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ANALYSIS OF THE IMPACT OF TERMINAL CONTROL AREA (TCA) IMPLEMENT--ETC(U)
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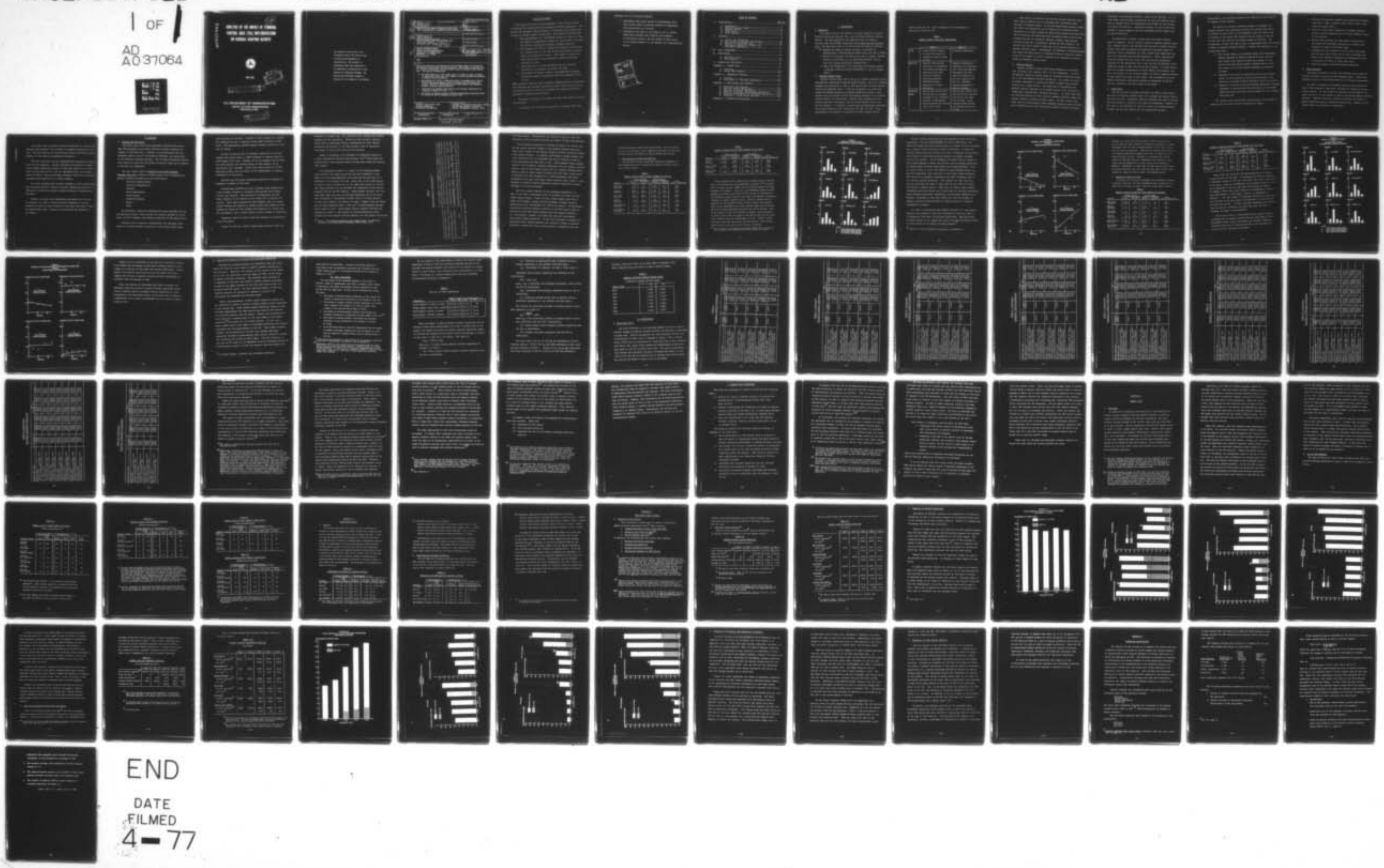

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ANALYSIS OF THE IMPACT OF TERMINAL CONTROL AREA (TCA) IMPLEMENTATION ON GENERAL AVIATION ACTIVITY

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16. Abstract

This report describes an investigation of the probable effect of selected TCA implementation upon general aviation operations. The results are obtained from an analysis of historical time series data as well as current traffic survey data. The specific findings were:

1. The establishment of a TCA (either Group I or Group II) does not appear to dramatically affect the total number of airport operations attributable to general aviation aircaraft;

2. The presence of a TCA at a large hub airport is accompanied by a marked shift in the type of general aviation aircraft using the primary TCA airport. This shift is towards the more sophisticated, more expensive, primarily business oriented aircraft;

3. Overflight and secondary operations are not obviously affected by the presence or absence of a TCA; and

4. The profile of general aviation overflight and secondary operations shows no correlation with the presence or type of TCA.

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EXECUTIVE SUMMARY

This report describes an investigation of the probable effect of selected TCA implementation upon general aviation operations. The results are obtained from an analysis of historical time series data as well as current traffic survey data. The specific findings were:

1. The establishment of a TCA (either Group I or Group II) does not appear to dramatically affect the total number of airport operations attributable to general aviation aircraft.
2. The presence of a TCA at a large hub airport is accompanied by a marked shift in the type of general aviation aircraft using the primary TCA airport. This shift is towards the more sophisticated, more expensive, primarily business oriented aircraft.
3. Overflight and secondary operations are not obviously affected by the presence or absence of a TCA.
4. The profile of general aviation overflight and secondary operations shows no correlation with the presence or type of TCA.

These objective findings when expressed mathematically in conjunction with existing FAA forecasts constitute a model which can be applied to existing traffic statistics to predict the impact upon general aviation of establishing new TCA's.

The model is applied to 25 large hub areas and numerical results are obtained.

In addition, the generalized expansion of existing TCA's was

analyzed with the following findings.

1. Expanding a TCA either upward or horizontally would have little effect on general aviation if reasonable VFR alternatives are retained.
2. Expanding a TCA down to the ground so as to include additional terminal area airports could produce contradictory results, the net effect of which would be of doubtful benefit to the national air transportation system.

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I. INTRODUCTION

A. Background

This report presents the results of a study conducted by General Aviation Operations Research, Inc., for the Federal Aviation Administration. The work reported on was conducted under the terms of Purchase Order W1-76-0278-1 during the period August through November 1975. The particular tasks to be accomplished are quoted as follows:

"a. Examine the impact on general aviation of selected TCA implementation, differentiating between Type I and Type II TCA's.

b. Develop a methodology for predicting impact on general aviation activity of new TCA's, or, in cases where Terminal Control Areas are already established, expanded TCA's.

c. Apply the methodology to all large hubs and forecast changes in general aviation activity attributable to new or expanded TCA's."

B. Terminal Control Areas

Terminal Control Areas (TCA's) are an air traffic management device developed and implemented during the current decade. The first (Atlanta, Georgia) was established in June of 1970 and has been followed successively by 20 additional TCA's. A TCA can be defined as a prescribed volume of airspace centered on a primary airport(s) serving a metropolitan area and contained within the airspace delegated to an approach control facility for IFR control. Within a TCA, specified aircraft avionics equipment requirements must be met by aircraft desiring to use the airspace. In addition, certain pilot qualifications,procedures, and flight restrictions are imposed upon the user of a TCA. These requirements are intended to facilitate the safe, orderly flow of traffic within the TCA. Table 1 summarizes the requirements for each class of TCA now in use.

TABLE 1

TERMINAL CONTROL AREA (TCA) REQUIREMENTS

	GROUP I	GROUP II
PILOT	Private Pilot's license or better for takeoff or landing at airports within the TCA.	No special requirements
EQUIPMENT	Adequate communications frequencies to communicate with controlling agencies. Transponder with 4096 codes plus altitude reporting capability. VOR/TACAN receiver appropriate to ground facilities.	Adequate communications frequencies to communicate with controlling agencies. Transponder with 4096 codes for operations to and from airports within the TCA. VOR/TACAN receiver appropriate to ground facilities.
OPERATING RULES	Two-way radio contact with ATC Facility and clearance required for all fixed-wing aircraft. Large turbine powered aircraft must operate above floor of TCA.	Two-way radio contact with ATC facility and clearance required for all fixed-wing aircraft. Large turbine powered aircraft must operate above floor of TCA.

Five years of experience with the TCA concept indicates that TCA's are an effective way of providing safe separation among aircraft in terminal areas. As the ATC system moves forward toward the 1980's one alternative way of dealing with expected traffic increases is to create additional TCA's and/or expand existing TCA's. TCA restrictions and operating rules apparently pose no particular problems for the air transport industry, however, some general aviation groups have consistently opposed the TCA concept on the grounds that TCA's tended to deny the use of certain airports to general aviation users. Accordingly, the Secretary of Transportation has tasked the FAA's Office of Aviation Policy to provide an evaluation of the impact on general aviation of an increase in size or number of Terminal Control Areas.

C. <u>General Effects</u>

General Aviation, unlike other major categories of aviation (eg., military, air carrier, etc.), is not homogeneous. In fact, the general aviation category spans all aviation activities except for a few experimental military operations. As a result it would be almost impossible to discuss the effect of TCA's upon general aviation as a single entity. The usual way of classifying the general aviation community is by flight purpose, such as business, commercial, instructional, personal and other. It seems clear that the expected effects of TCA's would be somewhat different among the various classes of general aviation users. In other words, some users such as professionally flown corporate aircraft would probably not be affected by the TCA environment inasmuch as their operating procedures are generally similar to those of air carriers. On the other hand, instructional flying would be very much affected inasmuch as student pilots are prohibited from taking off and landing at certain TCA airports. Subjective analysis of each of the other classes of users suggests that TCA requirements would affect each of them differently.

An examination of Table 1 shows that three major effects might be expected. First, certain classes of general aviation users (eg., student pilots) are excluded from the use of certain airports. Second, since IFR procedures are essentially followed within the positive control environment of a TCA, arrivals and departures are more time consuming than are VFR operations. Third, many general aviation aircraft are not fitted with the avionics equipments required for TCA operations; thus, they must buy and maintain these additional items if they wish to use TCA airspace. It seems likely that the ultimate consequences of these effects are economic, however, an analysis of the economic impact of TCA's on general aviation is well beyond the scope of this study. The intermediate and more readily observable consequences should be operational in nature and are, therefore, the focal point of the study.

D. Study Goals

The obvious way to analyze the effect of TCA's on the numbers and kinds of general aviation users is to compare air traffic before and after the TCA. Historical data was available and used to support such an analysis of trends in the number of operations. However, in the case of user profiles we could not follow the obvious approach because user profile records are not accumulated and kept.

Consequently, an alternative approach was required for the analysis of changes in user profile.

The method of analysis selected consists of comparing the general aviation user population profiles at airports with TCA's to airports without TCA's on the assumption that the latter type is typical of the before TCA condition and the former is typical of the after TCA condition at various stages of maturity. The differences (if any) are used to test our hypotheses about the effects of TCA's on general aviation traffic. Briefly the hypotheses to be tested were that:

1. TCA's would create an environment which would discourage certain segments of general aviation from use thereof. This result would manifest itself by a change in user profile from the typical general aviation mix at a non-TCA airport to one that favored business and executive aircraft.
2. Because of the change in population mix and the greater amount of time required to effect IFR procedures some reduction in primary airport operations would be expected.
3. Because of the need to buy and maintain additional avionics equipments it was expected that secondary and overflight operations would also show similar changes in user profile and operations.

The overall study requirements can,therefore, be expressed in terms of the following specific objectives or goals:

1. Establish the general aviation user profile for airports with Group I TCA's, airports with Group II TCA's, and airports without TCA's.
2. Develop a time series comparison of general aviation primary airport operations for the three different types of TCA airports.
3. Develop user profiles and time series comparisons of secondary and overflight operations in terminal area airspace for each of the three types.
4. Integrate results obtained from the first three goals and develop a model which can be used to describe and predict the effects of expansion at existing TCA sites or extension of TCA's to other large hubs.
5. Apply the model at selected large hub airports.

E. Study Approach

The report documents in detail the specific steps taken and results obtained in pursuit of the foregoing goals. These basic operative steps are briefly described in the following paragraphs.

In order to establish the general aviation user profile for each of the airports it was first necessary to conduct an on-site survey thereof. At each airport an observer was stationed in the tower cab for a 24 hour period to observe and record general aviation activity. TRACON's were also visited at airports with TCA's to gather additional general aviation activity data. Details of the survey effort are presented in Appendix A.

Historical data on general aviation operations for time series analysis was extracted from a series of documents published by the FAA. Data was compiled for the five-year period 1970 through 1974. Details of this step are presented in Appendix C.

The data collected was then aggregated and displayed in graphical form for analysis. Analysis consisted principally of comparisons between appropriate graphs to infer the effects of the TCA's. These effects were used to test our hypotheses about the probable effect of TCA's. Those hypotheses, accepted, modified, or rejected as appropriate constituted the study findings.

The study findings were suitably combined to form a model which can be applied against currently available operations statistics to forecast the effects on general aviation activity of establishing new TCA's.

Finally, the model was demonstrated and applied to 25 large hub airports in order to develop specific forecasts of general aviation activity at those airports in the event that Group I TCA's are established there. Results of the exercise are included in the report.

II ANALYSIS

A. Primary Use Categories

The first part of our basic hypothesis contained the premise that TCA procedures would affect different general aviation user classes in different ways. Moreover, it was postulated that the different effects would be reflected by different user populations at the different category airports. The following discussion expands those ideas and shows how our survey of aircraft types can be equated to aircraft use categories.

The most recent issue of Census of U.S. Civil Aircraft, Calendar Year 1973 in Table 20 thereof shows 8 user categories for general aviation aircraft which are listed below:

Executive Transportation
Business Transportation
Personal
Aerial Application
Instructional
Industrial Special
Rental
Other

By definition, executive transportation means aircraft that are professionally flown. Such aircraft are usually operated in an IFR mode, are well equipped, and probably unaffected by TCA requirements.

Aircraft used in business transportation are typically owner flown or at least piloted by someone who has primary duties other than piloting the aircraft. Aircraft in this category are usually well equipped and may be regularly flown under instrument flight rules. TCA requirements probably impose a modest restraint on this type of flying.

Aircraft primarily used for personal flying are a mixed bag ranging from single place, no radio antiques to superbly equipped multi-engine turbo jets. However, it is our judgment that aircraft not used primarily for business would, on the average, not be particularly well equipped. Often their owners would not be IFR qualified either, thus the effect of TCA requirements is probably substantial on this group.

Aircraft used for aerial application would not in general be equipped to operate in TCA areas.

Instructional aircraft are also a diverse group ranging from 2 seat primary trainers to completely IFR equipped multi-engine airline type aircraft. The majority of instructional aircraft would, however, be two seaters of the Cessna 150 or Cherokee 140 variety. These small aircraft are most commonly used for primary flight training and inasmuch as student pilots are prohibited from landing and taking off from certain TCA airports it is likely that TCA requirements have a severe effect on this category of operations.

Industrial Special aircraft would not generally be operated in a TCA environment.

Rental aircraft are usually single engine aircraft flown for business or personal use. As a group they are probably well enough equipped for TCA operations. Pilots who rent aircraft, however, would often be infrequent flyers, consequently the more complex operational environment of the TCA probably tends to discourage this group of pilots from using the TCA airspace.

Table 2, following, is an abridged and summarized version of a table prepared by Aviation Data Services, Inc.*/ which shows the distribution of each aircraft type's flying hours across the various user classes.

An examination of Table 2 in light of our foregoing remarks about probable TCA impact shows that the user categories to the right of the Business/Executive use column are the most apt to be affected by the presence of a TCA. Since most of the single-engine (3 seats or less) aircraft are in the right hand columns it follows that these aircraft will be operated less frequently at TCA primary airports than at non-TCA airports. Single-engine aircraft with more than three seats are also, by the same reasoning, apt to be found less frequently at TCA primary airports than at non-TCA airports. In this case, however, the numbers of Table 2 suggest that the effect will be less pronounced than in the case of single-engined aircraft with 3 seats or less. Multi-engine (piston powered) aircraft are, according to Table 2, used mostly for business/executive travel purposes and multi-engine (turbine powered) are used almost exclusively

*/ Table 5 from General Aviation Cost Impact Study, by Battelle-Columbus, 505 King Avenue, Columbus, Ohio; June, 1973.

TABLE 2

HOURS OF SERVICE BY USER CATEGORY a/

	Total	Bus./ Exec.	Pers.	Aerial App.	Instr.	Indus. Spec.	Rental	Other
Single-Engine(3 seats or less)	7116193	283049	1966480	1221404	2490817	260723	767079	126641
Single-Engine(more than 3 seats)	13056848	3529437	5506194	27840	2269748	271262	1299602	152765
Multi-Engine(piston powered)	3888046	3026488	366295	36121	159958	137585	78068	83531
Multi-Engine(turbine powered)	1173122	1095295	14190	---	936	7407	2017	53277
Total	25234209	7934269	7853159	1285365	4921459	676977	2146766	416214

a/ Does not include air taxi operations

for that purpose. Consequently, one would not expect to see much diversion of multi-engined aircraft as a result of TCA implementation.

The foregoing discussion is intended to support the notion that one can equate expected changes in the general aviation user population with changes in the general aviation aircraft population around a TCA primary airport. In summary, multi-engine turbine powered aircraft operations will be unaffected and may be expected to grow at rates prevailing had there been no TCA. Multi-engined piston powered aircraft used in general aviation operations would be slightly reduced owing to some of their number being used for personal transportation. General aviation single engine aircraft with more than 3 seats would be operated much less frequently in a TCA environment that would otherwise be the case, and single engine aircraft with 3 seats or less employed in general aviation operations could be expected to almost disappear in a TCA environment.

With the changes forecast in the preceding paragraph it is easy to see that a substantial shift in aircraft mix among the four types (single engine, 3 seats or less; single engine, more than 3 seats; multi-engine, piston; and multi-engine, turbine) could be expected with the introduction of a TCA at an airport. In particular, the general aviation aircraft profile at a non-TCA airport would be expected to have more single engine than multi-engine operations. At a TCA airport, however, one might well see more multi-engine than single engine operations. It has been necessary to express the hypothesis about general aviation user classes in terms of aircraft categories because the survey data described in Appendix A was for aircraft categories rather than flight purpose. The next section shows how the empirical data of Appendix A supports the translated hypothesis about the effect of a TCA on various user classes.

B. Data Display by Airport and TCA Type

The aircraft activity survey data described in Appendix A is shown (aggregated into 4 categories) by airport in Table 3 and by type of TCA in Table 4.

TABLE 3

GENERAL AVIATION ARRIVAL COUNT SUMMARY (BY AIRPORT)

	SINGLE ENGINE		MULTI ENGINE		
Airport	1 - 3 Place	More Than 3 Place	Piston Engines	Turbine Engines	Total Sample Operations
San Diego (Percent)	18 (13.7)	67 (51.2)	35 (26.7)	11 (8.4)	131 (100)
Phoenix (Percent)	121 (27.3)	206 (46.4)	92 (20.7)	25 (5.6)	444 (100)
Las Vegas (Percent)	76 (16.8)	251 (55.0)	85 (18.6)	44 (9.6)	456 (100)
Seattle (Percent)	5 (7.0)	43 (60.6)	19 (26.8)	4 (5.6)	71 (100)
San Francisco (Percent)	5 (4.0)	44 (35.2)	46 (36.8)	30 (24.0)	125 (100)
Los Angeles (Percent)	4 (3.7)	17 (15.9)	29 (27.1)	57 (53.3)	107 (100)

TABLE 4

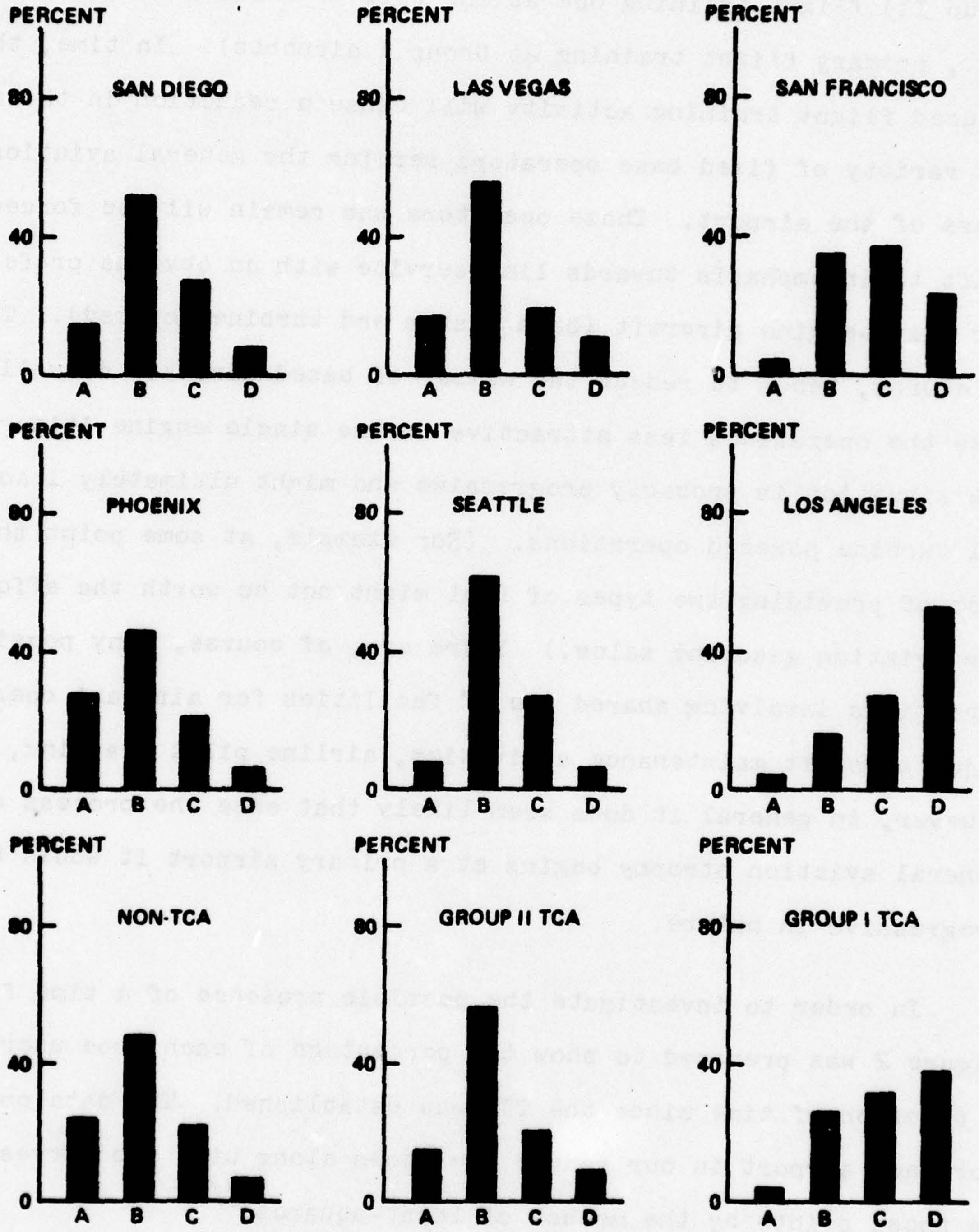
GENERAL AVIATION ARRIVAL COUNT SUMMARY (BY TCA TYPE)

Airport	SINGLE ENGINE 1 - 3 Place	SINGLE ENGINE More Than 3 Place	MULTI-ENGINE Piston Engines	MULTI-ENGINE Turbine Engines	Total Sample Operations
No TCA (Percent)	139 (24.2)	273 (47.5)	127 (22.1)	36 (6.2)	575 (100)
Group II TCA (Percent)	81 (15.4)	294 (55.8)	104 (19.7)	48 (9.1)	527 (100)
Group I TCA (Percent)	9 (3.9)	61 (26.3)	75 (32.3)	87 (37.5)	232 (100)

These combined traffic statistics for non-TCA, Group II TCA and Group I TCA airports are shown graphically in Figure 1.*/ An examination of Figure 1 shows a rather clear distinction between the three categories of airports. To be sure, the differences between non-TCA airports and airports with Group II TCA's are not as pronounced as the differences between Group II and Group I TCA airports; nonetheless, a pattern is clearly evident; that is, there is a marked shift in aircraft mix from non-TCA to Group II TCA to Group I TCA airports. There is also something else at work, however, which was not anticipated in the basic hypothesis and which must now be included. That is the element of time in the process of change. Upon reflection, it seems unlikely that the change in aircraft activity profile would occur instantly with the establishment of a TCA. Indeed it seems much more likely that the process would be gradual. Some possible reasons for this are given in the following paragraph.

*/ In both Group I and Group II airport categories the two airports of the sample are significantly different from one another.

FIGURE 1
GENERAL AVIATION ARRIVALS
(DISTRIBUTION BY AIRCRAFT CATEGORY)



LEGEND

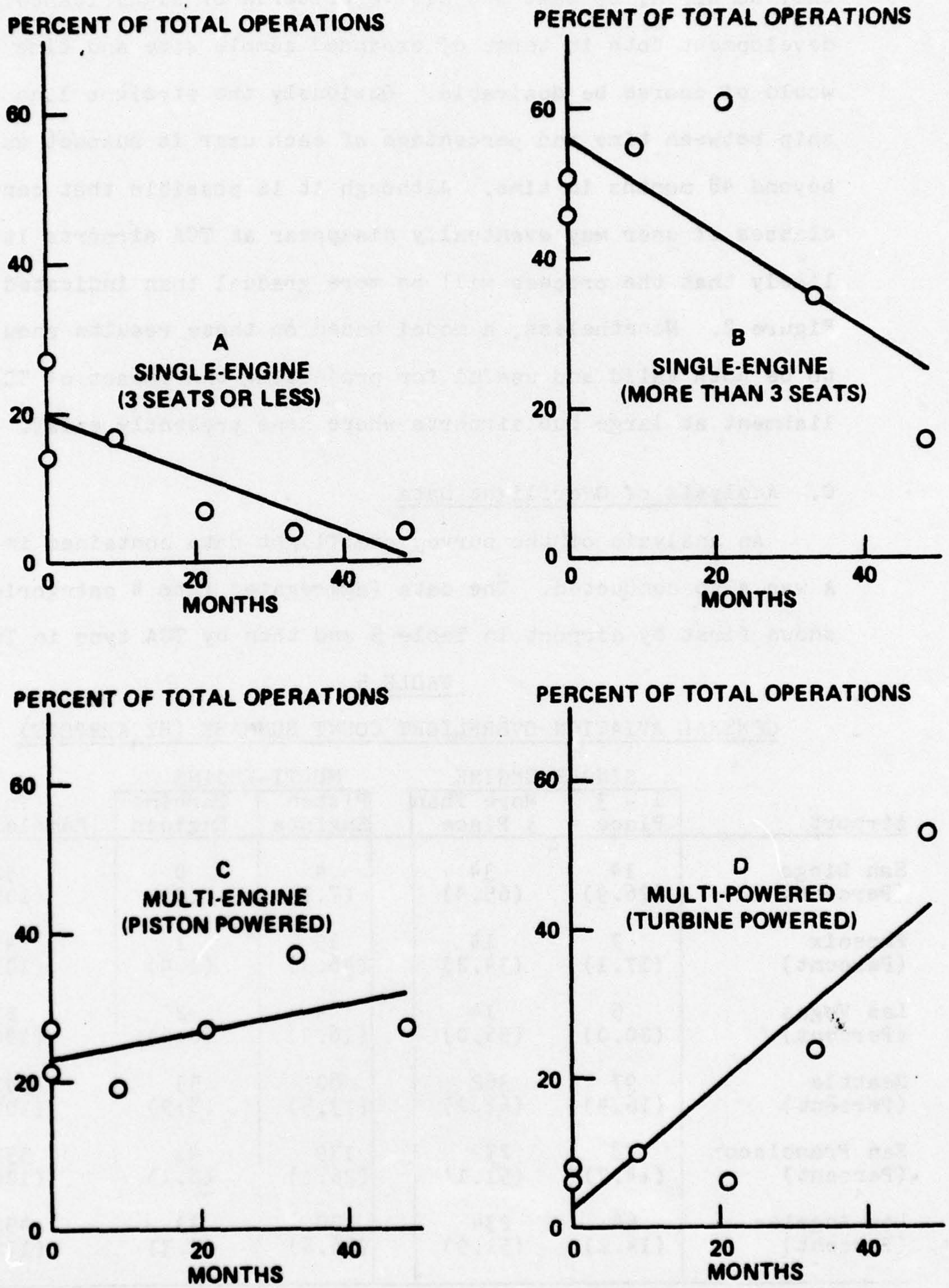
A ... SINGLE ENGINE (3 SEATS OR LESS)
B ... SINGLE ENGINE (MORE THAN 3 SEATS)
C ... MULTI-ENGINE (PISTON POWERED)
D ... MULTI-ENGINE (TURBINE POWERED)

Flight training operations are the backbone of many fixed base operations. With the establishment of a TCA (either Group I or Group II) flight training operations will be reduced if not eliminated (eg., primary flight training at Group I airports). In time, the reduced flight training activity will cause a reduction in the number and variety of fixed base operators serving the general aviation users of the airport. Those operators who remain will be forced to shift their emphasis towards line service with an obvious preference for multi-engine aircraft (both piston and turbine powered). This, of course, tends to reduce the number of based aircraft as well as make the operations less attractive to the single engine itinerant. The situation is probably progressive and might ultimately lead to all turbine powered operations. (For example, at some point the cost of providing two types of fuel might not be worth the effort for aviation gasoline sales.) There are, of course, many possible variations involving shared use of facilities for air taxi operations, major aircraft maintenance activities, airline pilot training, etc. However, in general it does seem likely that once the process of general aviation atrophy begins at a primary airport it would be progressive in nature.

In order to investigate the possible presence of a time factor, Figure 2 was prepared to show the percentage of each type user as a function of time since the TCA was established. The data points for each airport in our sample are shown along with the curves fitted to those points by the method of least-squares.[*/]

[*/] Details of this calculation are given in Appendix B

FIGURE 2
GENERAL AVIATION ARRIVAL OPERATIONS
VERSUS
MONTHS SINCE TCA ESTABLISHED



Although the curves are based on a small number of data points they do appear to meet subjective criteria of significance. Further development both in terms of expanded sample size and time horizon would of course be desirable. Obviously the straight line relationship between time and percentage of each user is suspect as we go beyond 48 months in time. Although it is possible that certain classes of user may eventually disappear at TCA airports it seems likely that the process will be more gradual than indicated by Figure 2. Nonetheless, a model based on these results should prove to be both valid and useful for projecting the impact of TCA establishment at large hub airports where none presently exist.

C. Analysis of Overflight Data

An analysis of the survey overflight data contained in Appendix A was also conducted. The data (aggregated into 4 categories) is shown first by airport in Table 5 and then by TCA type in Table 6.

TABLE 5

GENERAL AVIATION OVERFLIGHT COUNT SUMMARY (BY AIRPORT)

	SINGLE ENGINE		MULTI-ENGINE		
Airport	1 - 3 Place	More Than 3 Place	Piston Engines	Turbine Engines	Total Sample Operations
San Diego (Percent)	14 (26.9)	34 (65.4)	4 (7.7)	0 (0)	52 (100)
Phoenix (Percent)	7 (17.1)	14 (34.2)	19 (46.3)	1 (2.4)	41 (100)
Las Vegas (Percent)	5 (20.0)	14 (56.0)	4 (16.0)	2 (8.0)	25 (100)
Seattle (Percent)	97 (16.4)	362 (61.2)	80 (13.5)	53 (8.9)	592 (100)
San Francisco (Percent)	78 (14.7)	272 (51.1)	139 (26.1)	43 (8.1)	532 (100)
Los Angeles (Percent)	64 (14.2)	234 (51.9)	120 (26.6)	33 (7.3)	451 (100)

TABLE 6

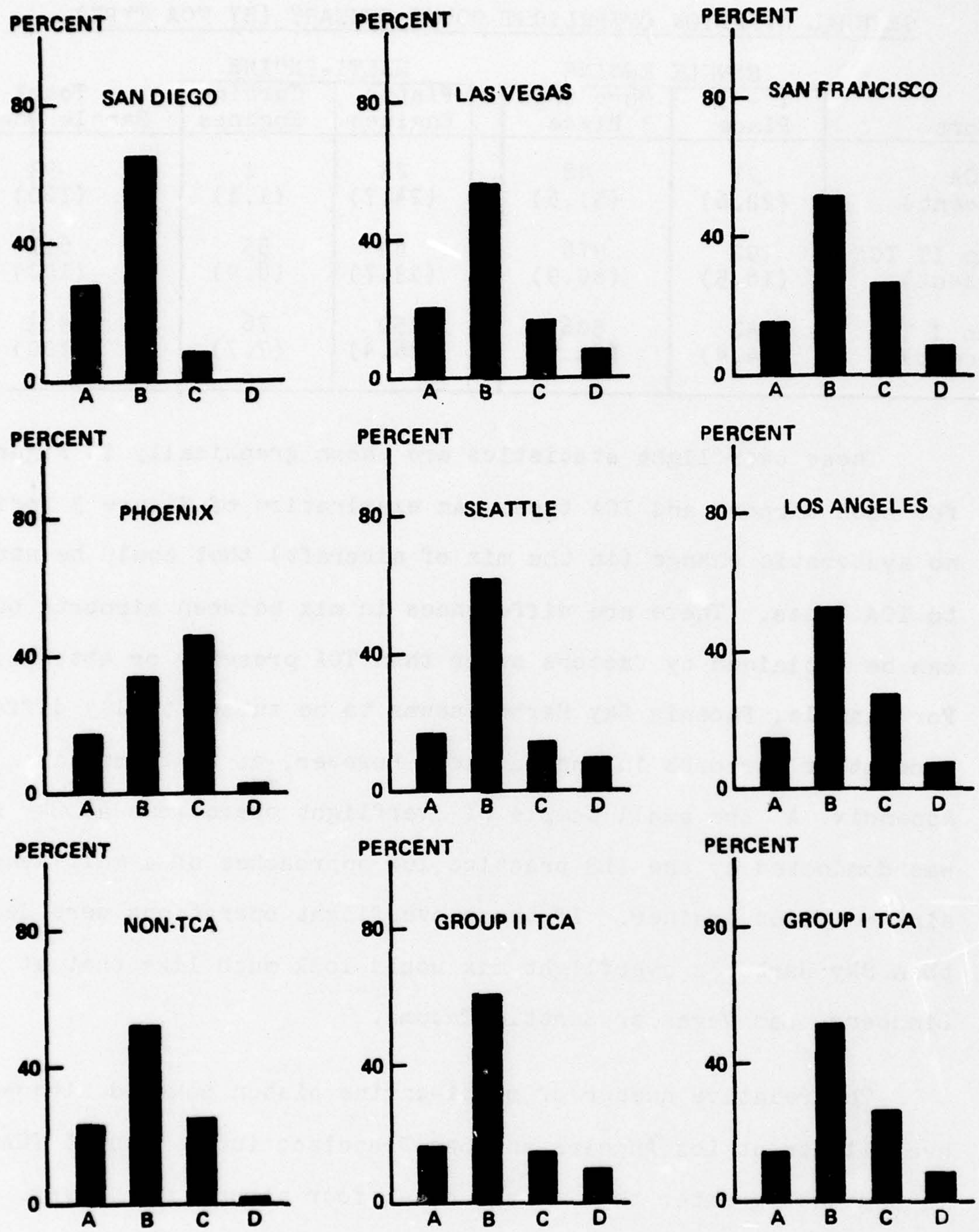
GENERAL AVIATION OVERFLIGHT COUNT SUMMARY (BY TCA TYPE)

Airport	SINGLE ENGINE 1 - 3 Place	SINGLE ENGINE More Than 3 Place	MULTI-ENGINE Piston Engines	MULTI-ENGINE Turbine Engines	Total Sample Operations
No TCA (Percent)	21 (22.6)	48 (51.6)	23 (24.7)	1 (1.1)	93 (100)
Group II TCA (Percent)	102 (16.5)	376 (60.9)	84 (13.7)	55 (8.9)	617 (100)
Group I TCA (Percent)	142 (14.4)	506 (51.5)	259 (26.4)	76 (7.7)	983 (100)

These overflight statistics are shown graphically in Figure 3 for each airport and TCA type. An examination of Figure 3 indicates no systematic change (in the mix of aircraft) that could be attributed to TCA types. There are differences in mix between airports but they can be explained by factors other than TCA presence or absence. For example, Phoenix Sky Harbor seems to be substantially different from other airports in the sample. However, as discussed in Appendix A the small sample of overflight operations at Sky Harbor was dominated by the ILS practice low approaches of a multi-engine airline pilot trainer. If those overflight operations were deleted then Sky Harbor's overflight mix would look much like that at Lindberg, Las Vegas or Seattle-Tacoma.

The relative number of multi-engine piston powered aircraft overflights at Los Angeles and San Francisco (both Group I TCA's) is somewhat greater than at the other four airports, however, a presumtion that this is caused by the TCA is not supported by a similar trend at the Group II airports.

FIGURE 3
GENERAL AVIATION OVERFLIGHTS
AND
SECONDARY OPERATIONS
(DISTRIBUTION BY AIRCRAFT CATEGORY)



LEGEND

A --- SINGLE ENGINE (3 SEATS OR LESS)
B --- SINGLE ENGINE (MORE THAN 3 SEATS)
C --- MULTI-ENGINE (PISTON POWERED)
D --- MULTI-ENGINE (TURBINE POWERED)

FIGURE 4
GENERAL AVIATION OVERFLIGHT AND SECONDARY OPERATIONS
VERSUS
MONTHS SINCE TCA ESTABLISHED

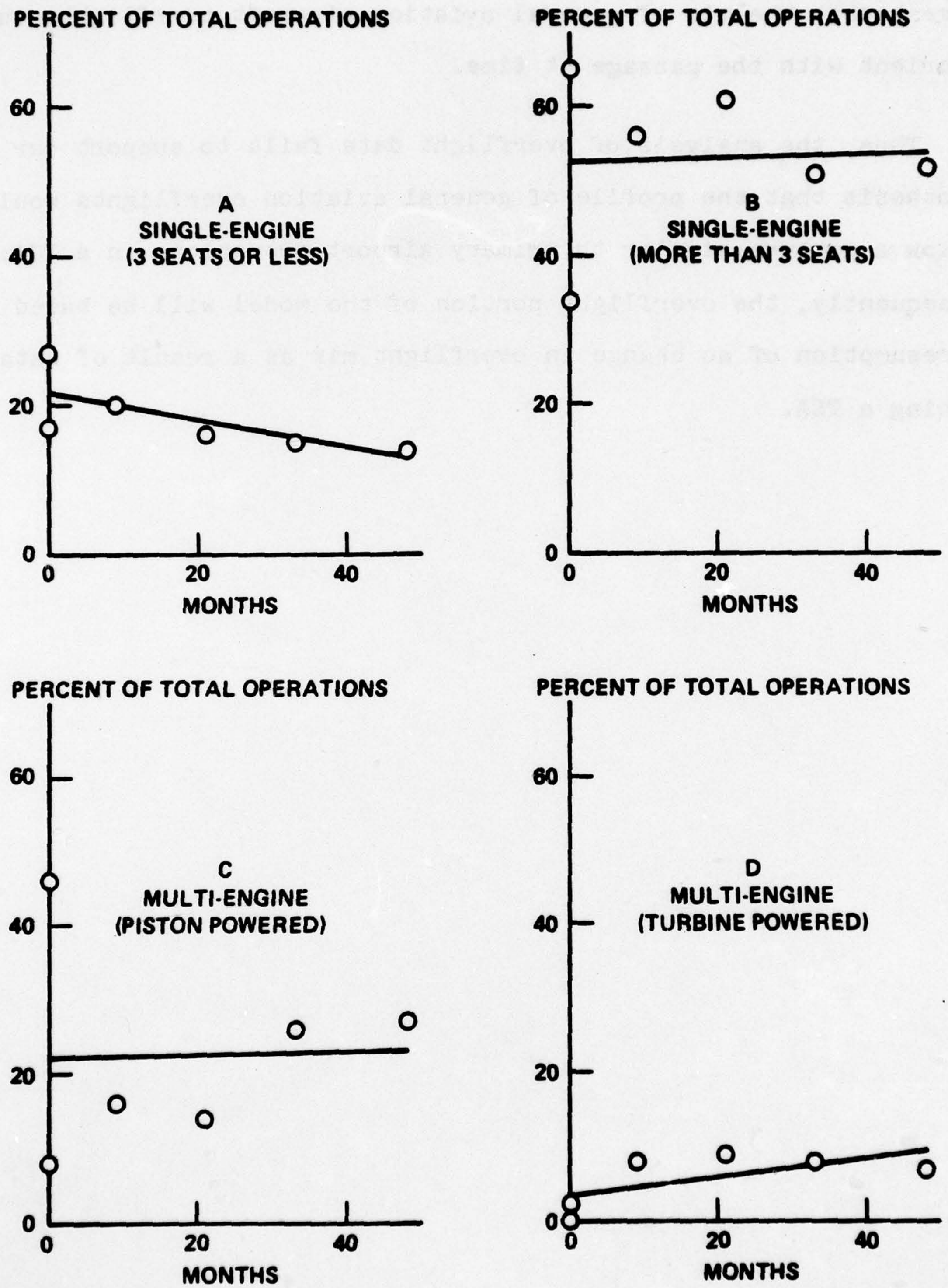


Figure 4 is an examination of the data for a possible relationship between the percentage of each type of general aviation overflight as a function of time since the TCA was established. Unlike Figure 2 for airport operations the data and curves of Figure 4 suggest that the mix of general aviation aircraft overflights is invarient with the passage ot time.

Thus, the analysis of overflight data fails to support our hypothesis that the profile of general aviation overflights would follow a pattern similar to primary airport operations in a TCA. Consequently, the overflight portion of the model will be based on a presumption of no change in overflight mix as a result of establishing a TCA.

D. Time Series Analysis of Airport and Overflight Operations

Although the foregoing results are worthwhile, they say little about the trend in total numbers of general aviation operations at TCA locations. Therefore, the purpose of this portion of the study was to test our hypothesis about the impact of TCA's on the number of general aviation operations. The procedure used consisted of a comparison of the five year trend in general aviation operations at each of the sample airports to the five year trend for all U.S. airports with FAA towers. The basic data and details of this comparative analysis are presented in Appendix C; however, the conclusions are presented and discussed below.

First, the introduction of TCA's around large hub airports has not affected the number of general aviation primary airport operations in any obvious way. These primary airport operations appear to have followed approximately the same year-to-year trend at TCA airports as at non-TCA airports with FAA towers. Second, the introduction of a TCA does have a marked effect on the total number of instrument operations*/ associated with the primary airport. In each case a sharp upward shift in the number of instrument operations was observed coincident with the establishment of the TCA. That sudden increase, however, can be explained by the fact that primary instrument operations increase to approximately equal airport operations because TCA operations are counted as IFR flights. With the exception of the jump at TCA start-up, the aggregate level of instrument operations at TCA airports seems to follow the national trend both before and

*/ Includes primary, secondary and overflight operations.

after the TCA is established. In terms of the study objectives this leads to the circumstantial conclusion that secondary and over-flight operations are not significantly affected by the presence or absence of a TCA.*/

III. MODEL DEVELOPMENT

The end purpose of the foregoing analysis is to be able to develop a model (or methodology) with which to predict future events, in particular, the effect upon general aviation operations of additional TCA's at large hubs. We have thus far developed the following facts:

1. The number of general aviation operations at the primary TCA airport is essentially unaffected by the presence of the TCA.
2. The profile of general aviation airport operations is progressively changed by the presence of a TCA in a manner that relates to how long the TCA has been in effect.
3. The number of reported general aviation over-flights and secondary operations is unaffected by establishment of the TCA.**/
4. The profile of general aviation over-flight and secondary operations is also unaffected by the presence or absence of a TCA.
5. As an ancillary result it has been demonstrated that the number of primary instrument operations at the hub airport of a TCA does (as expected) increase sharply with the establishment of the TCA.

*/ A five year trend analysis of just overflight and secondary operations could not be accomplished for reasons given in Appendix C.

**/ Unreported traffic in and around air carrier airports has, at times, been cited as a potential safety problem. However, there is no data, either historical or current, to be compared or analyzed with respect to such activity. In our opinion, unreported traffic is minimal around large hubs; consequently, that lack of data should not adversely affect this finding.

We now proceed to use those facts to develop the desired model. Referring to Figure 2 and the discussion attendent thereto we can estimate the general aviation user profile for an airport at various points in time between 9 and 48 months after establishment of a TCA. Table 7 following is a tabular presentation from the estimating relationships developed in Appendix B.

TABLE 7
(Percent of Total Operations)

CATEGORY(i)	MONTHS SINCE TCA ESTABLISHED (t) 12	24	36	48
Single Engine (3 seats or less)	14.67	9.94	5.21	.48
Single Engine (more than 3 seats)	48.18	40.47	32.75	25.04
Multi-Engine (Piston powered)	24.93	27.16	29.40	31.63
Multi-Engine (Turbine powered)	12.22	22.43	32.64	42.85

Since the number of general aviation airport operations follows national trends after establishment of a TCA it follows that we can project the number and profile of general aviation operations simply by applying the national growth factor and the percentages of Table 7 at each point in time out to 48 months. The model is:

$$pa_{it} = (PA)\ w_t\ (X_{it})$$

where pa_{it} = Primary airport general aviation operations in category i at time t.

PA = Total primary airport general aviation operations when the TCA is established.

w_t = Predicted average growth rate of general aviation airport operations at all airports with FAA towers.

X_{it} = Percentage of category i at time t (from table 7).

Overflight and secondary operations are predicted by the relationship:

$$OS_t = (OS_o)(y_t)$$

where OS_t = Overflight and secondary operations t months after the TCA is established.

OS_o = Overflight and secondary operations when the TCA is established.

y_t = Predicted average growth rate of general aviation instrument operations at all airports with FAA towers.

And finally the percentage increase in primary airport instrument operations is given by:

$$Z_{pi} = \frac{PA-PI}{PI} \times 100\%$$

where Z_{pi} = The percentage increase in primary airport instrument operations when the TCA is established.

PA = Total primary airport general aviation operations when the TCA is established.

PI = Primary instrument operations when the TCA is established.

The model inputs for PA, PI and OS_o are available in FAA air activity reports. Values for X_{it} have been developed in this study and are tabulated in Table 7. Values for w_t and y_t were calculated from data contained in Tables 11 and 14 of the FAA publication

"Aviation Forecasts Fiscal Years 1975-1986" of September 1974. These computed values are shown in Table 8 which follows.

TABLE 8

GENERAL AVIATION ACTIVITY GROWTH RATES

(Predicted Average Per FAA Tower)

FISCAL YEAR	w_t	y_t
1974	1.0000	1.0000
1975	1.0007	1.0731
1976	1.0659	1.1400
1977	1.1012	1.1858
1978	1.1394	1.4340
1979	1.1782	1.6863
1980	1.2060	1.8287

IV. APPLICATION

A. Additional TCA's

The model developed in the preceding chapter can now be used to forecast changes in general aviation activity attributable to new TCA's at large hubs. Certain assumptions are also necessary---first, all existing Group II TCA's will be upgraded to Group I TCA's; second, Group I TCA's will be established at large hubs that do not currently have TCA's; and, third, these upgrade and establishing actions will take place at the end of fiscal year 1976. The level of operations, both airport and instrument (primary, secondary and overs), at the start of the TCA are an extrapolation of calendar year 1974 actuals. The results are shown in Tables 9 and 10 following.

TABLE 9

PROJECTED AIRPORT OPERATIONS

Airport Hub Area	Calendar 1974	End Fiscal Year 1976	1977	1978	1979	1980
CHICAGO (ORD)	59674	63606	65713	67993	70308	71967
Single Engine(3 seats or less)			315	326	337	345
Single Engine(more than 3 seats)			16455	17025	17605	18021
Multi-Engine(piston powered)			20785	21506	22238	22763
Multi-Engine(turbine powered)			28158	29135	30127	30838
NEW YORK (LGA)	58938	62822	64903	67154	69441	71079
Single Engine(3 seats or less)			312	322	333	341
Single Engine(more than 3 seats)			16252	16815	17388	17798
Multi-Engine(piston powered)			20529	21241	21964	22482
Multi-Engine(turbine powered)			27811	28775	29755	30457
ATLANTA (ATL)	60415	64396	66529	68837	71181	72860
Single Engine(3 seats or less)			319	330	342	350
Single Engine(more than 3 seats)			16659	17237	17824	18244
Multi-Engine(piston powered)			21043	21773	22515	23046
Multi-Engine(turbine powered)			28508	29497	30501	31220
LOS ANGELES (LAX)	56467	60188	62181	64338	66529	68099
Single Engine(3 seats or less)			298	309	319	327
Single Engine(more than 3 seats)			15570	16110	16659	17052
Multi-Engine(piston powered)			19668	20350	21043	21540
Multi-Engine(turbine powered)			26645	27569	28508	29180
FT. WORTH, DALLAS (DFW)	17513	18667	19285	19954	20634	21121
Single Engine(3 seats or less)			93	96	99	101
Single Engine(more than 3 seats)			4829	4996	5167	5289
Multi-Engine(piston powered)			6100	6311	6526	6681
Multi-Engine(turbine powered)			8264	8550	8842	9050

TABLE 9 (Continued)

PROJECTED AIRPORT OPERATIONS

Airport Hub Area	Calendar	End Fiscal Year				
	1974	1976	1977	1978	1979	1980
WASHINGTON, D.C. (DCA)	74298	79194	81817	84655	87538	89603
Single Engine(3 seats or less)			393	406	420	430
Single Engine(more than 3 seats)			20487	21198	21919	22437
Multi-Engine(piston powered)			25879	26776	27688	28341
Multi-Engine(turbine powered)			35059	36275	37510	38395
MIAMI (MIA)	69785	74384	76847	79513	82221	84161
Single Engine(3 seats or less)			369	382	395	404
Single Engine(more than 3 seats)			19242	19910	20588	21074
Multi-Engine(piston powered)			24307	25150	26007	26620
Multi-Engine(turbine powered)			32929	34071	35231	36063
SAN FRANCISCO (SFO)	42271	45057	46549	48164	49804	50979
Single Engine(3 seats or less)			223	231	239	245
Single Engine(more than 3 seats)			11656	12060	12471	12765
Multi-Engine(piston powered)			14723	15234	15753	16125
Multi-Engine(turbine powered)			19946	20638	21341	21844
DENVER (DEN)	184293	196438	202943	209983	217134	222257
Single Engine(3 seats or less)			10573	1008	1042	1067
Single Engine(more than 3 seats)			66464	52580	54370	55653
Multi-Engine(piston powered)			59665	66418	68679	70300
Multi-Engine(turbine powered)			66241	89978	93042	95237
BOSTON (BOS)	46358	49413	51049	52820	54619	55908
Single Engine(3 seats or less)			245	254	262	268
Single Engine(more than 3 seats)			12783	13226	13677	13999
Multi-Engine(piston powered)			16147	16707	17276	17684
Multi-Engine(turbine powered)			21874	22633	23404	23957

TABLE 9 (Continued)

PROJECTED AIRPORT OPERATIONS

Airport Hub Area	Calendar 1974	End Fiscal Year 1976	1977	1978	1979	1980
HONOLULU (HNL)	106442	113457	117214	121280	125410	128369
Single Engine(3 seats or less)			17195	12055	6534	616
Single Engine(more than 3 seats)			56474	49082	41072	32144
Multi-Engine(piston powered)			29221	32940	36871	40603
Multi-Engine (turbine powered)			14324	27203	40934	55006
DETROIT (DTW)	70711	75371	77867	80568	83312	85277
Single Engine(3 seats or less)			4057	387	400	409
Single Engine(more than 3 seats)			25501	20174	20861	21353
Multi-Engine(piston powered)			22893	25484	26352	26973
Multi-Engine(turbine powered)			25416	34523	35699	36541
PITTSBURGH (PIT)	47603	50740	52420	54239	56086	57409
Single Engine(3 seats or less)			2731	260	269	276
Single Engine(more than 3 seats)			17168	13581	14044	14375
Multi-Engine(piston powered)			15411	17156	17740	18158
Multi-Engine(turbine powered)			17110	23241	24033	24600
PHILADELPHIA (PHL)	87203	92950	96028	99359	102743	105167
Single Engine(3 seats or less)			9545	5177	493	505
Single Engine(more than 3 seats)			38862	32540	25727	26334
Multi-Engine(piston powered)			26081	29212	32498	33264
Multi-Engine(turbine powered)			21539	32431	44025	45064
NEWARK (EWR)	36305	38697	39979	41366	42775	43784
Single Engine (3 seats or less)			192	199	205	210
Single Engine(more than 3 seats)			10011	10358	10711	10963
Multi-Engine(piston powered)			12645	13084	13530	13849
Multi-Engine(turbine powered)			17131	17725	18329	18761

TABLE 9 (Continued)

PROJECTED AIRPORT OPERATIONS

Airport Hub Area	Calendar 1974	End Fiscal Year 1976	1977	1978	1979	1980
ST. LOUIS (STL)	116743	124436	128557	133017	137547	140792
Single Engine(3 seats or less)			6698	638	660	676
Single Engine(more than 3 seats)			42102	33307	34442	35254
Multi-Engine(piston powered)			37796	42073	43506	44533
Multi-Engine(turbine powered)			41961	56998	58939	60329
MINNEAPOLIS (MSP)	83700	89216	92170	95368	98615	100942
Single Engine(3 seats or less)			4802	458	473	485
Single Engine(more than 3 seats)			30186	23880	24693	25276
Multi-Engine(piston powered)			27098	30165	31192	31928
Multi-Engine(turbine powered)			30084	40865	42256	43254
HOUSTON (IAH)	35439	37774	39025	40379	41754	42739
Single Engine(3 seats or less)			2033	194	200	205
Single Engine(more than 3 seats)			12781	10111	10455	10702
Multi-Engine(piston powered)			11473	12772	13207	13518
Multi-Engine(turbine powered)			12738	17302	17892	18314
CLEVELAND (CLE)	99954	106541	110069	113888	117766	120545
Single Engine(3 seats or less)			5735	547	565	579
Single Engine(more than 3 seats)			36048	28518	29489	30184
Multi Engine(piston powered)			32360	36023	37249	38128
Multi Engine(turbine powered)			35927	48801	50463	51654
SEATTLE (SEA)	21492	22908	23667	24488	25322	25919
Single Engine(3 seats or less)			1233	117	122	124
Single Engine(more than 3 seats)			7751	6132	6341	6490
Multi Engine(piston powered)			6958	7746	8009	8198
Multi Engine(turbine powered)			7725	10493	10850	11106

TABLE 9 (Continued)

PROJECTED AIRPORT OPERATIONS

Airport Hub Area	Calendar 1974	1976	1977	End Fiscal Year 1978	1979	1980
LAS VEGAS (LAS)	152044	162064	167431	173239	179138	183365
Single Engine(3 seats or less)			16643	9026	860	880
Single Engine(more than 3 seats)			67759	56736	44856	45915
Multi-Engine(piston powered)			45474	50932	56661	57998
Multi-Engine(turbine powered)			37555	56545	76761	78572
TAMPA (TPA)	78140	83289	86048	89033	92065	94237
Single Engine(3 seats or less)			12623	8850	4797	452
Single Engine(more than 3 seats)			41458	36032	30151	23597
Multi-Engine(piston powered)			21452	24181	27067	29807
Multi-Engine(turbine powered)			10515	19970	30050	40381
NEW ORLEANS (MSY)	39356	41950	43339	44842	46369	47463
Single Engine(3 seats or less)			4308	2336	223	228
Single Engine(more than 3 seats)			17539	14686	11611	11885
Multi-Engine(piston powered)			11771	13184	14666	15013
Multi-Engine(turbine powered)			9721	14636	19869	20338
KANSAS CITY (MCI)	24043	25627	26476	27395	28327	28996
Single Engine(3 seats or less)			2632	1427	136	139
Single Engine(more than 3 seats)			10715	8972	7093	7261
Multi-Engine(piston powered)			7191	8054	8960	9171
Multi-Engine(turbine powered)			5939	8942	12138	12425
NEW YORK (JFK)	25783	27482	28392	29377	30378	31094
Single Engine(3 seats or less)			136	141	146	149
Single Engine(more than 3 seats)			7109	7356	7607	7786
Multi-Engine(piston powered)			8980	9292	9609	9835
Multi-Engine(turbine powered)			12166	12588	13017	13324

TABLE 10

PROJECTED INSTRUMENT OPERATIONS

Airport Hub Area	Calendar 1974	End Fiscal Year 1976	1977	1978	1979	1980
CHICAGO (ORD)	132495	147530	153102	176038	199351	212788
Overflights & secondary oper.	85117	97033	100932	122058	143533	155653
Primary instrument oper.	47378	50497	52170	53980	55818	57135
NEW YORK (LGA)	95394	104373	108123	119420	130903	137731
Overflights & secondary oper.	36448	41551	43220	52266	61462	66652
Primary instrument oper.	58946	62822	64903	67154	69441	71079
ATLANTA (ATL)	129731	143387	148693	168199	188025	199571
Overflights & secondary oper.	69290	78991	82164	99362	116844	126711
Primary instrument oper.	60441	64396	66529	68837	71181	72860
LOS ANGELES (LAX)	128011	141983	147285	167855	188764	200880
Overflights & secondary oper.	74669	85123	88543	107075	125914	136547
Primary instrument oper.	53342	56860	58742	60780	62850	64333
FT.WORTH,DALLAS (DFW)	117028	132170	137348	162729	188529	203194
Overflights and secondary oper.	99564	113503	118063	142775	167895	182073
Primary instrument oper.	17464	18667	19285	19954	20634	21121
WASHINGTON, D.C. (DCA)	103581	112612	116577	126691	136970	143209
Overflights & secondary oper.	29314	33418	34760	42036	49432	53606
Primary instrument oper.	74267	79194	81817	84655	87538	89603
MIAMI (MIA)	189269	209201	216938	245302	274133	290928
Overflights & secondary oper.	100637	114726	119335	144313	169704	184035
Primary instrument oper.	88632	94475	97603	100989	104429	106983

TABLE 10 (Continued)

PROJECTED INSTRUMENT OPERATIONS

Airport Hub Area	Calendar 1974	End Fiscal Year 1976	1977	1978	1979	1980
SAN FRANCISCO (SFO)	45560	49535	51207	53797	56428	58162
Overflights and secondary oper.	3928	4478	4658	5633	6624	7183
Primary instrument oper.	41632	45057	46549	48164	49804	50979
DENVER (DEN)	186410	240580	248858	265509	282429	293066
Overflights & secondary oper.	38721	44142	45915	55526	65295	70809
Primary instrument oper.	147689	196438	202943	209983	217134	222257
BOSTON (BOS)	113597	126320	131071	150252	169748	181005
Overflights & secondary oper.	70670	80564	83800	101341	119171	129234
Primary instrument oper.	42927	45756	47271	48911	50577	51771
HONOLULU (HNL)	7741	113490	117248	121322	125459	128422
Overflights & secondary oper.	29	33	34	42	49	53
Primary instrument oper.	7712	113457	117214	121280	125410	128369
DETROIT (DTW)	174400	201556	209122	239296	269967	287694
Overflights & secondary oper.	110689	126185	131255	158728	186655	202417
Primary instrument oper.	63711	75371	77867	80568	83312	85277
PITTSBURGH (PIT)	119622	137361	142521	163199	184216	196359
Overflights & secondary oper.	75983	86621	90101	108960	128130	138950
Primary instrument oper.	43639	50740	52420	54239	56086	57409
PHILADELPHIA (PHL)	109138	168839	174965	194819	214998	226902
Overflights & secondary oper.	66569	75889	78937	95460	112255	121735
Primary instrument oper.	42569	92950	96028	99359	102743	105167

TABLE 10 (Continued)

PROJECTED INSTRUMENT OPERATIONS

Airport Hub Area	Calendar	End Fiscal Year				
	1974	1976	1977	1978	1979	1980
NEWARK (EWR)	46366	50503	52293	57122	62033	66112
Overflights & secondary oper.	14568	16608	17275	20890	24566	26640
Primary instrument oper.	31798	33895	35018	36232	37467	39472
ST. LOUIS (STL)	171086	193460	210405	231997	253941	267015
Overflights & secondary oper.	60547	69024	81848	98980	116394	126223
Primary instrument oper.	110539	124436	128557	133017	137547	140792
MINNEAPOLIS (MSP)	141113	158723	164469	182800	201430	212440
Overflights & secondary oper.	60971	69507	72299	87432	102815	111498
Primary instrument oper.	80142	89216	92170	95368	98615	100942
HOUSTON (IAH)	164633	185635	192827	226373	260472	279927
Overflights & secondary oper.	129703	147861	153802	185994	218718	237188
Primary instrument oper.	34930	37774	39025	40379	41754	42739
CLEVELAND (CLE)	158015	204245	211698	236789	262290	277274
Overflights & secondary oper.	85705	97704	101629	122901	144524	156729
Primary instrument oper.	72310	106541	110069	113888	117766	120545
SEATTLE (SEA)	97374	110820	115111	135072	155363	166941
Overflights & secondary oper.	77116	87912	91444	110584	130041	141022
Primary instrument oper.	20258	22908	23667	24488	25322	25919
LAS VEGAS (LAS)	33689	164524	169990	176334	182777	187311
Overflights & secondary oper.	2158	2460	2559	3095	3639	3946
Primary instrument oper.	31531	162064	167431	173239	179138	183365

TABLE 10 (Continued)

PROJECTED INSTRUMENT OPERATIONS

Airport Hub Area	Calendar 1974	End Fiscal Year 1976	1977	1978	1979	1980
TAMPA (TPA)	143641	179093	199653	226417	253620	269435
Overflights & secondary oper.	84039	95804	113605	137384	161555	175198
Primary instrument oper.	59602	83289	86048	89033	92065	94237
NEW ORLEANS (MSY)	93022	97617	101243	114866	128713	136760
Overflights & secondary oper.	48831	55667	57904	70024	82344	89297
Primary instrument oper.	44191	41950	43339	44842	46369	47463
KANSAS CITY (MCI)	64836	86093	89371	103454	117768	125990
Overflights & secondary oper.	53040	60466	62895	76059	89441	96994
Primary instrument oper.	11796	25627	26476	27395	28327	28996
NEW YORK (JFK)	38405	41322	42788	46786	50850	53294
Overflights & secondary oper.	12140	13840	14396	17409	20472	22200
Primary instrument oper.	26265	27482	28392	29377	30378	31094

B. TCA Expansion

Thus far the analysis has been concerned with the study of historical events for the purpose of predicting the impact of future events of similar kind. It is also necessary to consider the consequences of expanding existing TCA's---an event for which there is no historical precedent.

There are three principal ways in which a TCA might be enlarged.*/ It could grow upward (as is being done at Atlanta); it could be expanded horizontally without enclosing any additional airports (it might, however, overlie additional airports); or, it could grow downward to enclose additional airports now underlying the TCA.

The impact of these alternatives will be considered in order, starting first with TCA expansion in an upward direction. This study found no significant changes occuring in the number of overflights or the user profile of overflights as a result of TCA implementation. Consequently, if similar TCA regulatory provisions were maintained, the addition of TCA airspace vertically would have little or no effect on general aviation activity.**/

*/ The obvious combinations are also possible but will not be discussed herein.

**/ Regulatory provisions in mind allow VFR aircraft to cross the area. This can be accomplished with a VFR tunnel (such as at Los Angeles) or some VFR airspace between the top of the TCA and the bottom of the overlying positive control airspace. Other ways of providing for VFR traffic are no doubt also available. On the other hand if no provision is made for VFR traffic one can only speculate about the results. A large percentage of higher altitude general aviation users are no doubt already equipped for TCA operation, and should not be significantly affected. Some general aviation operators would probably circumnavigate the TCA area, divert or discontinue operations. Others would perhaps violate the TCA airspace, and others would no doubt upgrade to an IFR operation. Therefore, the net effect of an extension upward of TCA control with no provision for general aviation VFR traffic is unknown.

The second alternative for expansion would have the TCA grow horizontally, possibly overlying additional airports. Based on our time series analysis of general aviation activity in the TCA environment, the following impact might be anticipated. First, primary airport overflights and arrivals would probably be unaffected. The level of secondary operations would increase if additional airports underlying the TCA were instrument airports (such as Washington Dulles). On the other hand, if the underlying airports were VFR only and VFR access were maintained then secondary operations should not be affected. In either event, the activity level of general aviation operations would probably not be significantly reduced following horizontal expansion of the TCA.

Finally, if the TCA were to be lowered to include additional airports in the primary zone the analysis of likely effects is more complex. First of all, some general aviation users would be displaced.[a] Our study suggests that such displaced users would be rather quickly replaced by a different class of general aviation user. However, in the case of these secondary airports such replacement might not occur for two reasons. First, the primary airport would, in general, still be available to the business/corporate user and, second, some of these secondary airports might not be adequate landing sites for the heavier more sophisticated general aviation aircraft. Therefore, some reduction in total (VFR and IFR) terminal area activity levels is likely. While the magnitude of this reduction is a function of several speculative variables it can be estimated (for planning

[a] This conclusion is also consistent with an earlier study for the FAA(eg., see General Aviation Cost Impact Study, Vol.II, DOT, FAA June 1973, p. 67).

purposes) that surface TCA's would reduce the level of general aviation activity in the terminal areas of the 25 largest hubs by less than 10 percent.*/ Other effects can also be anticipated. First, there should be a significant jump in instrument arrivals/departures at these new TCA airports since all general aviation users remaining thereat would have to operate under Instrument Flight Rules. Second, there should be a progressive shift in the kind of user towards corporate and business aircraft if facilities are adequate. Moreover, if these new TCA airports are convenient for business/corporate travelers and if local airport authorities take steps to make these reliever airports attractive to prospective FBO's it seems most likely that considerable business/corporate traffic could be diverted from existing primary airports in the TCA.

One final implication of this third alternative should be discussed. If surface TCA's displaced less than 10 percent of all general aviation traffic in the large hub terminal areas, then, under the same set of assumptions, approximately 25 percent of the large hub general aviation users would elect to purchase the required suit of avionics equipment and continue operations.**/

*/ This estimate assumes that 60 percent of all general aviation users are not equipped for TCA operations; that TCA avionics requirements increase annualized fixed user costs by 10 percent; and, finally the 1973 Battelle elasticities of demand. See Appendix D for detailed analysis of this estimate.

**/ See Appendix D.

Once equipped, many of these operators might choose to relocate to the primary large hub airports.*/ Any significant increase in the level of general aviation traffic at some major commercial airports would have a detremental effect on airport delays.**/ Surface TCA's, in other words, might reduce the overall level of general aviation traffic in the terminal area (due to the demise of VFR traffic) but at a cost of increased delays to air carriers and other general aviation users at the larger commercial airports. Thus, marginal system costs of the surface TCA alternative might exceed the benefits provided.

In summary, three alternatives for expanded TCA implementation have been reviewed. These were:

(1) Expanding the TCA upward.

(2) TCA horizontal expansion.

(3) Expanding the TCA to the surface, enclosing additional airports.

*/ All things equal, general aviation users will choose airports for base operations on the basis of facilities and services offered. Frequently, the overall level of general aviation services at primary air carrier airports are superior to those at reliever airports. Consequently, in the absence of counter action by local authorities, the possibility of significant general aviation diversions to primary airports, under the conditions described, cannot be discounted.

**/ It has been observed that airport delay is an exponential phenomenon. That is, for an airport operating at capacity conditions, an increase in aircraft traffic will cause more than a proportional increase in delay. See FAA Report No. RD-67-70, <u>Alternative Approaches for Reducing Delays in Terminal Areas</u>.

Overall, the analysis has shown that TCA expansion via the first two alternatives could be expected to produce only modest effects if appropriate VFR alternatives are retained. The third alternative would reduce general aviation traffic in the terminal area by less than 10 percent. However, this alternative may be counter-productive from the system point of view in that it may precipitate additional costs (airport delays) to achieve desired benefits (reduced airspace congestion) in terminal areas. Consequently, we conclude that expansion of existing TCA's would be of doubtful benefit to the air transportation system.

V. SUMMARY AND CONCLUSIONS

The study was undertaken in order to accomplish the following tasks:

a. Examine the impact on general aviation of selected TCA implementation, differentiating between Type I and Type II TCA's.

b. Develop a methodology for predicting the impact on general aviation activity of new TCA's, or, in cases where Terminal Control Areas are already established, expanded TCA's.

c. Apply the methodology to all large hubs and forecast changes in general aviation activity attributable to new or expanded TCA's.

The analysis produced the following objective findings in response to the first task:

1. The establishment of a TCA (either Group I or Group II) does not appear to dramatically affect the total number of airport operations attributable to general aviation aircraft.

2. The presence of a TCA at a large hub airport is accompanied by a marked shift in the type of general aviation aircraft using the primary TCA airport. This shift is towards the more sophisticated, more expensive, primarily business orientated aircraft.

3. Overflight and secondary operations are not obviously affected by the presence or absence of a TCA.

4. The profile of general aviation overflight and secondary operations shows no correlation with the presence or type of TCA.

It appears that the rise in business/corporate aircraft activity has been sufficient to offset the diversion from TCA primary airports of instructional and personal use aircraft. Since the growth rates in business/corporate aircraft activity necessary to achieve that offset at TCA airports are well in excess of the business/corporate aircraft population growth rates, it follows that TCA's must attract aircraft of that type.*/ The fact that the additional traffic just balances the diversion of traffic probably reflects the availability of airport service facilities at these TCA airports.**/

In retrospect, the finding that reported overflight and secondary operations are not affected by the presence or absence of a TCA is not surprising because, to date, the TCA environment did not really constrain those operations. So long as VFR approaches are available for the secondary airports there would be no obvious reason for a mass shift to IFR for secondary operations. Overflight operations can also be conducted either IFR or VFR at the users option; thus, there would be no compelling reason to switch to IFR for these operations either.***/

*/ It should be noted that aircraft of this type tend to be compatible with air carrier aircraft, thus, are easier to work into the flow of traffic at these TCA airports. This may tend to reduce congestion and improve safety even though the number of operations was not affected.

**/ We believe that actions taken by local airport authorities which increase or decrease the amount of ground services for general aviation have affected the level of general aviation operations more than have TCA's.

***/ Even though TCA procedures for VFR overflights (usually over the top) and VFR secondary airport operations are perhaps inconvenient, they are still evidently preferable to IFR procedures for many operators.

The data and analyses which support the findings have been developed from study of a system that has certain basic characteristics. In particular, the size and location of TCA's has been such that reasonable alternatives were available to those who were unable or unwilling to operate in the TCA environment. Also the number of TCA's has been quite small in relation to the total number of airports available to general aviation. As long as these conditions continue, the model presented (which is a logical extension of the objective findings to non-TCA airports) should remain valid. The model so developed and applied to 26 large hub areas constitutes satisfaction of the second and third tasks with respect to the establishment of new TCA's.

With respect to expanding existing TCA's, we find that:

1. Expanding a TCA either upward or horizontally would have little effect on general aviation if reasonable VFR alternatives are retained.
2. Expanding a TCA down to the ground so as to include additional terminal area airports could produce contradictory results, the net effect of which would be of doubtful benefit to the national air transportation system.

Since these results were of necessity developed principally by subjective analysis, additional explanation is necessary.

It is our opinion that TCA's should serve two basic purposes. They should reduce the overall number of reported operations in the terminal and airport areas and they should separate IFR and known VFR traffic so that a more compatible mix of operations is obtained. During this study we have, however, noted two counter trends. First, the TCA environment seems to attract certain kinds of general aviation traffic and second there is some upgrading of VFR to IFR by other general aviation operators---an upgrading that probably reflects the operators perception of the relative inconvenience associated with following more complicated VFR procedures versus following TCA IFR procedures. The net effect seems to be that, to date, VFR terminal area activity may have been reduced somewhat, but, at the price of increased IFR activity. Since this pattern has evolved in a system that provides alternatives for VFR traffic around, over and under the TCA's, we believe that regulatory actions (such as expanding the TCA down to ground level around additional airports) which eliminate VFR alternatives may induce additional upgrading from VFR to IFR operations and add substantially to the ATC system workload---this at a time when the system is already showing signs of strain due to existing traffic loads.

These last two findings and associated comments complete the second and third tasks and thereby conclude the study.

APPENDIX A

SURVEY DATA

A. Procedure

In addition to reviewing published data it was necessary to conduct on-site surveys at TCA and non-TCA airports in order to acquire activity statistics by aircraft category.*/ The data obtained through surveys in the control tower cabs was stratified as it was recorded. The six categories recorded were single engine (3 seats or less); single engine (more than 3 seats); multi-engine (piston powered); multi-engine (turbo-prop); multi-engine (turbo-jet); and helicopter. In addition to the real time survey data a 24 hour data sample was taken from the IFR data strips**/ maintained by the TRACON at each TCA location. This information augmented the real-time tower counts and provided data on secondary and overflight operation.

*/ The Air Traffic Activity statistics do not subdivide the general aviation category by flight purpose and the "Census of U.S. Civil Aircraft" statistics do not show activity statistics by airport or terminal areas. Consequently, it was decided to conduct an on-site survey of a sample of TCA and non-TCA airports in order to acquire the necessary data.

**/ TRACON personnel prepare an IFR strip for each TCA operation (arrivals and departures, both primary and secondary as well as overflights). These strips are retained for 15 days and constitute a complete record of known activity in the TCA airspace. Consequently, 24 hour samples were reviewed and data as to aircraft make and model was extracted and recorded just as was done visually from the tower. The IFR strips also identify the operation as primary, secondary or overflight.

According to the "FAA Air Traffic Activity" report for calendar year 1974, (the most recent available) general aviation aircraft operations at airports with FAA operated control towers in the Western and Northwestern regions accounted for 28.7% of the United States total of such operations. There are two Group I TCA's (Los Angeles and San Francisco) and two Group II TCA's (Seattle and Las Vegas) in the Western and Northwestern regions. Those four airports along with two non-TCA airports (Phoenix and San Diego) were selected for the traffic profile survey. It was assumed that these airports would provide a typical profile of general aviation activity.

There are, however, some data anomalies and inconsistencies to be noted. At a non-TCA airport such as San Diego's Lindberg Field the airport control tower has cognizance and control of all of the traffic in the airport control zone including overflights. At the TCA airports and Phoenix Sky Harbor, however, all overflights except low approaches were worked by approach control rather than the tower. Very few overflight operations were recorded by the tower observer at the TCA airports. Phoenix Sky Harbor showed a number of overflights (low approaches) owing to the use of Litchfield Park (a few miles west of Phoenix) for airline pilot training. The data for Phoenix overflights is thus somewhat heavy on multi-engine piston powered aircraft. At the four TCA airports the problem was solved as noted earlier by going into the TRACON IFR strips and identifying overflight and satellite operations. This procedure produced good sized samples to work with for each of the TCA airports. Such an approach is not practical for non-TCA airports inasmuch as radar service is not provided on a 100% basis for all aircraft using the approach control airspace as it is in a TCA. The result is that the overflight data collected for Phoenix Sky Harbor and San Diego Lindberg Fields is only a subset of what would have been collected if those airports were surrounded by TCA's. It is our judgment that neither of those non-TCA samples is a representative subset; however, the data is processed for the sake of completeness.

Helicopter operations, other than air carrier, were infrequent and in most cases difficult to spot. It seems that helicopters, because of their unique flight characteristics, can be handled rather perfunctorily --- almost like ground vehicles moving about on the airport. There would be an occasional helicopter overflight in some part of the airport control zone which was accorded aircraft-like treatment; but, for the most part, helicopter operations were most conspicuous by their apparent absence. At any rate, the amount of general aviation helicopter information collected was so small as to be useless for our purposes.

B. Survey Data Summary

The data collected for 1334 arrival operations and 1693 overflight/secondary operations is shown in Tables A-1 through A-4 which follow.

TABLE A-1

TRAFFIC ACTIVITY COUNT SUMMARY (ARRIVALS)

(Tower Observations) a/

	SINGLE ENGINE		MULTI-ENGINE			
Airport & Date	1 - 3 Place	More Than 3 Place	Piston Engines	Turbo Prop	Turbo Jet	Total Tower
9/10/75 Phoenix	121	206	92	9	16	444
9/11/75 Las Vegas	33	114	40	17	9	213
9/15/75 Seattle-Tacoma	0	7	9			16
9/17/75 San Francisco	0	26	29	4	13	72.
9/19/75 Los Angeles	2	11	11	9	16	49
9/8/75 San Diego	4	19	12	0	2	37
9/23/75 San Diego b/	14	48	23	6	3	94

a/ Only arrivals were counted. On the average, arrivals equal departures. Total airport operations reported by FAA towers usually consist of arrivals plus departures plus overflights actually controlled by the tower.

b/ Two tower samples were taken at Lindberg Field because of unusually bad weather during the first 24 hour period.

TABLE A-2

TRAFFIC ACTIVITY COUNT SUMMARY (ARRIVALS)

(TRACON Observations)[a/]

Airport & Date	SINGLE ENGINE		MULTI-ENGINE			Total TRACON
	1 - 3 Place	More Than 3 Place	Piston Engines	Turbo Prop	Turbo Jet	
9/2/75 Las Vegas	43	137	45	3	15	243
9/15/75 Seattle-Tacoma b/	2	12	5	4		23
9/10/75 Seattle-Tacoma b/	3	24	5			32
9/11/75 San Francisco	5	18	17	6	7	53
9/12/75 Los Angeles	2	6	18	16	16	58

a/ The data from the TRACON files for the four TCA airports tended to validate and re-enforce our sampling procedure for tower observations. As noted earlier the IFR strips are coded to indicate primary operations (arrivals and departures at the primary airport) as well as overflight and satellite operations. Therefore, at each TCA primary airport arrival data for one or more additional 24 hour periods was recorded. This data, with one exception (Seattle-Tacoma) was very similar to that recorded by the tower observers for a 24 hour period. Thus, in addition to expanding the data base for TCA primary airports the TRACON data also supported the presumtion that the samples were typical.

b/ Weather conditions at Seattle-Tacoma Airport were unusually bad, even for the Northwest, on the day of the tower observation. Two TRACON samples were recorded which show some difference from the tower sample.

TABLE A-3

TRAFFIC ACTIVITY COUNT SUMMARY (OVERFLIGHTS)

(TOWER OBSERVATIONS)[a/]

Airport & Date	SINGLE ENGINE 1 - 3 Place	SINGLE ENGINE More Than 3 Place	MULTI-ENGINE Piston Engines	MULTI-ENGINE Turbo Prop	MULTI-ENGINE Turbo Jet	Total Tower
9/8/75 San Diego	0	11	3	0	0	14
9/23/75 San Diego	14	23	1	0	0	38
9/10/75 Phoenix	7	14	19	0	1	41
9/11/75 Las Vegas	3	9	0	0	1	13

TABLE A-4

TRAFFIC ACTIVITY COUNT SUMMARY (OVERFLIGHTS)

(TRACON Observations)[a/]

Airport & Date	SINGLE ENGINE 1 - 3 Place	SINGLE ENGINE More Than 3 Place	MULTI-ENGINE Piston Engines	MULTI-ENGINE Turbo Prop	MULTI-ENGINE Turbo Jet	Total TRACON
9/2/75 Las Vegas	2	5	4	0	1	12
9/10/75 Seattle-Tacoma	77	232	42	11	19	381
9/15/75 Seattle-Tacoma	20	130	38	13	10	211
9/11/75 San Francisco	78	272	139	29	14	532
9/12/75 Los Angeles	64	234	120	27	6	451

a/ In retrospect the TRACON IFR strips would seem to offer the most economical and complete source of information for TCA airports. For non-TCA airports tower counts provide the best source of information.

APPENDIX B

REGRESSION ANALYSIS

A. Arrivals

The arrival data collected during the survey described in Appendix A, when aggregated and plotted by TCA type, showed as much profile variation within each TCA type as between TCA types. After the data was normalized*/ and displayed as a function of how long each TCA had been in effect it appeared that a relationship existed between the percentage of arrival operations in a given aircraft category and the number of months since the TCA was established. Accordingly, a simple least squares regression was performed on the normalized arrival data in order to fit a linear curve to the data; a curve which could then be used as a means of calculating the expected number in each category of aircraft at discrete points in time after a TCA is established. The data used in the regression is shown in table B-1.

TABLE B-1

PERCENTAGE OF ARRIVALS BY AIRCRAFT CATEGORY

Airport	SINGLE ENGINE 1 - 3 Place	SINGLE ENGINE More Than 3 Place	MULTI-ENGINE Piston Engines	MULTI-ENGINE Turbine Engines	Months (t) Since TCA Established
San Diego	13.7	51.2	26.7	8.4	0 (No TCA)
Phoenix	27.3	46.4	20.7	5.6	0 (No TCA)
Las Vegas	16.8	55.0	18.6	9.6	9
Seattle	7.0	60.6	26.8	5.6	21
San Francisco	4.0	35.2	36.8	24.0	33
Los Angeles	3.7	15.9	27.1	53.3	48

*/ The number of aircraft operations in each category was expressed as a percentage of the total operations at each airport.

The resultant equations are as follows:

Percent Single Engine Aircraft (3 seats or less)= 19.39 - .394(t)

Percent Single Engine Aircraft (more than 3 seats) = 55.9 - .643(t)

Percent Multi-Engine Aircraft (piston powered) = 22.7 + .186(t)

Percent Multi-Engine aircraft (turbine powered)= 2 + .851(t)

Statistically, the linear form is not a particularly good fit, however, the small sample size makes the value of investigating more complex models questionable. Even though the fit is not especially good it does capture the major trends, ie., the replacement of the small single engine aircraft by the larger multi-engine type.

B. Overflight and Secondary Operations

The overflight and secondary operations data was then given the same treatment as the arrival data. In this case, however the results do not provide a convincing pattern of change with time. The data used in this regression is shown in Table B-2.

TABLE B-2

PERCENTAGE OF OVERFLIGHTS BY AIRCRAFT CATEGORY

	SINGLE ENGINE		MULTI-ENGINE		
Airport	1 - 3 Place	More Than 3 Place	Piston Engines	Turbine Engines	Months (t) Since TCA Established
San Diego	26.9	65.4	7.7	0.0	0 (No TCA)
Phoenix	17.1	34.2	46.3	2.4	0 (No TCA)
Las Vegas	20.0	56.0	16.0	8.0	9
Seattle	16.4	61.2	13.5	8.9	21
San Francisco	14.7	51.1	26.1	8.1	33
Los Angeles	14.2	51.9	26.6	7.3	48

The equations resulting from this regression are as follows:

Percent Single Engine Aircraft (3 seats or less) = 21.51 - .178(t)

Percent Single Engine Aircraft (more than 3 seats) = 52.8 + .027(t)

Percent Multi-Engine Aircraft (piston powered) = 22.2 + .025(t)

Percent Multi-Engine Aircraft (turbine powered) = 3.47 + .126(t)

Although the linear models do show some change due to the time factor it is not considered significant for reasons which follow. It was noted in Appendix A that the data samples for the non-TCA airports were not comparable in size to the samples taken at the TCA airports.*/ It was further argued that the samples obtained at both non-TCA airports were probably not representative. By normalizing the data to percentages before performing the regressions we have given equal weight to all airports regardless of the number of observations obtained there at. Consequently, we have tempered the regression results by visual inspection of the last 4 lines of Table B-2. Those entries suggest no rational pattern of change with time; hence, the conclusion that the profile of overflight activity is probably invariant with time.

*/ An average of 46 observations per non-TCA airport as opposed to 400 per TCA airport.

APPENDIX C

TIME SERIES DATA ANALYSIS

A. Historical Data Sources

Three publications constituted the source of historical general aviation operational data.*/ These included:

1. Aviation Forecasts, Fiscal Years 1975-1986
2. Census of U.S. Civil Aircraft**/
3. FAA Air Traffic Activity***/

In addition, the following FAA data sources were examined:

1. Military Air Traffic Forecasts
2. Terminal Area Forecasts
3. Aviation Statistics Handbook
4. IFR Aircraft Handled at ARTC Centers

*/ In general these data files provide a satisfactory source for our purpose. It should be noted, however, that prior to 1972 air taxi operations were included with general aviation itinerant operations. Also, there is some time lag in the preparation and distribution of the reports, hence no data for calendar year 1975 is yet available. Because of the fact that air taxi operations were not always shown separately, it is necessary to show our time series comparison of airport operations as the aggregate of general aviation plus air taxi rather than as general aviation alone. Likewise for instrument operations, the time series comparisons are for the aggregate quantity of general aviation plus air taxi.

**/ Data in this series is derived from owner supplied answers to the annual Aircraft Registration Eligibility, Identification, and Activity Report. The current reporting system has only been in effect since 1970; hence, earlier data is not directly comparable.

***/ These statistics (for both airport and instrument operations) are compiled and published each six months as FAA Air Traffic Activity statistics. These publications are the source of data for the time series comparisons developed in this Appendix.

However, these four publications did not appear to contain any additional data which would be relevent to the study; consequently, were not used.

B. Data for Airport Operations*/

Table C-1 below presents the data**/ used as the baseline trend for general aviation operations at all FAA towered airports.

TABLE C-1

GENERAL AVIATION AIRPORT OPERATIONS

(All FAA Towered Airports)

	1970	1971	1972	1973	1974
Total General Aviation a/	41384006	40400593	38171922	41363042	43123407
Total Air Taxi b/			2042068	2227945	2582218
Number FAA Towers c/	331	343	348	362	394
Average General Aviation	125027	117786	109689	114262	109450
Average Air Taxi			5868	6154	6554

a/ The sum of local plus itinerant operations by calendar year.

b/ By calendar year. Prior to 1972 air taxi operations were counted as general aviation.

c/ By fiscal year.

*/ Because the first TCA was established in 1970 and because the current reporting basis for the Census of U.S. Civil Aircraft was established in 1970 it was decided to limit the study data base to the 1970 through 1974 time period.

**/ Extracted from Table 4, FAA Air Traffic Activity reports, calendar years 1970 through 1974.

Table C-2 shows similar data for each airport in the study sample.

TABLE C-2

GENERAL AVIATION AIRPORT OPERATIONS

(By Tower)

	1970	1971	1972	1973	1974
Los Angeles					
General Aviation a/	119941	111832	56055	58086	56467
Air Taxi b/			50284	50787	57711
San Francisco					
General Aviation a/	74121	74496	49554	42234	42271
Air Taxi b/			12371	11714	18100
Seattle-Tacoma					
General Aviation a/	45095	39089	23660	21376	21492
Air Taxi b/			17028	19368	31654
Las Vegas					
General Aviation a/	119336	100579	94101	115851	152044
Air Taxi b/			4435	2749	16741
San Diego					
General Aviation a/	125713	115914	105908	102082	104449
Air Taxi b/			6837	7292	8828
Phoenix Sky Harbor					
General Aviation a/	258193	265810	274156	259136	312632
Air Taxi b/			6644	7742	9010

a/ The sum of local plus itinerant operations by calendar year.

b/ By calendar year. Prior to 1972 air taxi operations were counted as general aviation.

C. Analysis of Airport Operations

The method of analysis consists of a comparison of the trend in operations at each of the sample airports to the baseline trend which is the average for all FAA towered airports. Figures C-1 through C-4, following, facilitate that comparison.

Figure C-1 shows the base line trend for all FAA towered airports. Data for that figure was taken from FAA activity reports for calendar years 1970 through 1974 and normalized to a per tower basis. This normalization was considered necessary in view of the increase in number of FAA towers over that time span.*/ Figure C-1 suggests that the sum of general aviation plus air taxi operations at towered airports has been relatively constant over the five year period.

Figures C-2 through C-4 show the equivalent trends for each of the airports under discussion. An analysis of those figures follows below.

At group I airports (Figure C-2) the trend lines do not exactly match the baseline trend shown in Figure C-1 but if the increased air taxi activity (above the national average) at the Group I airports is factored out the results become quite similar. Certainly there is no sharp change in the number of operations at each airport coincident with the establishment of the TCA. The most that could be said is that a small drop in operations occured followed by a recovery to a level that is consistent with the national trend.

*/ See Table C-1

FIGURE C-1
TOTAL GENERAL AVIATION AIRPORT OPERATIONS
(PER TOWER AVERAGE)

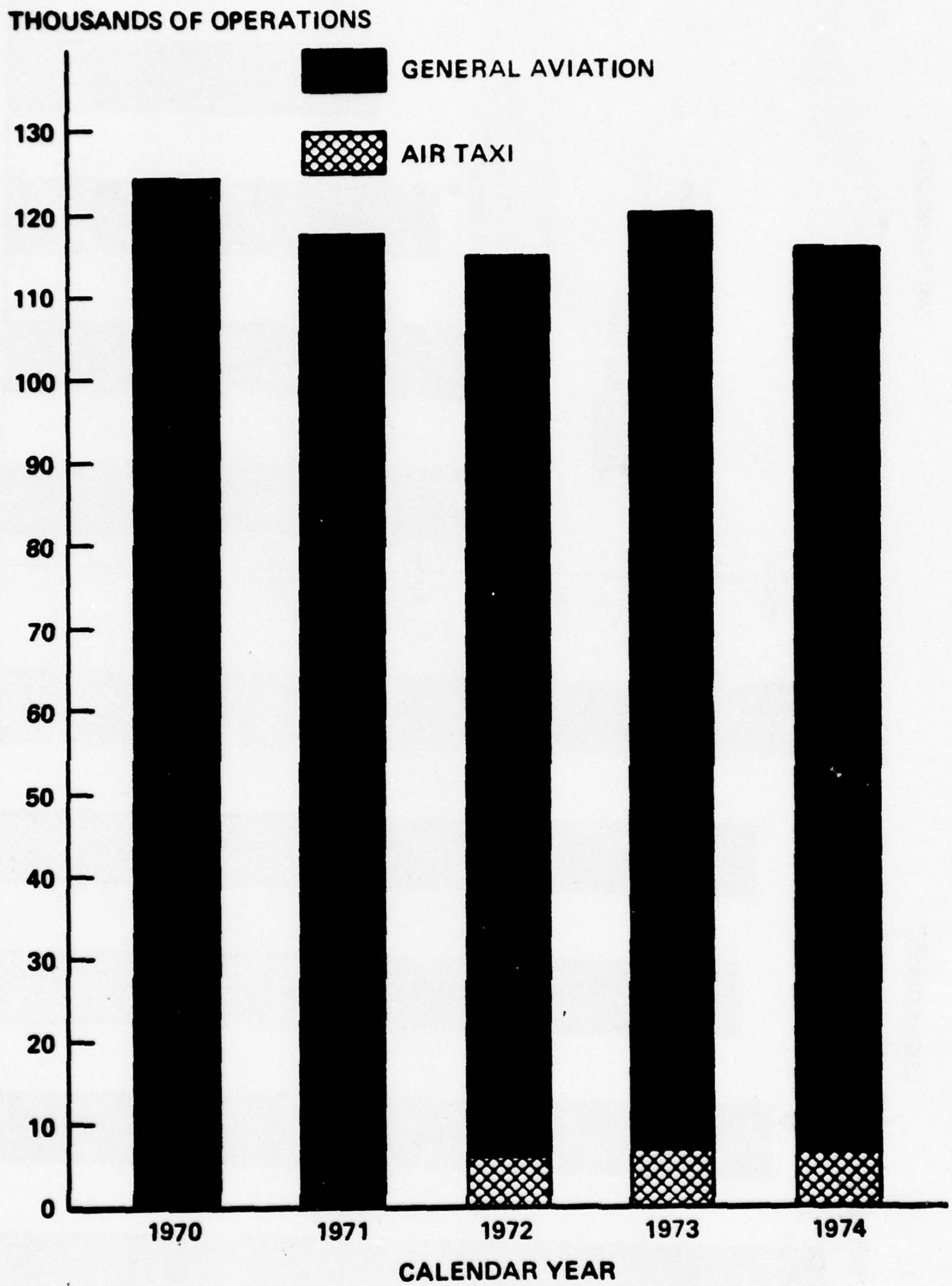


FIGURE C-2
GENERAL AVIATION AIRPORT OPERATIONS
GROUP I TCA's

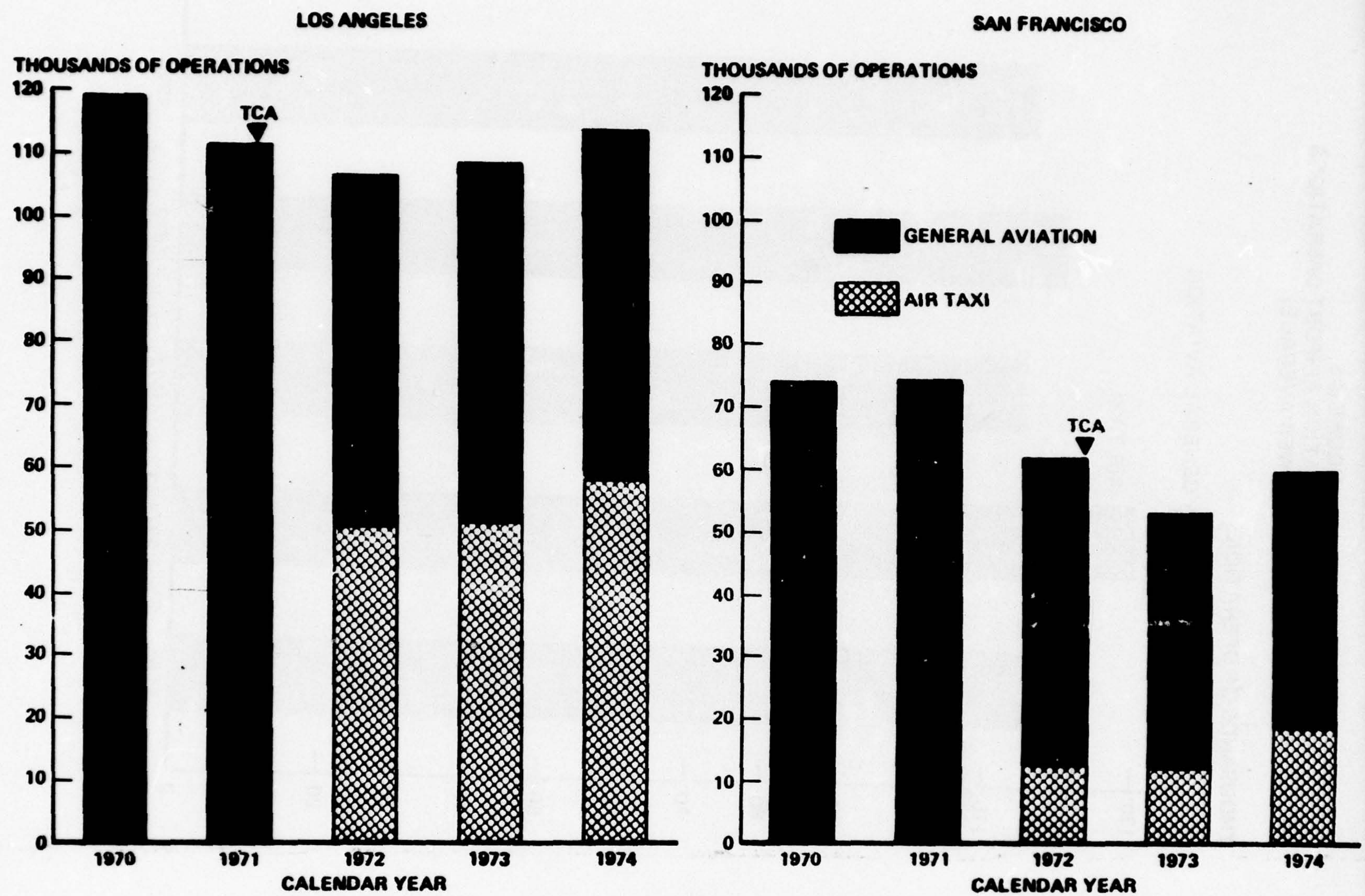
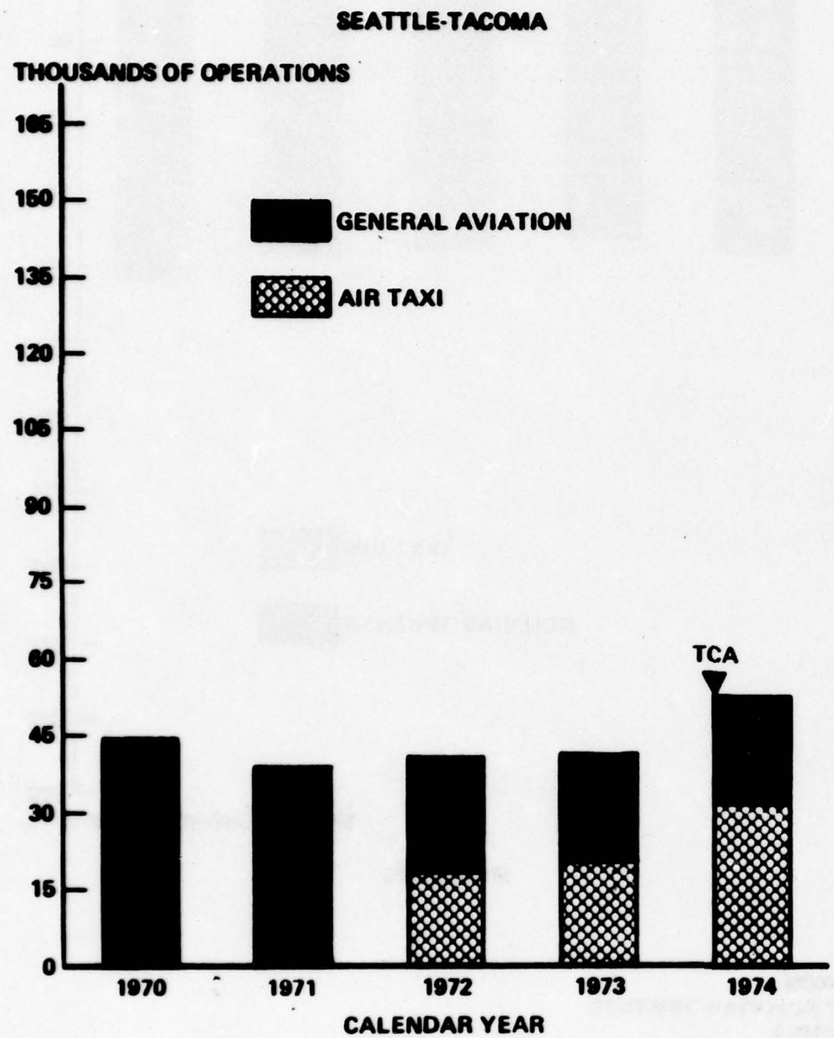


FIGURE C-3
GENERAL AVIATION AIRPORT OPERATIONS
GROUP II TCS's



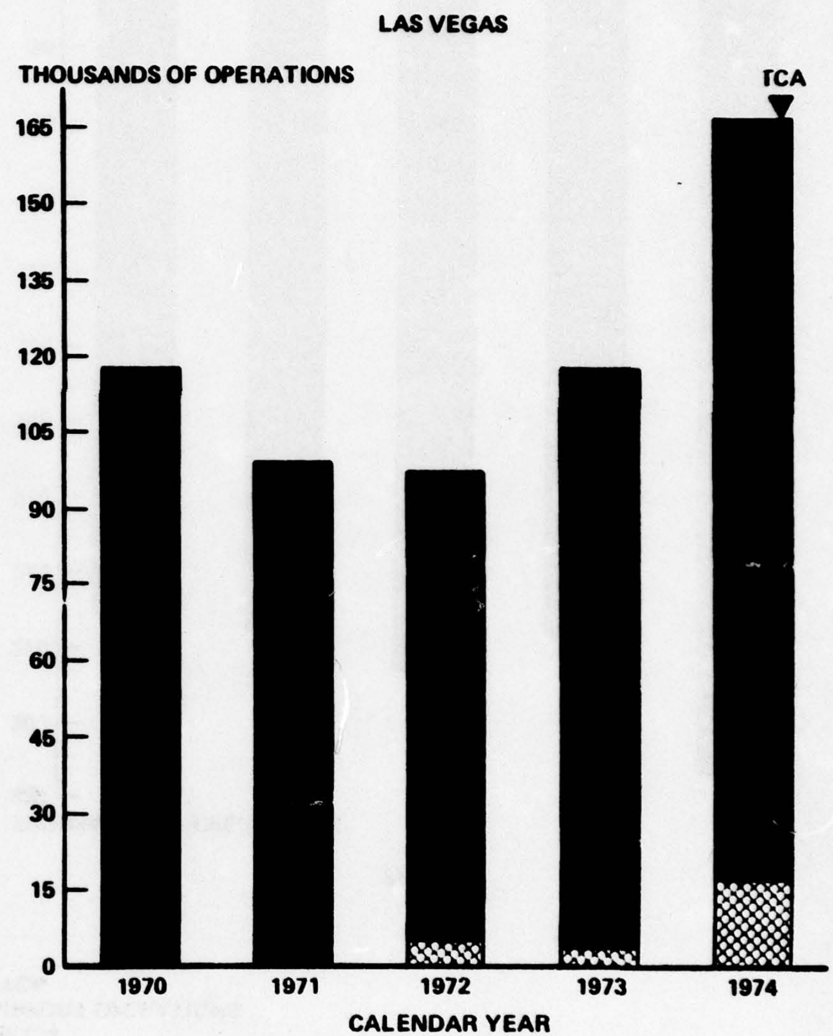
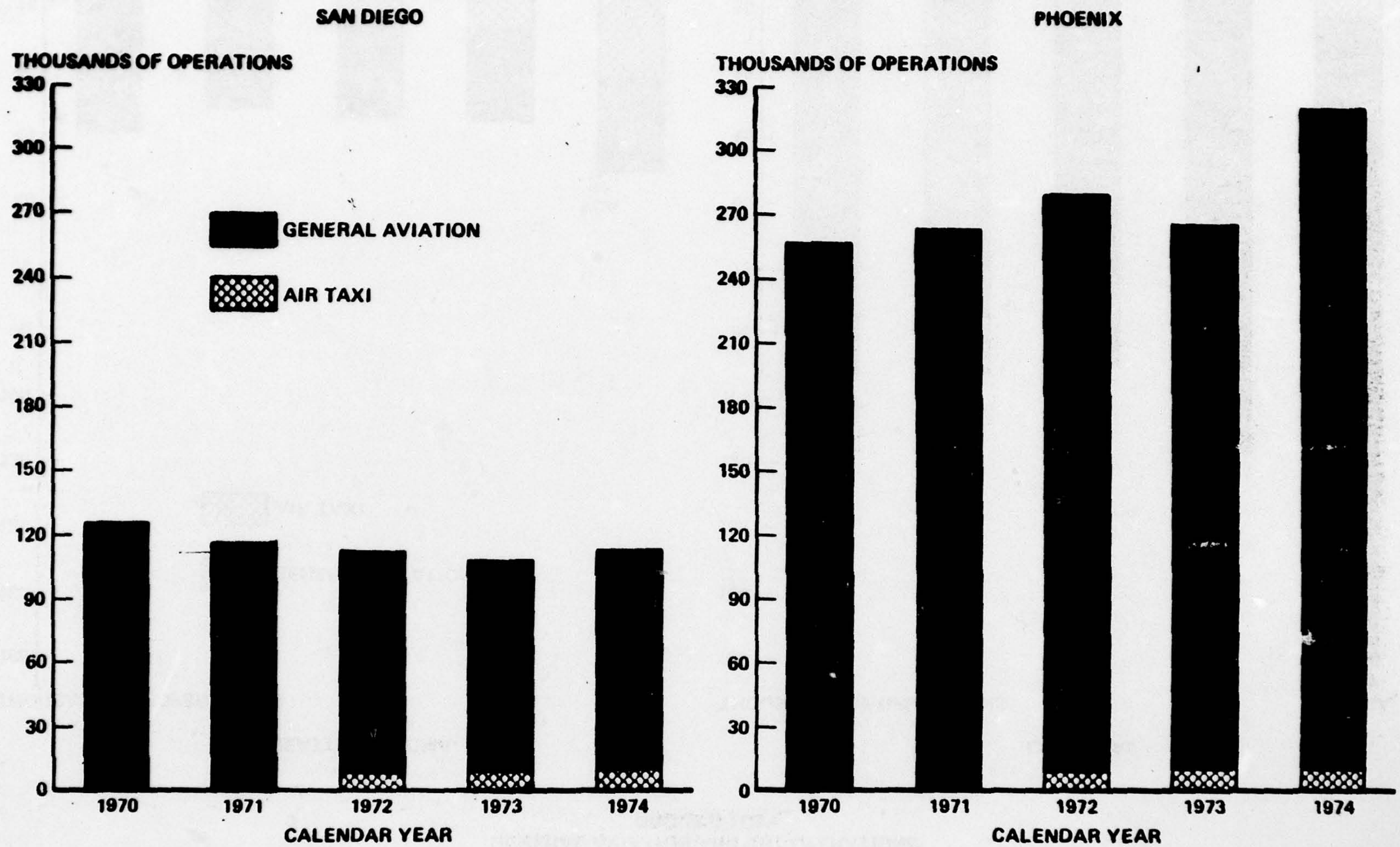


FIGURE C-4
GENERAL AVIATION AIRPORT OPERATIONS
NON-TCA



At Group II airports the trends appear to be somewhat different for calendar year 1974. In both cases (Figure C-3) there is a rather sharp increase in operations which appears to represent a significant departure from the national average. At Seattle-Tacoma, however, the increase can be attributed to increased air taxi activity; therefore, it is concluded that the introduction of the TCA did not cause any significant change in the level of general aviation operations. At Las Vegas the increase is mostly in general aviation, however, the data for Las Vegas may be inconclusive inasmuch as the TCA was not established until late 1974.

At the non-TCA airports (Figure C-4) the results are again mixed. The year-to-year trend at San Diego's Lindberg Field almost exactly parallels the national trend; however, Phoenix Sky Harbor is noticeably different from that baseline trend. Even so there is nothing in the data for those two airports to identify them as non-TCA airports.

Overall the conclusion must be that the introduction of TCA's around large hub airports has not affected the number of general aviation airport operations in any obvious way. General aviation airport operations appear to have followed approximately the same year-to-year trend at TCA airports as at non-TCA airports (with FAA towers).

D. Data for Overflight and Secondary Operations

Table C-3 following contains the data*/ used as the baseline trend for general aviation instrument operations at all FAA towered airports. Although the quantities of interest are overflights and

*/ Extracted from Table 9, FAA Air Traffic Activity reports, calendar years 1970 through 1974.

secondary operations it was not possible to obtain consistent five year data at that level of detail. Prior to 1972, overflights were included with primary instrument operations and air taxi flights were counted as general aviation operations. In order to get a five year comparison it was, therefore, necessary to work at the next higher level of aggregation, ie., total instrument operations.

TABLE C-3

GENERAL AVIATION INSTRUMENT OPERATIONS

(All FAA Towered Airports)

	1970	1971	1972	1973	1974
Total General Aviation a/	4297776	5174088	5986107	8624596	9928979
Total Air Taxi b/			986687	1289311	1674261
Number FAA Towers c/	331	343	348	362	394
Average General Aviation	12984	15085	17201	23825	25201
Average Air Taxi			2835	3562	4250

a/ The sum of primary plus secondary operations for calendar years 1970 and 1971. The sum of overflights, primary and secondary operations for calendar years 1972, 1973 and 1974.

b/ By calendar year as above except that prior to 1972 air taxi operations were included in the general aviation category.

c/ By fiscal year.

Table C-4 shows similar data for each individual airport in the study sample.

TABLE C-4

GENERAL AVIATION INSTRUMENT OPERATIONS

(By Tower)

	1970	1971	1972	1973	1974
Los Angeles					
General Aviation a/	82051	99128	113597	125875	128011
Air Taxi b/			51896	52446	60748
San Francisco					
General Aviation a/	17372	20065	12469	42234	45560
Air Taxi b/			3367	11714	18100
Seattle-Tacoma					
General Aviation a/	40834	42430	41895	76767	97374
Air Taxi b/			11149	19225	37815
Las Vegas					
General Aviation a/	8776	9672	10969	14684	33689
Air Taxi b/			569	946	4500
San Diego					
General Aviation a/	19363	21962	19972	25904	28049
Air Taxi b/			2502	3358	4546
Phoenix Sky Harbor					
General Aviation a/	15368	18026	19649	23400	17321
Air Taxi b/			927	182	251

a/ The sum of primary plus secondary operations for calendar years 1970 and 1971. The sum of overflights, primary and secondary operations for calendar years 1972,1973, and 1974.

b/ By calendar year as above except that prior to 1972 air taxi operations were included in the general aviation category.

FIGURE C-5
TOTAL GENERAL AVIATION INSTRUMENT OPERATIONS
(PER TOWER AVERAGE)

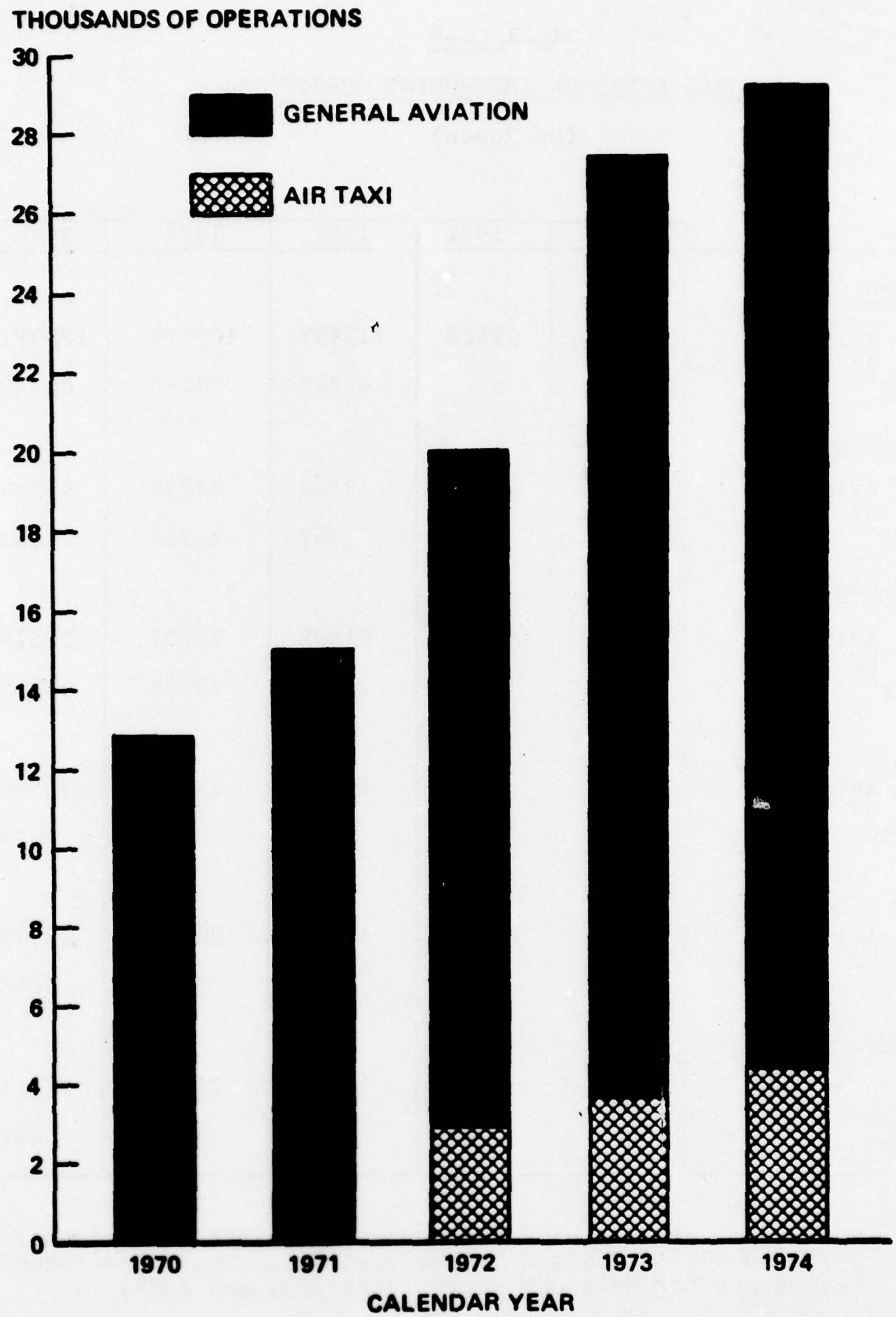
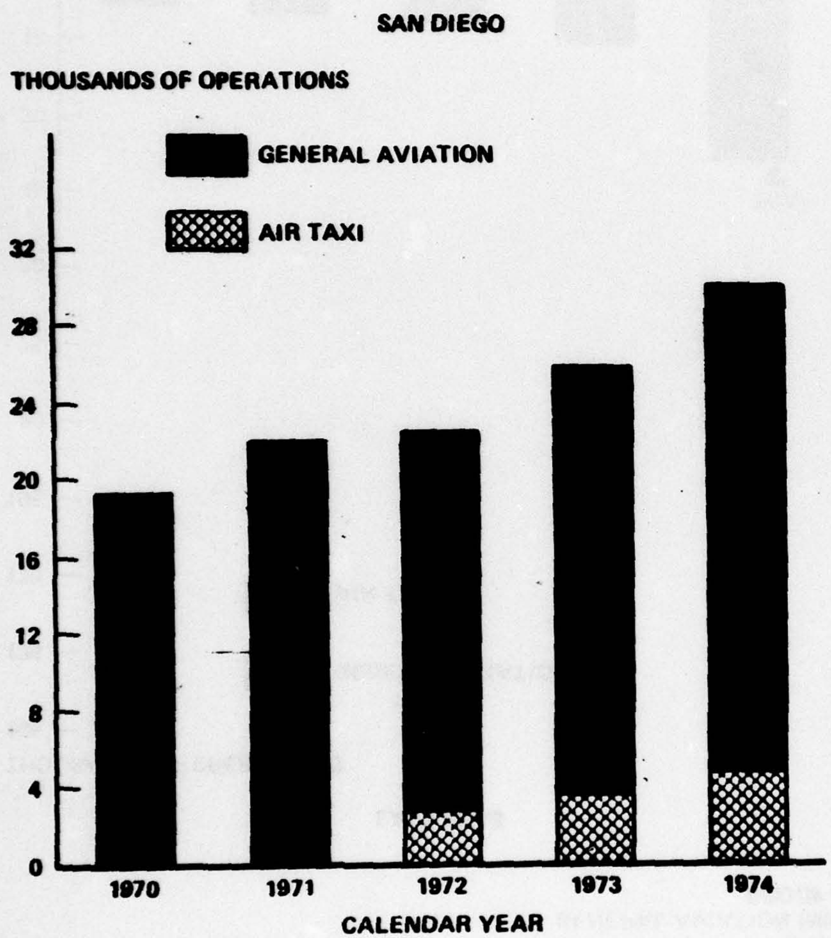


FIGURE C-6
GENERAL AVIATION INSTRUMENT OPERATIONS
NON-TCA



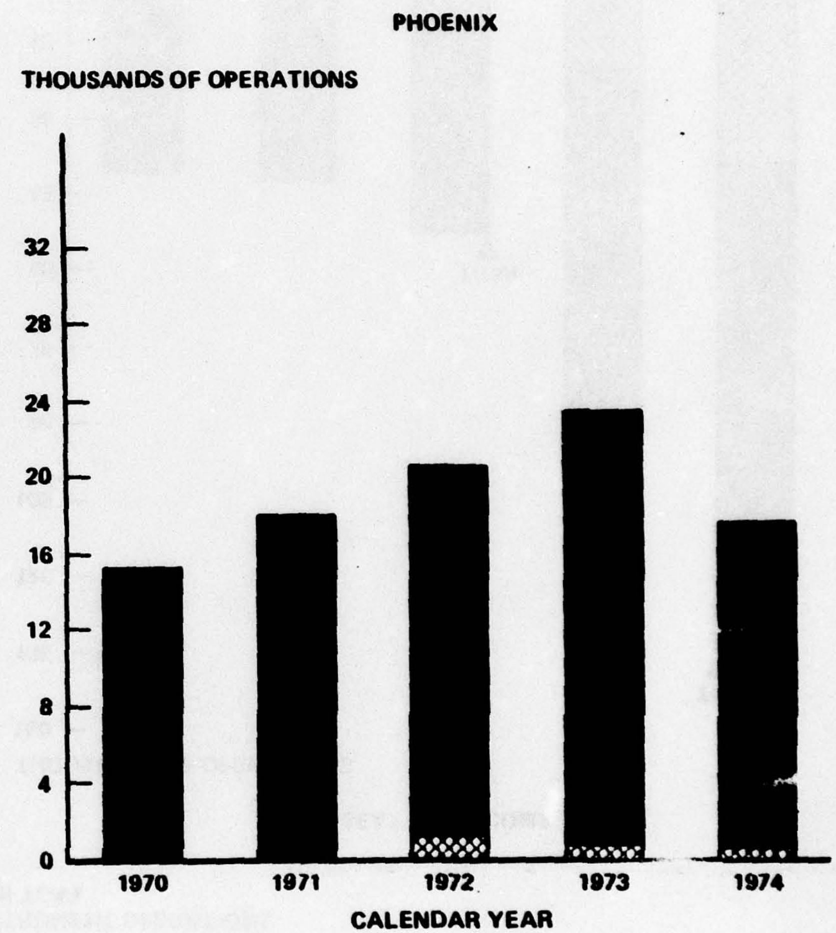


FIGURE C-7
GENERAL AVIATION INSTRUMENT OPERATIONS
GROUP II TCA's

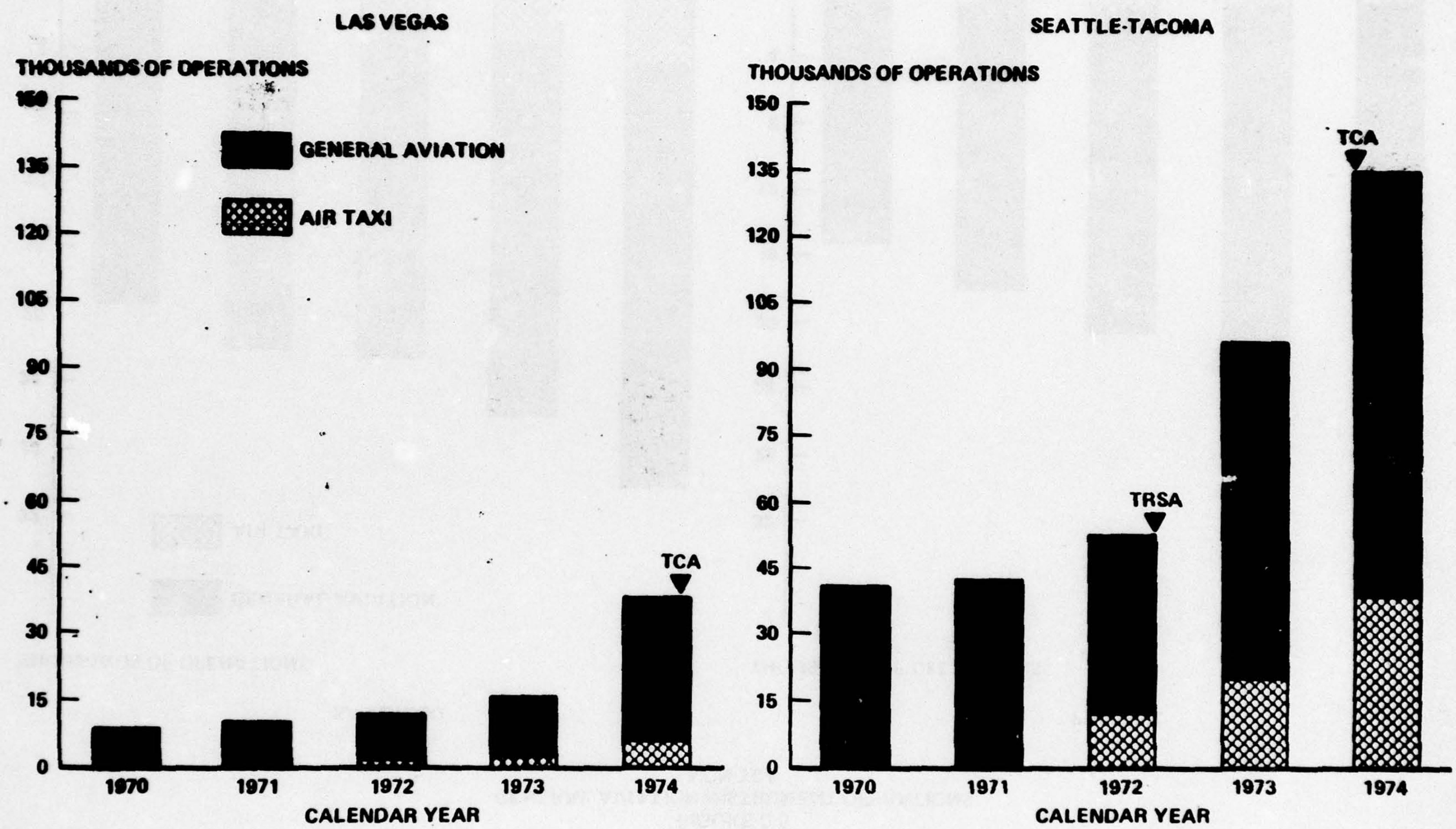
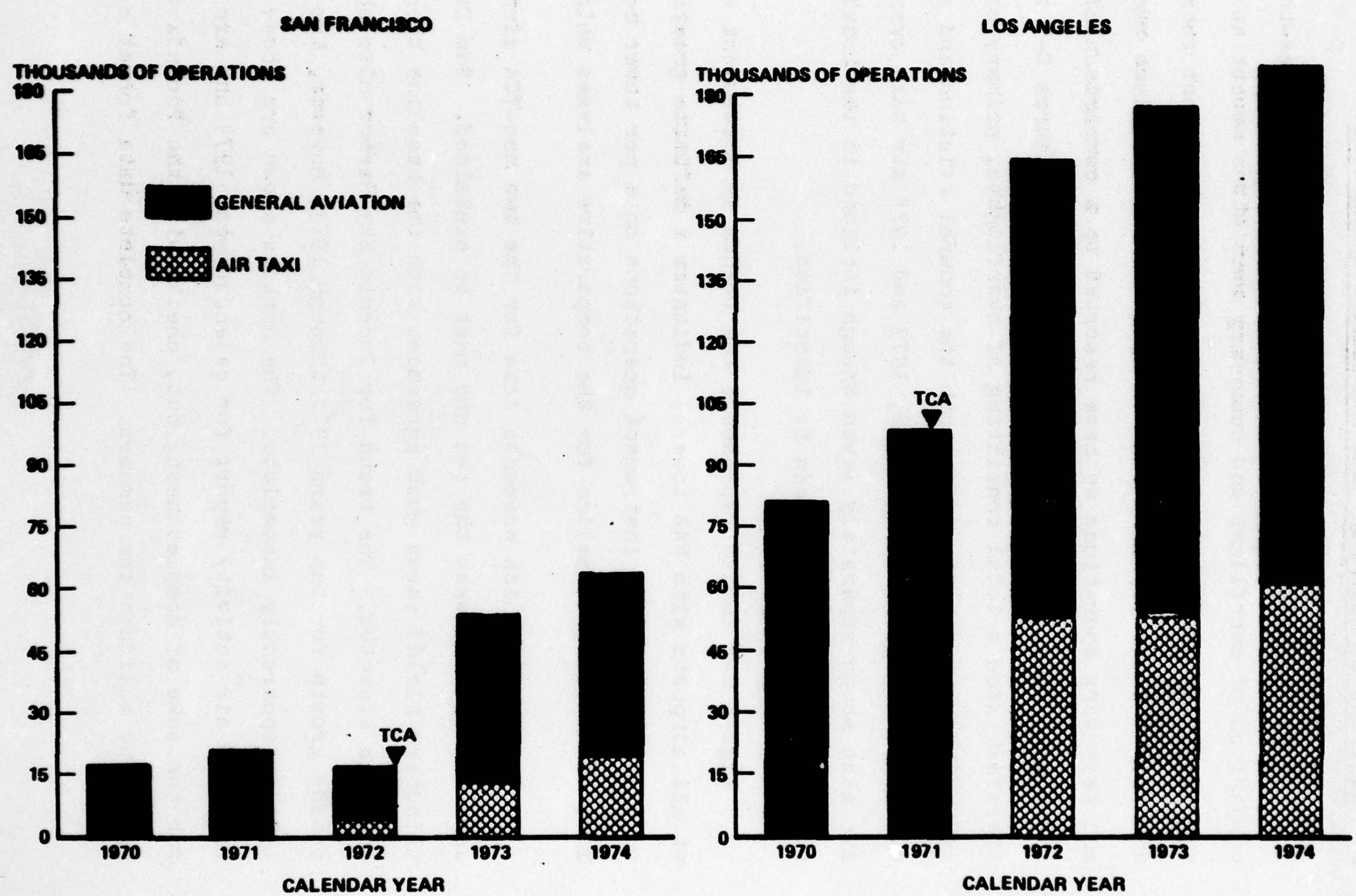


FIGURE C-8
GENERAL AVIATION INSTRUMENT OPERATIONS
GROUP I TCA's



E. Analysis of Secondary and Overflight Operations

As noted earlier it is not possible to do an "apples-to-apples" comparison of overflight and secondary operations except at an aggregate level---a level that also includes instrument operations to and from the primary airport. Thus, in order to analyze overflight and secondary operations we have resorted to a comparison of total instrument operations at our sample airports. Figures C-5 through C-8 therefore show a total consisting of overflights, primary operations and secondary operations for both the general aviation and air taxi categories. For the years 1972, 1973 and 1974 air taxi operations are also shown separately (even though included in the totals) so that the changes therein can be identified.

Figure C-5 (which represents the trends in instrument operations at all airports with FAA towers) indicates a definite growth pattern in all categories of instrument operations on a per tower basis. This trend is the baseline for the comparative analyses which follow.

Figure C-6 which presents data for the two non-TCA airports shows some variance between the two and must be explained. San Diego (Lindberg Field) shows good agreement with the baseline trend as would be expected. The trend for Phoenix Sky Harbor also shows steady growth for the years 1970 through 1973, however, the data for 1974 is apparently incomplete. The numbers shown are those extracted from the air activity report for calendar year 1974 and are presented for the sake of completeness; but, checks with the Phoenix tower failed to validate the numbers. The complete data format could not be duplicated from records still available at Phoenix so no alternative 1974 data is shown for that airport. Nonetheless, the steady growth in instrument operations prior to 1974 supports a conclusion that instrument operations at Phoenix follow the national trends.

Data for Group II airports (Figure C-7) shows a marked departure from the regular growth rate of the base line trend line. In particular, Seattle-Tacoma shows a more or less typical growth pattern for 1970 through 1972 with rather sharp increases in 1973 and 1974. These increases coincide with the establishment of a TRSA in September 1972 and the TCA in January 1974. Las Vegas shows the typical pattern for 1970 through 1973 with a sharp increase in 1974. The Las Vegas TCA was established at the end of November 1974 and at first look the 1974 increase seems excessive for just one month of TCA operation. Additional investigation showed, however, that the count of primary instrument operations for 1975 is currently running some 10 to 12 times that which existed prior to December 1974. Consequently, we conclude that the sharp increase in operations at Las Vegas is in fact due to the establishment of the TCA.

At the Group I airports (Figure C-8) the departures from baseline trend are quite marked and also coincident with the introduction of TCA's at those airports---ie., September 1971 for Los Angeles and December 1972 for San Francisco. Prior to the introduction of TCA's the instrument traffic growth at these airports seems to have followed the baseline trend. (The low reading for 1972 at San Francisco does not fit that pattern, nor was an explanation sought therefor.) After the TCA, the growth in instrument operations again follows the baseline trends.

F. Comparison of Time Series Analyses

When the results of the preceeding sections are considered together some useful conclusions can be obtained. A comparison of Figures C-1 and C-5 shows that during a five year period of essentially level general aviation/air taxi airport operations a growth of over 100 percent in instrument operations occured at FAA towered airports. Although the creation of a TCA does not appear to affect the number of airport operations it does have an impact on instrument operations---ie., primary instrument operations increase to approximately equal airport operations because TCA operations are counted as IFR flights. This causes an abrupt upward shift in the number of instrument operations at the time a TCA is established---the magnitude of that shift being related to the ratio of VFR to IFR operations prior to the TCA. (eg., at Las Vegas where most operations were VFR prior to the TCA, the increase in instrument operations was by a factor of 10 or more. At Seattle, on the other hand, a high percentage of operations prior to the TCA were IFR, thus, the increase at TCA establishment was a rather modest 40%.)

In general, our analyses show that at the aggregate level instrument operations at TCA airports seem to follow the national trend both before and after the TCA is established (with the exception of the jump at TCA start-up). Although data at the detail level (secondary, primary, overflight) is inadequate to support a conclusive analysis thereof, it appears that prior to, or in the absence of a TCA, growth is spread between all three categories of operations. At TCA start-up there is a jump in primary operations which seems to account for the jump in total instrument operations. After the TCA is established primary operations follow the pattern of airport operations, therefore, secondary and overflight operations must approximate the national trend for all instrument operations.

In terms of our study objectives this leads us to the circumstantial conclusion that secondary and overflight operations are not much affected by the presence or absence of a TCA.

APPENDIX D

DIVERSION CALCULATIONS

The purpose of this section is to quantify the likely reduction in general aviation activity at the 25 largest air carrier airports if existing TCA's were expanded downward to enclose additional airports now underlying the TCA. The reduction in activity is computed by multiplying the assumed increase in fixed annualized investments attributable to TCA implementation by the weighted average price elasticity of demand for user groups most likely impacted by the additional costs of TCA operation. This provided the percentage reduction in general aviation activity expected at the primary large hub airports. Conservative estimates have been used throughout; therefore, the impact on general aviation activity is likely to be overstated rather than understated.

General aviation user categories most likely affected by the increased costs of TCA operation include:

Personal
Instructional
Aerial Application
Industrial

The above user categories accounted for 54 percent of all general aviation hours flown in 1971 [1/] (this distribution is assumed to remain constant).

The following categories were assumed tc be unaffected by TCA requirements:

Business
Executive
Air Taxi

1/ General Aviation Cost Impact Study, Battelle, DOT, FAA, June, 1973, Vol. I, page 12.

It was presumed that the majority of users in these categories were already equipped for TCA operation and would not suffer additional cost impacts.

The weighted average price elasticity of demand for the cost impacted user groups was computed as shown below:

User Category	Fixed-Cost Elasticity 2/	% Total Hours Flown By User Category	Weighted Fixed-Cost Elasticity
Personal	3.578	.52	1.88
Instructional	0.478	.32	.16
Aerial Application	2.277	.09	.21
Industrial	0.852	.06	.05
Price Elasticity weighted over the 4 groups			2.30

The following additional assumptions were also central to this analysis:

1. Percent of general aviation users not equipped for TCA operation 60%
2. Percent increase in annualized investment attributable to TCA requirements 10%

2/ Op cit, page 25.

Price elasticity may be considered in the following relationship, where the Δ notation is used to indicate change:

$$\text{Elasticity} = \frac{\%\ \Delta\ \text{Activity}}{\%\ \Delta\ \text{Cost}}$$

Given the elasticity, % Δcost, and the % of the total population affected, the change in activity can be determined as follows:

$$\%\ \Delta\ \text{Activity} = (\text{Elasticity})(\%\ \Delta\ \text{Cost})(\%\ \text{Population Impacted})$$

That is:

$$\%\ \Delta\ \text{Activity} = (2.3)\ (.10)\ (.60 \times .54) = 7\%$$

That is, surface TCA's would reduce the level of general aviation activity in the terminal areas of the 25 largest hubs by less than 10%, Faced with the requirement to equip their aircraft for TCA operations, however, most owners will elect to buy the necessary equipment and continue flying. In fact, under the same set of assumptions used in the analysis above, almost 25% of all general aviation users operating in the large hub terminal areas would purchase the required suit of avionics equipment and continue operations. The calculations leading to this conclusion are shown below:

1. Assumptions:

   - 60% of the personal, instructional, aerial application, and industrial users do not have TCA equipment.

   - Essentially all of the business, executive, and air taxi users are equipped for TCA operation.

   - Large hub general aviation user group distributions conform with those presented in the Battelle General Aviation Impact Report (Vol. I, page 12).

- Additional TCA equipment would increase annualized investment in the aircraft by an average of 10%.

2. The weighted average price elasticity for TCA impacted groups is 2.3.

3. TCA impacted groups account for 15.3/28.6 or 54% of the general aviation activity within the terminal area.

4. The percent of general aviation users electing to purchase additional equipment is:

$$(.60)\ (.54)\ \left[\ 1-\ (.10)\ (2.3)\ \right]\ =\ 25\%$$