.80	.70	.30	.13	1.00	.24	.11	.34		
16										
	.42	.43	.11	.44	.26	-.27	.11	.11	.35	.18
	.16	.16	.26	.32	.24	1.00	-.37	.27		
17										
	-.13	-.09	.02	.04	-.14	.19	.38	.22	-.08	-.02
	.14	.00	-.03	-.05	.11	-.37	1.00	-.03		
18										
	.70	.71	.18	.35	.71	-.18	.10	.33	.70	.70
	.33	.39	.80	.51	.34	.27	-.03	1.00		

FINAL ITERATION - ITINERANT OPERATIONS (HRS FLOWN)

1ST REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?17
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,5,6,7,8,9,10
?11,12,13,14,15,16,17,18

MULTIPLE REGRESSION RESULTS

DEP 1 IND 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.2464	.0520	4.741	.190328E-01	.401424E-02	.4073
4	.3179	.0787	4.041	2.60665	.645056	.3553
5	-.0518	.0877	-.591	-.114452	.193810	-.0555
6	-.0527	.0526	-1.002	-.813112	.811759	-.0938
7	-.1126	.0651	-1.729	-.201811E-01	.116694E-01	-.1605
8	.0573	.0537	1.067	6.74770	6.32365	.0999
9	.0433	.0751	.577	.691590	1.19862	.0542
10	-.0663	.1755	-.378	-.315538	.835253	-.0355
11	-.0247	.0803	-.307	-.304046E-01	.990030E-01	-.0289
12	-.0193	.0717	-.269	-.198160E-01	.736683E-01	-.0253
13	.0240	.2173	.110	.781735E-01	.707779	.0104
14	.2464	.0656	3.756	.370807	.987146E-01	.3332
15	.2402	.0949	2.531	.305017	.120515	.2316
16	-.0339	.0606	-.560	-3.44357	6.14543	-.0526
17	-.1196	.0564	-2.121	-.388899	.183345	-.1957
18	.3724	.0880	4.232	.757491E-02	.178979E-02	.3699
		NDF =100	INT =	-6.68490		

MULTIPLE R= .8896, STD.ERR.EST.= 63.760 , UNEXPLAINED= .2086

F= 23.7096 , NDF= 16.0, 100.0

2ND REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?10
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,6,7,8,14,15,
?17,18

MULTIPLE REGRESSION RESULTS

DEP 1 IND 3 4 6 7 8 14 15 17 18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.2482	.0500	4.960	.191733E-01	.386554E-02	.4228
4	.3172	.0710	4.471	2.60136	.581865	.3877
6	-.0437	.0495	-.882	-.673655	.763627	-.0827
7	-.1085	.0624	-1.739	-.194379E-01	.111771E-01	-.1615
8	.0573	.0510	1.124	6.74915	6.00487	.1051
14	.2110	.0528	3.997	.317527	.794418E-01	.3519
15	.2058	.0525	3.919	.261404	.666949E-01	.3459
17	-.1082	.0509	-2.128	-.351845	.165370	-.1963
18	.3452	.0580	5.951	.702155E-02	.117986E-02	.4885
		NDF =107	INT =	-21.5304		

MULTIPLE R= .8871, STD.ERR.EST.= 64.433 , UNEXPLAINED= .2130

F= 43.9158 , NDF= 9.0, 107.0

3RD REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?9
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,7,8,14,15,17,
?18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.2509	.0501	5.007	.193850E-01	.387134E-02	.4261
4	.3345	.0684	4.889	2.74326	.561112	.4178
7	-.1139	.0623	-1.828	-.204013E-01	.111619E-01	-.1695
8	.0464	.0496	.935	5.46926	5.84700	.0877
14	.2065	.0527	3.917	.310786	.793454E-01	.3457
15	.2076	.0527	3.943	.263702	.668731E-01	.3478
17	-.1131	.0507	-2.228	-.367570	.164971	-.2051
18	.3521	.0577	6.105	.716183E-02	.117311E-02	.4980
		NDF =108	INT =	-24.9698		

MULTIPLE R= .8863, STD.ERR.EST.= 64.655 , UNEXPLAINED= .2145

F= 49.4335 , NDF= 8.0, 108.0

4th REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?9
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,7,9,14,15,17,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.2597	.0496	5.234	.200610E-01	.383309E-02	.4417
4	.3314	.0686	4.831	2.71741	.562497	.4137
7	-.1211	.0619	-1.955	-.216898E-01	.110924E-01	-.1809
9	.0694	.0649	1.071	1.10788	1.03484	.1002
14	.2018	.0532	3.792	.303589	.800629E-01	.3360
15	.2044	.0524	3.902	.259628	.665288E-01	.3446
17	-.0952	.0491	-1.940	-.309402	.159516	-.1795
18	.3228	.0672	4.807	.656643E-02	.136588E-02	.4121
		NDF =108	INT =	-23.0595		

MULTIPLE R= .8866, STD.ERR.EST.= 64.578 , UNEXPLAINED= .2140

F= 49.5834 , NDF= 8.0, 108.0

FINAL REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?8
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?1,3,4,7,14,15,17,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.2574	.0498	5.167	.198857E-01	.384897E-02	.4371
4	.3480	.0672	5.182	2.85354	.550707	.4382
7	-.1198	.0622	-1.926	-.214670E-01	.111465E-01	-.1783
14	.2119	.0526	4.027	.318882	.791768E-01	.3543
15	.2031	.0526	3.859	.257946	.668467E-01	.3412
17	-.1003	.0491	-2.045	-.326197	.159546	-.1889
18	.3612	.0571	6.330	.734721E-02	.116072E-02	.5116
		NDF =109	INT =	-27.3049		

MULTIPLE R= .8853, STD.ERR.EST.= 64.905 , UNEXPLAINED= .2162

F= 56.4608 , NDF= 7.0, 109.0

ITINERANT OPERATIONS MODEL
(HOURS FLOWN)

AIRPORT	ACTUAL OPS	ESTIMATED OPS	ABSOLUTE ERROR	PERCENTAGE ERROR
21	500.000	358.944	-141.056	-28.211
31	261.000	318.103	57.103	21.879
51	402.000	292.076	-109.924	-27.344
61	403.000	474.255	71.255	17.681
71	296.000	280.946	-15.054	-5.086
91	235.000	281.549	46.549	19.808
101	217.000	264.952	47.952	22.098
111	303.000	313.086	10.086	3.329
121	394.000	408.271	14.271	3.622
131	240.000	342.351	102.351	42.646
141	266.000	196.507	-69.493	-26.125
151	296.000	437.693	141.693	47.869
161	440.000	429.038	-10.962	-2.491
171	279.000	249.347	-29.653	-10.628
191	371.000	262.724	-108.276	-29.185
211	488.000	388.751	-99.249	-20.338
221	432.000	316.024	-115.976	-26.846
241	303.000	264.061	-38.939	-12.851
261	206.000	211.397	5.397	2.620
271	371.000	404.379	33.379	8.997
281	549.000	450.387	-98.613	-17.962
291	562.000	510.710	-51.290	-9.126
301	436.000	438.311	2.311	.530
311	230.000	353.468	123.468	53.682
321	205.000	334.622	129.622	63.230
331	159.000	131.630	-27.370	-17.214
341	258.000	252.321	-5.679	-2.201
351	281.000	188.496	-92.504	-32.920
411	105.000	213.493	108.493	103.327
431	139.000	192.292	53.292	38.339
441	174.000	224.507	50.507	29.027
451	275.000	348.270	73.270	26.644
461	230.000	250.385	20.385	8.863
491	265.000	197.142	-67.858	-25.607
501	230.000	216.380	-13.620	-5.922
511	285.000	148.335	-136.665	-47.952
521	215.000	155.583	-59.417	-27.636
531	295.000	269.553	-25.447	-8.626
541	298.000	253.514	-44.486	-14.928
551	395.000	225.886	-169.114	-42.814
561	192.000	244.528	52.528	27.358
571	218.000	294.666	76.666	35.168
591	260.000	212.906	-47.094	-18.113
601	300.000	250.995	-49.005	-16.335
1011	335.000	396.551	61.551	18.373
1021	493.000	434.531	-58.469	-11.860
1031	487.000	477.829	-9.171	-1.883
1051	414.000	386.044	-27.956	-6.753
1091	416.000	270.396	-145.604	-35.001
1101	429.000	366.400	-62.600	-14.592
1121	291.000	269.799	-21.201	-7.286
1131	373.000	336.183	-36.817	-9.871
1141	394.000	342.015	-51.985	-13.194
1151	383.000	330.976	-52.024	-13.583
1161	407.000	383.898	-23.102	-5.676

$$\text{ITN. OPS} = 100\left[.019\,X_3 + 2.85\,X_4 - .021\,X_7 + .319\,X_{14} + .258\,X_{15} - .326\,X_{17} + .0073\,X_{18} - 27.30\right]$$

1181	225.000	248.598	23.598	10.488
1191	422.000	458.268	36.268	8.594
1221	361.000	327.031	-33.969	-9.410
1241	331.000	451.889	120.889	36.522
1251	387.000	333.475	-53.525	-13.831
1281	328.000	297.881	-30.119	-9.183
1291	292.000	337.019	45.019	15.417
1301	272.000	244.757	-27.243	-10.016
1311	398.000	414.602	16.602	4.171
1321	419.000	414.222	-4.778	-1.140
1401	135.000	184.777	49.777	36.872
1411	600.000	614.848	14.848	2.475
1431	590.000	374.024	-215.976	-36.606
1441	314.000	238.018	-75.982	-24.198
1451	310.000	281.162	-28.838	-9.303
1461	135.000	235.570	100.570	74.496
1471	220.000	221.967	1.967	.894
1481	258.000	297.231	39.231	15.206
1501	290.000	300.000	10.000	3.448
1511	349.000	341.133	-7.867	-2.254
1521	170.000	226.533	56.533	33.255
1531	254.000	174.010	-79.990	-31.492
1541	164.000	115.460	-48.540	-29.597
1551	399.000	465.450	66.450	16.654
1561	378.000	369.978	-8.022	-2.122
1601	169.000	236.413	67.413	39.889
1621	295.000	290.109	-4.891	-1.658
1631	214.000	213.932	-.068	-.032
1641	142.000	211.057	69.057	48.632
1661	243.000	284.323	41.323	17.005
1671	398.000	383.992	-14.008	-3.520
1681	405.000	341.008	-63.992	-15.801
1691	215.000	205.338	-9.662	-4.494
1701	270.000	255.292	-14.708	-5.447
1711	255.000	250.582	-4.418	-1.732
1721	240.000	240.700	.700	.292
1791	250.000	284.586	34.586	13.834
1801	175.000	268.246	93.246	53.284
1831	207.000	330.535	123.535	59.679
1841	215.000	235.670	20.670	9.614
1861	258.000	346.524	88.524	34.312
1871	285.000	327.703	42.703	14.983
1891	160.000	109.933	-50.067	-31.292
2001	54.000	81.037	27.037	50.068
2021	32.000	54.416	22.416	70.049
2031	22.000	33.607	11.607	52.761
2041	27.000	71.091	44.091	163.300
2051	11.000	50.584	39.584	359.853
2061	9.000	56.948	47.948	532.752
2071	42.000	80.548	38.548	91.780
2081	72.000	86.657	14.657	20.358
2091	29.000	71.327	42.327	145.956
3001	31.000	13.675	-17.325	-55.886
3011	80.000	107.974	27.974	34.968
3021	20.000	5.122	-14.878	-74.390
3031	90.000	107.002	17.002	18.891
3041	26.000	50.209	24.209	93.111
3061	39.000	-5.557	-44.557	-114.248
3071	21.000	47.950	26.950	128.332
3081	54.000	86.623	32.623	60.413
3091	27.000	80.694	53.694	198.868
4001	60.000	112.788	52.788	87.979

FINAL ITERATION - TOTAL OPERATIONS (HRS FLOWN) MODEL

1st REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?13
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?2,3,4,5,7,8,9,10,
?12,13,14,16,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1170	.0607	1.926	.200521E-01	.104120E-01	.1783
4	.1693	.0926	1.829	3.08047	1.68456	.1695
5	.2439	.0984	2.479	1.19668	.482741	.2271
7	-.0465	.0694	-.670	-.184718E-01	.275775E-01	-.0629
8	.0964	.0587	1.642	25.2025	15.3448	.1527
9	-.0627	.0881	-.712	-2.22140	3.12018	-.0668
10	-.1842	.2076	-.887	-1.94556	2.19230	-.0832
12	.1158	.0676	1.715	.264166	.154077	.1592
13	-.0368	.2554	-.144	-.265766	1.84613	-.0135
14	.3132	.0766	4.089	1.04603	.255827	.3590
16	.1086	.0649	1.675	24.4596	14.6015	.1557
18	.3989	.1034	3.856	.180078E-01	.466956E-02	.3410
		NDF =104	INT =	-114.427		

MULTIPLE R= .8372, STD.ERR.EST.= 169.43 , UNEXPLAINED= .2991

F= 20.3140 , NDF= 12.0, 104.0

2nd REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?17
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?2,3,4,5,6,7,8,9,10
?11,12,13,14,15,16,17,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1131	.0616	1.835	.193897E-01	.105687E-01	.1701
4	.1766	.0933	1.892	3.21313	1.69831	.1752
5	.2744	.1040	2.639	1.34647	.510263	.2409
6	.0369	.0624	.591	1.26343	2.13720	.0555
7	-.0559	.0773	-.723	-.222177E-01	.307232E-01	-.0679
8	.0915	.0637	1.437	23.9181	16.6489	.1339
9	-.0620	.0891	-.696	-2.19584	3.15572	-.0653
10	-.1904	.2082	-.914	-2.01083	2.19906	-.0857
11	.0286	.0952	.301	.783478E-01	.260656	.0283
12	.0617	.0850	.726	.140726	.193954	.0681
13	-.0711	.2578	-.276	-.513647	1.86344	-.0259
14	.2990	.0778	3.842	.998517	.259896	.3399
15	.0759	.1126	.674	.213858	.317292	.0633
16	.0969	.0719	1.349	21.8211	16.1797	.1259
17	-.0254	.0669	-.379	-.182928	.482713	-.0356
18	.4117	.1044	3.944	.185832E-01	.471216E-02	.3478
		NDF =100	INT =	-99.5931		

MULTIPLE R= .8405, STD.ERR.EST.= 167.87 , UNEXPLAINED= .2936

F= 15.0392 , NDF= 16.0, 100.0

3RD REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?9
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?2,3,4,5,8,12,14,16,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1370	.0619	2.215	.234882E-01	.106062E-01	.2040
4	.1219	.0770	1.584	2.21912	1.40139	.1473
5	.1498	.0865	1.732	.735133	.424403	.1608
8	.0775	.0587	1.321	20.2553	15.3331	.1233
12	.1158	.0691	1.675	.264171	.157694	.1557
14	.2664	.0752	3.540	.889537	.251257	.3160
16	.1276	.0640	1.993	28.7306	14.4186	.1842
18	.2955	.0856	3.452	.133375E-01	.386388E-02	.3088
		NDF =108	INT =	-104.666		

MULTIPLE R= .8269, STD.ERR.EST.= 174.25 , UNEXPLAINED= .3163

F= 29.1785 , NDF= 8.0, 108.0

4TH REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?7
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?2,3,5,12,14,16,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1795	.0605	2.968	.307805E-01	.103712E-01	.2689
5	.1326	.0878	1.510	.650844	.431089	.1406
12	.1501	.0658	2.280	.342258	.150130	.2097
14	.2547	.0762	3.344	.850395	.254330	.3001
16	.1743	.0584	2.987	39.2461	13.1399	.2705
18	.3473	.0846	4.103	.156764E-01	.382077E-02	.3601
		NDF =110	INT =	-9.08621		

MULTIPLE R= .8176, STD.ERR.EST.= 178.40 , UNEXPLAINED= .3316

F= 36.9571 , NDF= 6.0, 110.0

FINAL REGRESSION

TYPE NUMBER OF VARIABLES FOR THIS REGRESSION?6
TYPE IN ORDER OF VARIABLES--DEPENDENT FIRST?2,3,12,14,16,18

VAR	BETA	STD ERR	T	B COEF.	S.E.B.	PART R.
3	.1838	.0610	3.011	.315047E-01	.104640E-01	.2725
12	.1429	.0663	2.155	.325861	.151239	.1986
14	.3072	.0684	4.488	1.02575	.228530	.3890
16	.1733	.0589	2.939	39.0063	13.2707	.2665
18	.4163	.0719	5.789	.187950E-01	.324652E-02	.4783
		NDF =111	INT =	-8.48571		

MULTIPLE R= .8135, STD.ERR.EST.= 180.19 , UNEXPLAINED= .3383

F= 43.4279 , NDF= 5.0, 111.0

TOTAL OPERATIONS MODEL
(HOURS FLOWN)

AIRPORT	ACTUAL OPS	ESTIMATED OPS	ABSOLUTE ERROR	PERCENTAGE ERROR
21	804.000	593.731	-210.269	-26.153
31	361.000	611.527	250.527	69.398
51	717.000	545.938	-171.062	-23.858
61	644.000	741.478	97.478	15.136
71	485.000	504.649	19.649	4.051
91	474.000	426.418	-47.582	-10.038
101	311.000	420.842	109.842	35.319
111	359.000	559.751	200.751	55.920
121	873.000	771.159	-101.841	-11.666
131	890.000	730.834	-159.166	-17.884
141	585.000	432.093	-152.907	-26.138
151	564.000	659.557	95.557	16.943
161	878.000	921.841	43.841	4.993
171	437.000	520.059	83.059	19.007
191	657.000	380.990	-276.010	-42.011
211	972.000	671.727	-300.273	-30.892
221	644.000	542.720	-101.280	-15.727
241	548.000	447.372	-100.628	-18.363
261	247.000	394.724	147.724	59.807
271	552.000	735.789	183.789	33.295
281	855.000	923.462	68.462	8.007
291	1028.000	747.284	-280.716	-27.307
301	854.000	733.876	-120.124	-14.066
311	510.000	721.045	211.045	41.381
321	355.000	607.246	252.246	71.055
331	299.000	275.412	-23.588	-7.889
341	482.000	642.556	160.556	33.310
351	402.000	289.932	-112.068	-27.878
411	343.000	484.141	141.141	41.149
431	231.000	429.380	198.380	85.879
441	345.000	324.853	-20.147	-5.840
451	435.000	635.424	200.424	46.074
461	730.000	681.646	-48.354	-6.624
491	500.000	389.232	-110.768	-22.154
501	395.000	342.984	-52.016	-13.169
511	525.000	331.165	-193.835	-36.921
521	250.000	204.771	-45.229	-18.092
531	405.000	508.418	103.418	25.535
541	468.000	533.530	65.530	14.002
551	1165.000	545.603	-619.397	-53.167
561	286.000	364.200	78.200	27.343
571	1078.000	888.166	-189.834	-17.610
591	360.000	382.756	22.756	6.321
601	692.000	635.925	-56.075	-8.103
1011	587.000	686.677	99.677	16.981
1021	841.000	764.652	-76.348	-9.078
1031	1053.000	1004.864	-48.136	-4.571
1051	678.000	691.971	13.971	2.061
1091	1241.000	487.708	-753.292	-60.700
1101	843.000	716.837	-126.163	-14.966
1121	464.000	642.959	178.959	38.569
1131	616.000	634.642	18.642	3.026
1141	873.000	688.908	-184.092	-21.087
1151	592.000	559.811	-32.189	-5.437
1161	721.000	720.611	-.389	-.054

$$\text{TotalOps} = 100\Big[.0315X_3 + .326X_{12} + 1.026X_{14} + 39.0X_{16} + .019X_{18} - 8$$

1181	419.000	389.422	-29.578	-7.059
1191	796.000	945.924	149.924	18.835
1221	487.000	571.341	84.341	17.319
1241	477.000	900.682	423.682	88.822
1251	791.000	588.212	-202.788	-25.637
1281	430.000	472.291	42.291	9.835
1291	430.000	513.454	83.454	19.408
1301	491.000	393.632	-97.368	-19.830
1311	637.000	657.028	20.028	3.144
1321	655.000	771.824	116.824	17.836
1401	185.000	326.876	141.876	76.690
1411	1464.000	1527.602	63.602	4.344
1431	1340.000	579.985	-760.015	-56.718
1441	624.000	377.336	-246.664	-39.530
1451	635.000	510.477	-124.523	-19.610
1461	288.000	360.285	72.285	25.099
1471	260.000	319.338	59.338	22.822
1481	578.000	448.600	-129.400	-22.388
1501	873.000	784.122	-88.878	-10.181
1511	647.000	752.002	105.002	16.229
1521	470.000	374.707	-95.293	-20.275
1531	455.000	274.766	-180.234	-39.612
1541	354.000	190.431	-163.569	-46.206
1551	919.000	1037.825	118.825	12.930
1561	498.000	717.659	219.659	44.108
1601	343.000	411.538	68.538	19.982
1621	420.000	476.467	56.467	13.445
1631	275.000	301.471	26.471	9.626
1641	283.000	312.301	29.301	10.354
1661	493.000	676.289	183.289	37.178
1671	586.000	865.751	279.751	47.739
1681	904.000	938.625	34.625	3.830
1691	411.000	361.865	-49.135	-11.955
1701	410.000	571.835	161.835	39.472
1711	480.000	496.527	16.527	3.443
1721	550.000	600.288	50.288	9.143
1791	1150.000	698.001	-451.999	-39.304
1801	195.000	414.264	219.264	112.443
1831	417.000	573.144	156.144	37.445
1841	425.000	459.258	34.258	8.061
1861	530.000	595.157	65.157	12.294
1871	855.000	603.340	-251.660	-29.434
1891	220.000	223.828	3.828	1.740
2001	101.000	126.272	25.272	25.022
2021	82.000	138.482	56.482	68.881
2031	46.000	79.889	33.889	73.671
2041	34.000	160.014	126.014	370.629
2051	16.000	145.796	129.796	811.227
2061	28.000	103.812	75.812	270.759
2071	55.000	125.710	70.710	128.563
2081	136.000	227.811	91.811	67.508
2091	34.000	109.433	75.433	221.861
3001	36.000	95.833	59.833	166.203
3011	181.000	281.641	100.641	55.603
3021	36.000	90.605	54.605	151.681
3031	151.000	227.705	76.705	50.798
3041	36.000	99.399	63.399	176.108
3061	49.000	107.135	58.135	118.642
3071	26.000	98.064	72.064	277.169
3081	85.000	219.082	134.082	157.744
3091	32.000	127.743	95.743	299.197
4001	105.000	156.957	51.957	49.483

TEST RESULTS - HOURS FLOWN MODEL

ITINERANT OPERATIONS
TOTAL OPERATIONS

TEST AIRPORT	ACTUAL	ESTIMATE	ABSOLUTE Δ	% Δ
1	41.	42.	1.	2.
1	122.	187.	65.	53.
2	44.	103.	59.	133.
2	56.	211.	155.	277.
3	55.	79.	24.	43.
3	180.	217.	37.	21.
4	268.	269.	1.	0.
4	598.	571.	-27.	-4.
5	274.	277.	3.	1.
5	526.	443.	-83.	-16.
6	315.	318.	3.	1.
6	465.	586.	121.	26.
7	290.	328.	38.	13.
7	404.	686.	282.	70.
8	330.	296.	-34.	-10.
8	435.	487.	52.	12.
9	260.	303.	43.	17.
9	588.	534.	-54.	-9.
10	280.	244.	-36.	-13.
10	427.	329.	-98.	-23.
11	300.	182.	-118.	-39.
11	486.	467.	-19.	-4.
12	187.	268.	81.	43.
12	362.	539.	177.	49.
13	89.	120.	31.	35.
13	131.	394.	263.	200.
14	482.	412.	-70.	-14.
14	765.	843.	78.	10.
15	385.	429.	44.	11.
15	813.	785.	-28.	-3.
16				
16	= NO DATA =			
17	680.	566.	-114.	-17.
17	1198.	1219.	21.	2.

TEST AIRPORT	ACTUAL	ESTIMATE	ABSOLUTE Δ	% Δ
18	721.	429.	-292.	-41.
18	1223.	976.	-247.	-20.
19	430.	402.	-28.	-7.
19	658.	653.	-5.	-1.
20	365.	280.	-85.	-23.
20	561.	620.	59.	11.
21	291.	230.	-61.	-21.
21	716.	385.	-331.	-46.
22	345.	352.	7.	2.
22	720.	633.	-87.	-12.
23	395.	323.	-72.	-18.
23	965.	604.	-361.	-37.
24	430.	297.	-133.	-31.
24	1205.	775.	-430.	-36.
25	352.	335.	-17.	-5.
25	460.	611.	151.	33.
26	249.	324.	75.	30.
26	489.	474.	-15.	-3.
27	323.	303.	-20.	-6.
27	464.	489.	25.	5.
28	312.	288.	-24.	-8.
28	588.	510.	-78.	-13.
29				
29	= NO DATA =			
30	615.	352.	-263.	-43.
30	882.	679.	-203.	-23.
31				
31	= NO DATA =			
32	634.	498.	-136.	-21.
32	958.	867.	-91.	-10.
33	518.	363.	-155.	-30.
33	703.	698.	-5.	-1.
34	510.	474.	-36.	-7.
34	914.	864.	-50.	-6.