MASSACHUSETTS STATE AIRPORT SYSTEM PLAN FORECASTS

PART I:

A REVIEW OF AVAILABLE METHODOLOGIES AND MASTER PLANS

Dennis F.X. Mathaisel

FTL Report R78-3   February 1978

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EXECUTIVE SUMMARY

This report is a first step toward updating the forecasts contained

in the 1973 Massachusetts State System Plan. It begins with a presentation

of the forecasting techniques currently available; it surveys and appraises

the methodology used in prior aviation forecasts; it reviews the techniques

used in the master plan forecasts for Massachusetts' airports; it lists

factors which have an influence on aviation activity; and it makes some

conclusions designed to help in arriving at revised forecasts for the

Massachusetts System Plan.

A. Forecasting Methodology

The techniques that have been used for aviation demand forecasting

up to the present time can be grouped into the following categories:

1. Estimation involves a subjective assessment or judgement for
   forecasting future levels of aviation activity;

2. Trend Projection derives a forecast from a statistical analysis
   of historical data using time as the only variable to explain the
   rate of growth;

3. Ratio Analysis first requires a forecast of national activity,
   then uses a historically calculated percentage of regional levels
   to national totals as a basis for developing the future level of
   regional activity;

4. Econometrics is a statistical technique which expresses changes
   in the levels of aviation activity due to factors such as the
   cost of using the service, the socio-economics of the users,
   and the quality of the air service;

5. Spatial Equilibrium models are a special class of models which
   suppose a mathematical relationship for the movement of traffic
   between any two points or regions;

6. Surveys are based on the premise that if you want to know what
   is going to happen or is currently happening in a particular sector,
   go out and ask those who will be or are making things happen;

7. and finally, <u>Systems Dynamics</u>, which is a relatively new technique, uses complex computer models to simulate the behavior of aviation activity in response to both external and internal changes.

B. <u>An Appraisal of the Methodology Used in Prior Aviation Forecasts</u>

Throughout the report on prior aviation forecasts both for Massachusetts and elsewhere, one key point is repeatedly emphasized:

A GOOD FORECASTING MODEL SHOULD BE BOTH SUFFICIENTLY POLICY-SENSITIVE AND DETAILED ENOUGH TO BE UPDATED AND REVISED IN A TIMELY MANNER AS CONDITIONS CHANGE.

Unfortunately, this point was often overlooked in a number of the surveyed forecasts. The need for policy-sensitive models, which allow for the impacts of changes in socio-economic, technological and institutional (fuel, noise and regulatory) factors, cannot be stressed too strongly-- especially in airport planning where rapid rates of change are common.

There is also a need to question the scale at which forecasts are made. Frequently, "top-down" approaches were taken where nation-wide or state-wide projections were first made and then distributed to the planning area or airport level by historical share trends. Such approaches serve little planning purpose since no attempt was made to determine the underlying causes of the changes. On the other hand, the success of micro-level approaches, where individual airport or regional planning area forecasts are made, is predicated upon the availability of raw data and the sensitivity of the forecast to changes in local policy, socio-economic and technological factors.

C. <u>Composition of Airport Planning Forecasts</u>

Three basic steps are required for any airport planning forecast. These must be performed in order, as the results from one become the inputs for the next.

In order they are:

1. annual projections of basic measures of demand, such as passengers, cargo and mail;

2. the translation of these basic demand components into aircraft operations;

3. based on the distribution of aircraft operations by size and type, the establishment of peak aviation demand such as peak-day and busy-hour operations, which directly affect facility design.

D. Conclusions on Each Level of Aviation Activity Forecasting

1. Scheduled Air Carrier and Commuter

Airport planners are well along in their attempts to forecast reliably and accurately operations for the scheduled air carrier and commuter airline industry. The approaches taken generally use econometrics which captures important cause and effect relationships. Of course, much of the success in forecasting this activity is based on the availability of reliable and consistent historical data.

2. General Aviation Activity

In the case of general aviation operations, historical records, such as based aircraft and annual operations, do exist. However, the reliability of this data is considered to be poor at the individual airport scale. Recognizing this inadequacy, most attempts at forecasts have sought to relate general aviation activity to very local variables, such as population, income and education. The approach begins with projections of based aircraft, then forecasts of annual operations, peak-day and peak-hour operations, itinerant vs. local activity, etc., are developed as a function of the based aircraft.

3. Air Cargo Activity

The rapidly changing air cargo industry has made even short-term projections little more than educated guesses. Many forecasts were derived from simple trends or executive judgement. Because such methods do not adequately deal with how demand is formed, they are not very useful in helping us understand how air cargo will be affected by various changes and developments, such as regulatory reform for example.

4. __Military Activity__

The level of military activity is a function of national defense policy and, as such, it does not lend itself to such forecasting techniques as trend analysis or econometrics, which are a function of historic trends and variables relative to national defense. Thus, about all that can be done is either to use the planning information supplied by the Department of Defense, or to asume that the level of military activity will not change in the forecast period.

I. INTRODUCTION

The desire to know the future exists in nearly everyone, partly out of curiosity but more practically out of the need to plan for the future course of events. Unfortunately, despite the universal need, predicting the future, particularly in the long run, remains a hazardous activity and has been notoriously unreliable, and this is particularly true of aviation because of the rapid rate of change.

In order to appreciate this point with respect to airport forecasting, Table 1 presents a comparison of the predictions of airport activity at Massachusetts airports made by various consultants against actual operations. These comparisons, tabulated by the Massachusetts Aeronautics Commission, are for total aircraft operations during the year 1976 at the airports for which master plans were developed. In the extreme right-hand column the prediction error (difference between forecast and actual) is tabulated for each airport. Note the magnitude of the error. The Worcester forecast, for example, was nearly 48 percent above actual; the Plymouth prediction underestimated actual operations by 39 percent; Marshfield's forecast was overoptimistic by 38 percent; and so on. Thus, despite the growing sophistication of the techniques available, forecasting has, and will continue to possess, unreliable results even over fairly short time spans.

Nevertheless, the complexity of the aviation industry requires more forecasting to be attempted and more resources to be devoted to techniques of establishing what is going to occur. This need is true of airport planning where long lead times are required to plan for the introduction of new capital improvements and where, because of high average annual growths, slight variations in the rates of growth can produce marked differences in the absolute levels of traffic.

TABLE 1

DEMAND FORECAST VS. ACTUAL DEMAND COMPARISON -- 1976[**]

Airport	Consultant	Total 1976 Forecast	Interpolation	MPS Date	1976 Actual	Tower ?	Δ % Diff.
Logan	Ebbin et.al.	274,200	76	1975	306,655	Yes	-10.58
New Bedford	CEM	91,688	75-80	1975	85,089	Yes	7.76
Hyannis	E&K	L-H av. for '77 81,875	73-77	1973	96,874	Yes	-15.48
Lawrence	E&K	L-H av. for '72 168,386 &'77	72-77	1972	194,429	No*	-13.39
Norwood	FS&T	241,678	72-77	Delayed 1975	204,262	Yes	18.32
Worcester	Speas	112,513	71-77	1974	76,080	Yes	47.89
Beverly	E&K	77 high forecast (per MPS) 164,800	72-77	1973	220,375	Yes	-25.22
Plymouth	FS&T	42,500	71-77	1972	69,510	No*	-38.86
Westfield	Conlon	159,800	72-77		170,127	Yes	- 6.07
Bedford	Speas	270,522	75-80	1976?	244,096	Yes	10.83
Nantucket	TransPlan	65,400	73-77	1973	56,386	Yes	15.99
Provincetown	CEM	19,410	72-77		24,600	No*	-21.10
Turners Falls	CEM	36,232	75-80	1976	35,023	No*	3.45
Taunton	E&K	High forecasts (per MPS) 69,000	72-77	1973	64,500	No*	6.98
Marshfield	HTA	71,110	72-77	1975	51,670	No*	37.62
Chatham	E&K	Low forecasts (per MPS) 8,560	72-77	1973	11,940	No*	-28.31
Southbridge	E&K	Low forecasts (per MPS) 8,300	72-77	1973	8,160	No*	1.72

Mean Δ = -.497%   𝒪Δ = 23.04%

Mean /Δ/ = 18.21%   𝒪/Δ/ = 13.38%

(𝒪 based on N-1 weighting)

*1976 Demand from FAA Form 5010
Underscored date in forecast interpolation indicates actual demand (base year)
**Prepared by the Massachusetts Aeronautics Commission

This last point highlights perhaps the key attribute of a good

forecast: it should be both sufficiently policy-sensitive and detailed enough

to be updated and revised in a timely manner as conditions change.   At a

Transportation Research Forum meeting in Atlanta last year, Fisher stated:

> "An aviation forecast is a static tool in a dynamic environment.
> It is therefore inaccurate from the day it is made because the
> relationships it was based upon are constantly shifting. Nothing
> is of less use to a systems planner than a five year old forecast."(7)

Thus, it is far more important to produce policy-oriented and revisable

projections, than it is to obtain that additional decimal point of accuracy.

This report takes the very first step toward updating the forecasts

contained in the 1973 Massachusetts State System Plan.   It surveys and

appraises available methodology from prior aviation forecasts; it reviews the

techniques adopted by the various consultants who developed the Master Plan

forecasts at all Massachusetts airports; it outlines a list of variables

which reflect the different types of influences (such as the socioeconomic

and level of service factors) on aviation activity; and follows up with

some conclusions that should assist in the development of the revised forecast

for the Massachusetts State Master Plan.

II. FORECASTING METHODOLOGY

In order to facilitate the appraisal, some preliminary discussion of aviation demand forecasting methodology is first presented. There are a wide range of techniques available ranging from the extrapolation of known activity levels of past periods, to a detailed evaluation of the nature of historic developments in order to isolate by means of functional relationships those parameters which appear to be responsible for the change. From this point a forecast by means of extrapolation can be made, testing whether the established relationships between the variable and its regulators will persist and, if so, how these relationships will develop through time.

The forecasting methods used in the air transport business up to the present fall under the following groups:

1. estimation
2. trend projection
3. ratio analysis
4. econometrics
5. spatial equilibrium models
6. surveys
7. system dynamics

Each is briefly discussed below.

1. Estimation

Estimates as a rule involve a subjective assessment and a future prospect of certain situations. Though based on knowledge of past and planned development, they are arrived at without comprehensive statistical analysis. This method is often applied in the form of an additive process, in which the growth rates from year to year are estimated.

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2. Trend Projection

The projection of historical data by trend analysis uses time as the only explanatory variable. Thus, trend analyses assume that those components which have had a decisive influence in the past will continue to operate in the same way in the future(except that there may be a level of saturation beyond which traffic will not grow). Henning (11) further divides this technique up into three methods:

1. the mean variation method, which derives the forecast from an analysis of various growth rates (e.g. linear, exponential, or flexible) applied to base traffic;

2. the sliding averages method, for which the time series forecast points can be approximated by an analytical function of just a few neighboring values;

3. and the trend functions method, which draws upon linear, parabolic, logarithmic or logistic (saturation) functions to describe the trend development.

All of these methods are based upon the fundamentally unreliable but convenient premise that what has happened in the past has some relevance for what is going to happen in the future. The weakness of this premise is that it ignores the actual determinants of demand. Significant changes in the level of demographic, socioeconomic and air transportation system variables and their probable impact on air travel cannot be ascertained. If the trend changes, then the forecast will be inaccurate.

3. Ratio Analysis

Ratio analysis is another passenger forecast methodology that is commonly used. First, national traffic levels are forecast. Then a ratio of traffic in the region studied to national traffic levels is calculated. By extrapolating this historical ratio out in time, future projections are made. As with the trend extrapolation technique the ratio method ignores the local determinants of passenger demand. However, if local conditions have fluctuated in line with national conditions, and the relationships can be expected to continue into the future, then the ratio method is quite reasonable - at least for checking results obtained by more rigorous methods. In addition, the ratio method may be the most feasible alternative in terms of the time, cost and availability of data for the forecast.

4. Econometric Forecasting

If the statistical basis for trend projection is inadequate, if the past traffic development is erratic or if there is a risk that a continuation of the past trend is inconsistent with economic, social and operational development, it becomes necessary to study the significant factors underlying the determinants of demand. A technique of doing this, often referred to as econometric forecasting, is to develop mathematical relationships (models) expressing the dependence of traffic development upon the factors concerned, and verify the validity of these relationships by statistical methods.

types of influence on the traffic. Usually one or two variables will relate to the size and potential spending ability of the market, and the models may also include a variable related to the cost of using the air traffic service. Then there may be variables reflecting the influence of airport accessibility

and convenience, the quality of the air service, its competitive position

vis à vis alternative surface or air services, and the demographic and socio-

logical characteristics of the market. A list of variables reflecting

these different types of influences on traffic that were employed within

the surveyed forecasts are given later in Section VI of this report. As

shown in this list, the same type of influence on traffic may be expressed

by a variety of alternative variables.

5. Spatial Equilibrium Models

The need for explanatory models was briefly outlined in the last

section on econometrics. Another theoretical source of models identifying

the underlying determinants of demand is spatial equilibrium theory. Spatial

equilibrium postulates a basic relationship for the movement of traffic

between any two points or regions. The relationship is generally based on

the principles of least effort, minimum distance or cost minimization. At

its simplest, the approach relates the movement of traffic directly to the

size of each region and indirectly to the distance. From this simple begin-

ning, more complex trip distribution models can be derived weighting the

relative attractiveness of regions to each other with a constraint on distance

separation (in terms of time or cost). The most commonly used model of trip

distribution is the gravity model which, in its basic form, assumes the

level of air trips between two communities to be directly proportional to the

product of the population of two regions and inversely proportional to the

distance between them (i.e. a direct ratio of the mass and an inverse one of

the distance). Many of these distribution models are developed using multiple

regression techniques. The models can either be of a single-mode or a multi-

mode variety. The single-mode models generate and distribute air trips

between city pairs directly. They relate the intercity level of air trips to the socioeconomic characteristics of the cities concerned [Haney (10)].

While gravity models may serve a useful purpose as descriptive tools, their performance in projections into the future is less satisfactory. A major reason for this is that gravity models are essentially long-run models which concern themselves primarily with factors that change only slowly, such as population. In other words, gravity models deal with variables that an economist would tend to consider exogenous [see Sletmo, (25), p.19].

Another frequently used approach is the employment of a trip generation model, which relates the historical amounts of air trips generated by a particular area to certain socioeconomic characteristics of the area (such as population and per capita income). Through the use of multiple regression analysis, the magnitude and the significance of the historical effect of each of the causal variables on the level of air trips can be measured. Substitution of forecast values of the causal variables into the resulting equation will yield a forecast of air trips.

6. Surveys

There will always remain some data needs for which no adequate information is available (as in non-towered airports) and there will be a need for survey research. The survey approach is based on the premise that if you want to know what is going to happen or is currently happening in a particular sector, go out and ask those who will be or are making things happen. Although an informative method, it is not nearly as simple and as rational as it sounds. A survey is a relatively expensive research technique in relation to the amount of data collected and, except in very specific situations, resources are unlikely to extend to a

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total market coverage.

Surveys generally evaluate air travel as a commodity, competing with alternative potential uses of the consumer's dollar. The survey method presumes that consumers' spending decisions with respect to non-business air travel are correlated with their circumstances, as defined by such characteristics as income, occupation, age and education. Decisions to make business air trips, on the other hand, are assumed to be affected by the position, level of responsibility, and specific industry in which an individual is employed.

7. System Dynamics

System dynamics has received considerable attention in recent years as a result of Jay Forrester's work at M.I.T. In essence, it is a large-scale complex computer model of integrated mathematical formulae. Unlike econometric forecasting which uses variables to explain the variations in aviation activity, in systems dynamics mathematical <u>equations</u> explicitly describe the decision policies followed by the users of the aviation activity. An example of the structure of such a model, taken from Battelle's "General Aviation Dynamics" (2), is given in Figure 1. Dotted lines are used to indicate an information flow or a causal influence in the direction shown by the arrows. Solid lines represent physical flows such as aircraft or people. The symbols have various interpretations, such as source or sink, a result of an integration, a variable that is auxiliary to the formulation, or an exogenous input.

The model can be used to simulate the dynamic (time-dependent) behavior of the system in response to both exogenous and endogenous disturbances. Such models have been used for economic predictions, doomsday prophecies and social forecasting. Results over the years have ranged from gross inaccuracy to reasonable precision. At best, it is a useful planning tool, which cannot
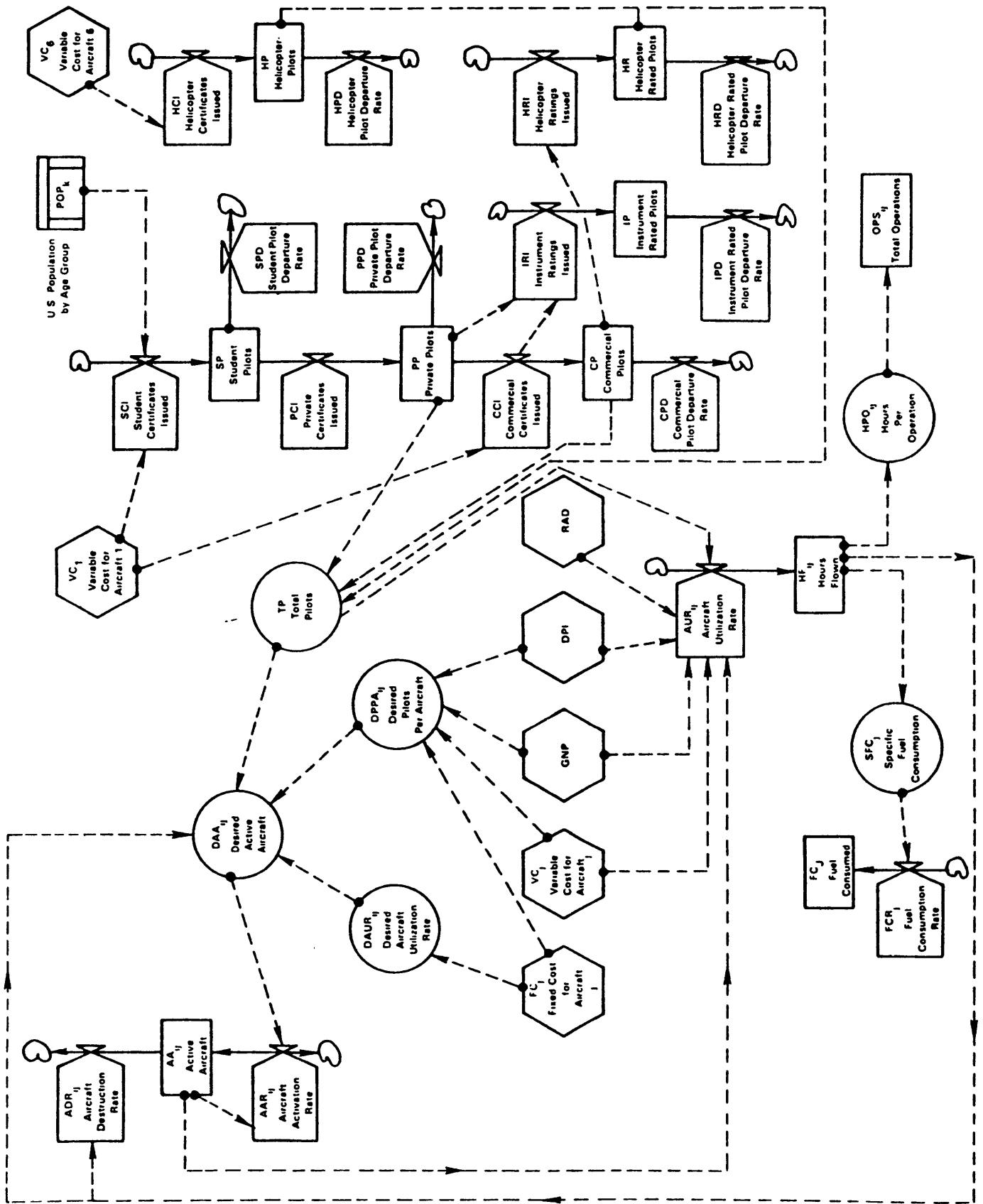
Figure 1
Sample Flowchart of a System Dynamics Model
(from Battelle-Columbus, "General Aviation Dynamics")

be expected to "predict" unforeseen happenings that may occur. However, as familiarity is gained with its responsiveness and as more is learned about the real system, it could become a useful tool for aviation activity forecasting and planning.

III.   DETAILED REVIEW OF PRIOR FORECASTS

Reviewing previously accomplished forecasts at an early stage in the project enables identification of significant interrelationships of demographic, socioeconomic and quality of service variables to air traffic activity in order to expedite subsequent development of several aviation demand models.   A literature search was made of FAA, State Master Plan, academic and other forecasting models appropriate for aviation, including general aviation, commuter, air taxi and air carrier operations.   Particular emphasis was devoted to a literature search of forecasts at a regional and state level.   The result was certainly not an exhaustive list of all aviation forecasts, but it is felt that the list adequately represents the state-of-the-art in airport forecasting.

The review will be partitioned according to five aviation activities:

A.   air carrier
B.   air taxi
C.   general aviation
D.   military aviation and
E.   air cargo

Since prior forecasts for Massachusetts involve all of these activities, and since the individual airport forecasts for Massachusetts are best evaluated relative to each other, the 1973 Massachusetts State System Plan Forecast as well as the individual airport master plan forecasts, are reviewed together in a subsequent section of this report.

All references are stated in full in the Bibliography.

A. Air Carriers

1. DOT-FAA "Aviation Forecasts - Fiscal Years 1978-1989", 1977.
   a. DESCRIPTION - this report contains the fiscal years 1978-1989 FAA forecasts of aviation activity and measures of workload at FAA facilities (airports with FAA control towers, air route traffic control centers, and flight service stations).
   b. SCOPE - 10 year forecast of certified route air carrier scheduled passenger traffic, operations, and revenue; cargo and mail volumes; fleet size, composition, and utilization; aircraft production; and international aviation activity.

c. METHODOLOGY - Air carrier demand forecasts of Revenue Passenger Miles (RPMs) and enplanements (ENPs) are generated using an econometric forecasting model derived from historical relationships between various measures of economic activity and air carrier demand. The econometric variables used are:

- personal consumption of services
- number of civilians employed
- gross investment by the air transport industry
- deflator for personal consumption of transportation
- index of airfares.

Two additional models - a macro and a micro method - are employed to forecast the level of air carrier activity and the anticipated work-load at FAA facilities. The macro model forecasts towered aircraft operations for the total air carrier industry based on the following variables:

- RPMs
- Average passenger load-factor
- Average seating capacity
- Average stage-length

The RPM forecast is generated from the econometric demand model, whereas the operating characteristics are based on time-series analysis, with adjustments made for changes in costs and fares. The micro model is used to forecast fleet size, hours and miles by equipment type and, in conjunction with the macro model, to forecast operations. It utilizes individual carrier forecasts by aircraft type and number as its base, and then uses judgement to project into the future.

d. COMMENTS - The FAA is well along in its program to develop and improve its forecasting methodology. Projects can be categorized in the following four mutually supportive areas of effort:

- increase forecast specificity and scope
- improve methodology(econometric and system dynamics techniques are being developed)
- analysis of alternative policies (aviation activity will be examined under various assumptions about alternative socio economic conditions).
- meeting the needs of users (encourage and facilitate dia-logue between forecasters and user community).

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2. Brown and Watkins "The Demand for Air Travel: A Regression Study of Time-Series and Cross-Sectional Data in the U.S. Domestic Market" , 1974.
    a. DESCRIPTION - the paper is a progress report of CAB staff studies of the effect of air fares upon demand for air travel.
    b. SCOPE - U.S. domestic passenger traffic (as measured by RPMs) for the scheduled trunk carriers is analyzed during the period 1947 - 1967.
    c. METHODOLOGY - The statistical method of multiple regression is applied to the the data in two ways: by analysis of time-series, and by analysis of cross-sectional data for city-pair markets. For the time-series model the variables employed were RPM per capita, fares per mile, and time. For the cross-sectional model the variables were: origin-destination passengers carried, fares per mile, quality of service (as measured by travel time and number of
    .stops), enroute distance, average number of business-day calls between two cities, number of passengers who are using the trip as a portion of an international journey, income, competition (traffic carried by the second largest carrier in the market, and time).
    d. COMMENTS - Inasmuch as the paper's primary concern is the elasticity of demand with respect to fare, the techniques applied namely time-series and cross-sectional analysis are applicable to other determinants of demand and to a regional level of demand as well. The methodology is "behavioral" - that is, it describes the causal relationships between socioeconomic and transport system characteristics on the one hand, and the number of air passengers on the other. But, broad national forecasts of total passenger miles are the easiest to make and they are of little real use. To serve any planning purpose they must be broken down to the level of individual airports and regions, and the process for breaking these aggregate projections down into sub-totals is ad hoc and lack a solid basis.

3. DeVany and Garges, "A Forecast of Travel and Airport and Airway Use in 1980", 1972.
    a. DESCRIPTION - The objective here is to forecast air traffic between two points in such a fashion that traffic forecast for any one airport is consistent with the forecast of each other airport. Thus, it is necessary to simultaneously forecast traffic between all cities in the system.
    b. SCOPE - U.S. domestic passenger travel and commercial trunk airline traffic is analyzed with cross-sectional data.
    c. METHODOLOGY - A function giving passenger demand for travel between cities is estimated and a simple model of predicting airline flights in domestic city-pair markets is developed. These models are then brought together to project passenger demand and airline service patterns. The determinants of passenger travel used in the demand function are:

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- cost of an air trip in terms of time and money relative to other modes

. consumer income

- populations of the cities.

the supply model, which forecasts airline flights, is a function of:

- frequency

- fare

- marginal cost

- landing fees

- variable cost

- fixed cost

d. COMMENTS - This approach adequately captures the interdependencies between the <u>demand</u> for transport services and the <u>supply</u> of transport services. Thus, it is one of the very few attempts utilizing the classical economic theory.

4. Rubin and Fagan, "Forecasting Air Passengers in a Multiairport Region", 1976.
   a. DESCRIPTION - the paper reports on a forecast of air passenger trips within the three airport Baltimore-Washington region. Forecasts in a multiairport environment must be geographically distributed. The generated air trips have to be split between the airports. Even in regions where all airports are operated by the same agency, as a market phenomenon, they compete.
   b. SCOPE - two forecasts were generated. On the national level time-series data from 1960 to 1973 was used for total trip originations. At the same time regional level surveys of 72 aviation analysis zones described the extent to which the public has used available air transport services.
   c. METHODOLOGY - A method similar to that used in ground transportation planning was applied. A share of the market forecast was developed based on a national forecast by using

- yield

- per capita disposable income

- government purchases.

Another forecast was completed based on an on-board origin-destination (O-D) survey and regional socioeconomic data including:

- population

- government employment

- non-government employment

- per capita income.

The two forecasts were adjusted to provide air passenger trip generation by aviation analysis zone. This forecast was then distributed to other U.S. cities based on an analysis of socio-economic data for Office of Business Economics analysis areas.

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The result was a zone-to-city forecast. The macro forecast was based on a multivariate regression technique, while the microforecast was based on an analysis of past travel behavior and socioeconomic environment data available form an on-board survey.

    d. COMMENTS - The forecasts developed were adequate for use in the modeling of air passenger distribution in a multiairport region. They appeared to be reasonable on inspection and intuitively correct, but they also have their limitations: a survey is a relatively expensive research technique in relation to the amount of data collected and, except in very specific situations, resources are unlikely to extend to total coverage; and, because the survey was taken only once, the change in traffic was being forecast based on a one-time measurement.

5. Johnson, "Forecasting Airport Traffic", 1964.
    a. DESCRIPTION - The discussion is focused on the practical translation of long-range national air traffic forecasts into local facility and service planning criteria useful to those faced with specific local airport planning and development problems. Newark aiport is used as an illustration.
    b. SCOPE - At the time the article was written in 1964 passenger aircraft movements at Newark Airport were forecast out to 1975 - the approximate mid-year of the service life of the terminal facilities. A forecast was made for this point in time because, according to Johnston, "as a general rule, new terminal facilities should be sized initially to the requirements of the forecast of 'average peak demands' at about the end of their physical half-life."
    c. METHODOLOGY - The forecast of air traffic is made by a Market Analysis Method which is found to be an improvement over extrapolations of past traffic and other systems of prediction. The method consists of conducting a year-long survey of a random sample of passengers on airplanes leaving the metropolitan area. The composition of the market by occupation, age, industry, family income and education provided a base from which the forecast was derived.
    d. COMMENT - A survey is a relatively expensive research technique in relation to the amount of data collected and, except in very specific situations, resources are unlikely to extend to a total market coverage.

6. Transplan, Inc. and S.S.V. & K.,Inc., "A Study for the Development of Stewart Airport", 1973.
    a. DESCRIPTION - The report was prepared for the Metropolitan Transportation Authority of New York to assist in undertaking the planning and development of Stewart Airport,
    b. SCOPE - The report is offered in three sections which relate to future aviation demands in the Stewart region. The first section covers overall regional aviation demand forecasts (for the three New York airports) of airline passengers, aircraft movements, airline cargo traffic, all-cargo aircraft movements, all-cargo aircraft load factors, mail traffic and general aviation aircraft operations. The second section contains estimates of the domestic airline passenger traffic to be carried in scheduled services and the related passenger aircraft movements at Stewart in future years from 1975 through 1990.

The final section contains estimates of other aviation activities at <u>Stewart</u>, consisting of airline traffic and operations in domestic charter services, international scheduled and charter services, and international all-cargo aircraft services.

c. METHODOLOGY - The methodologies used in the regional (three airport) forecasts vary according to the elements covered. Air carrier traffic and aircraft operations on the regional level were projected basically using time-series techniques. Allocations to individual airports and between domestic and overseas services were based on percentage distribution amounts indicated by a Port of New York Authority forecast for 1980. On the other hand, for the <u>Stewart</u> airport forecasts regression techniques were employed. The explanatory variables included: personal income, employment levels, population, and level of service (speed, cost and frequency). The estimating equations were calibrated using weighted least-squares, and a variety of mathematical forms were tested (such as, log-log, semi-log, and linear). The following sensitivity analysis were also performed: 1. sensitivity of demand to elasticities of the variables, 2. sensitivity of aircraft operations to airport capacity, 3. sensitivity of aircraft operations to airport capacity, 4. sensitivity of operations to scheduling rules, and 5. sensitivity of demand to the establishment of high-speed rail service. The other types of passenger traffic studied for <u>Stewart</u> were domestic charter, international scheduled and international charter. Such estimates involved a subjective assessment of past and planned development without comprehensive statistical analysis.

d. COMMENT - The time-series analysis used at the regional level is not structural - that is, the relationship between socioeconomic and air transportation variables and the number of enplaned passengers is not described. Otherwise, the techniques used to forecast activity at Stewart Airport are quite adequate.

7. Haney, "St. Louis Aviation Forecast Study," 1975.
   a. DESCRIPTION - Forecasts of aviation activity are developed for the St. Louis region.
   b. SCOPE - Forecasts are presented through the year 2000 for Lambert-St. Louis scheduled air carrier, commuter, general aviation, and other types of aviation activity. General aviation forecasts are also reported for the region. Detailed reports of peak hour operations, VFR/IFR operations, and day/night operations are developed. Sensitivity analyses are included on a number of future uncertainties.
   c. METHODOLOGY - For air carrier forecasts of originating passengers two basic approaches were taken. The first, termed a "top-down" approach, examines the relationship between St. Louis air trips and the national total of originating air passengers, using a linear regression equation. The second, a "bottom-up" approach, relates air trip levels for St. Louis to selected socioeconomic characteristics of the region and transportation system variables. These variables are:

   - population
   - employment
   - disposable personal income
   - yields (average U.S.)

Both linear and logarithmic forms of the equation were tested. For
passenger origin-destination air carrier forecasts a number of
multiple regression models were developed. The variables considered
were:

- population
- total personal income
- fares
- distance
- time
- highway miles
- passenger originations

The most acceptable models included: population product, income product,
travel time and fare.
Adjustments were then made to the baseline traffic to account for
policy analysis on fuel prices and different fare schemes. Because
these policy decisions affect relative attractiveness of air vs.
surface travel, a multi-modal intercity travel mode was used.
Transfer passengers were forecast using a top-down approach relating
the historical level of St. Louis transfer passengers to total U.S.
passenger originations.
Forecasts of aircraft operations for scheduled passenger service were
developed by using a flight assignment procedure. The principle
input to this procedure is average day/peak month originating
passengers by city-pair. A basic output of the procedure is average
day/peak month aircraft departures by aircraft type and city-pair.

d. COMMENTS - The forecasting techniques that were used were well
documented, were quite adequate for the purpose of airport planning
and represents the state-of-the-art for air carrier forecasts. The
reports greatest contribution is the sensitivity analyses that were
conducted. Because the forecasts were based on a number of explicit
and implicit assumptions, the purpose of sensitivity analyses were
to determine how the most-likely forecasts might change, given changes
in assumptions and input data. A total of 15 sensivity cases have
been examined for air passenger acitivity based on assumptions regarding
future population and economic growth, assumptions regarding the
nature of airline services (such as fare levels, passenger levels,
separate short-haul system for St. Louis, and St. Louis as an inter-
national gateway), and conditions affecting competing modes of inter-
city travel (such as fuel, rail service, and decreases in intercity
travel). The sensitivity results were assessed in term of high and
low forecasts for comparison with the most-likely forecasts.

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8. DOT-FAA, "Terminal Area Forecast: 1978-1988," 1977.
   a. DESCRIPTION - the document presents forecasts of key aviation
      activity measures for meeting the manpower and equipment planning
      needs of the FAA offices and services concerned with future traffic
      levels at these facilities.
   b. SCOPE - the report forecasts for air carrier enplanements and
      operations and itinerant, total and instrument aircraft operations at
      894 airports throughout the U.S. The airports include all those
      with FAA air traffic control towers and those with air carrier
      service. Forecasts are for fiscal years 1978, 1979, 1980, 1983 and
      1988. The report is organized by FAA region and within each region
      by state. Base year enplanement data represents activity for 1975.
   c. METHODOLOGY - the general approach to the facility forecasts presented
      here is "top-down". National forecasts were distributed over the
      regions, states, and then to individual airports. Supplementing this
      technique is a forecast of air carrier enplanements at the airports
      in the 23 largest hubs in the continental U.S. At other air
      carrier airports, average aircraft size, the carriers serving the
      airport, their historic and present capacity in terms of frequency
      and aircraft type, the markets served, and the composition of future
      fleets of the relevant carriers were used to test the internal
      consistency of the air carrier forecasts.
          Forecasts of annual instrument approaches were based on assumed
      growth rates in the amount of instrument flight rule flights for each
      airport. The operations forecasts were adjusted in order to take
      into account airport capacity.
          Forecasts of general aviation aircraft operations were based on
      past trends modified by known considerations such as airport facilities,
      available reliever airports, and official attitudes toward general
      aviation activity.
   d. COMMENT - the forecasting techniques that were used were not
      documented, but appeared to be entirely judgmental. If this were the
      case, then the methodology is not sufficiently "behavioral" in that
      the relationships between the socioeconomic and air transportation
      variables and the level of aircraft operations are not considered.
      This methodology is inadequate.

9. The Port of New York Authority, "Airport Requirements and Sites to Serve
   the New Jersey-New York Metropolitan Region," 1966
   a. DESCRIPTION - the study, written in 1966, assessed the need for and
      possible locations of a new major airport to serve the metropolitan
      region of New York and northern New Jersey.
   b. SCOPE - the forecasts consist of three components: commercial
      passenger demand, cargo service demand, and general aviation demand.
      The basic forecast of air passenger demand projected traffic estimates
      for 1965 and 1975. Essentially, two independent forecasts were
      made - one for business air travel and one for non-business air
      travel. The estimated passenger levels were translated into plane
      movements to determine the basic aircraft requirements for airport
      facilities to accommodate the traffic demand.
   c. METHODOLOGY - the domestic air traffic forecast was based upon a
      market analysis method developed by the Port Authority in 1955 [see also
      Johnson (14)].It involves the findings resulting from national consumer

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surveys. The survey delinated the characteristics of a cross-section
of the population that are associated with air travel. It also
determined the frequency of air travel undertaken by people with
uniform and measurable economic and social characteristics. The
findings from the survey were extrapolated into the future and applied
to corresponding population and demographic projections supplied by
the U.S. Government.

   To estimate the future plane movements, the projected domestic
and overseas passenger demand was distributed to its probable local
origin or destination within the metropolitan area on the basis of
the survey results. The county passenger demand was sub-divided
into long- and short-haul service, and assigned to existing airports.
This demand was then reduced to an hourly distribution of busy day
demand. Finally, by estimating average-seats-per-aircraft at each
airport and future load factors, the number of plane movements
required to accommodate the average peak-hour passenger demand was
computed.

d. COMMENT - a survey is a relatively expensive research technique in
   relation to the amount of data collected and, except in very specific
   situations, resources are unlikely to extend to total coverage; and,
   because the survey was taken only once, the change in traffic was
   being forecast based on a one-time measurement of population,
   demographic and economic factors.

10. DOT-FAA, "New England Aviation System Ten-Year Plan. Fiscal 1976-1986", 1976.
   a. DESCRIPTION - This plan continues the FAA effort to identify the
      long-range needs of the aviation community in the six-state New England
      region. It projects the regional requirements for a ten-year period
      on the basis of national programs and standards.
   b. SCOPE - The plan looks at aviation activity trends on a national
      scale, relating them to economic and demographic characteristics
      evident accross the U.S.. It includes national forecasts of scheduled
      air carrier and general aviation activity over the next ten years
      (through 1986). The New England Region is compared with national
      trends, and regional forecasts are included.
   c. METHODOLOGY - First, the fiscal 1995 aviation activity in the nation
      and the New England Region as measured by FAA facilities is reviewed.
      Then they look at the national forecasts through 1987 prepared by
      FAA's Office of Aviation Policy. Finally, they describe the major
      factors influencing the New England regional economy, leading into
      a discussion of aviation forecasts for the region.

      For the regional forecasts beyond 1976 the FAA estimates rate of growth
      in IFR aircraft handled gradually increasing to slightly below the
      national rate of 5.2% in 1982. The projections of terminal area
      activity also are roughly parallel to national trends.
   d. COMMENT - Forecasts for a broad region like New England are the easiest
      to make as individual hub anomalities will tend to balance out. But,
      such forecasts are of little real use. To serve any useful planning
      purpose they must be broken down to the level of individual airports or
      regions. Here, everything is reduced to generalizations with little real
      attempt to determine the cause of changes and with little attempt to predict
      changes in activity as a result of changes in explanatory factors.

B. Air Taxis and Air Commuters

1. DOT-FAA, "Aviation Forecasts - Fiscal Years 1978-1989", 1977.

   a. DESCRIPTION - see air carrier
   b. SCOPE - 12 year national and terminal area forecasts for passenger enplanements, operations, and fleet composition for the 48 contiguous states and Puerto Rico. In addition, those points likely to become candidates for commuter service in future years were identified.
   c. METHODOLOGY - An econometric model was used. Variables employed were not documented in this report. A detailed presentation of commuter air carrier forecasts is found in the FAA report "Forecast of Commuter Airlines Activity".
   d. COMMENTS - see air carriers.

2. Haney, "St. Louis Aviation Forecast Study," 1975.
   a. DESCRIPTION - forecasts of aviation activity are developed for the St. Louis region.
   b. SCOPE - there are two principal types of scheduled and contract services provided in the St. Louis area: scheduled commuter service for passengers and freight, and air freight and mail flights (no passengers). Forecasts of these two types of commuter airine services have been prepared for the years 1980, 1990, and 2000. Nonscheduled air taxi activity is discussed under general aviation.
   c. METHODOLOGY - for scheduled commuter passenger service, both a baseline and a "most-likely" forecast of enplaned passengers have been prepared. In preparing the baseline forecast it has been assumed that the annual growth rate in enplanements will be the same as the baseline growth rate for certificated airline passenger originations This assumption was made on the basis of judgemental assessments regarding the likelihood of various changes in the air service for surrounding small communities. Commuter aircraft operations were calculated using the most likely forecast of enplanements and the following planning factors:

   - average seats per aircraft ⎫
   - average load factor   ⎬ for passengers
   - passengers per flight   ⎭

   - average payload per aircraft⎫
   - tons per flight   ⎬ for freight

   Just how these factors influenced the forecasts was not clearly documented.
   Forecasts of freight and mail tonnage were based on the same annual growth rate as that adopted for certificated air carriers.
   d. COMMENT - methodology was judgemental and some assumptions were made, as in the use of the planning factors outlined above for the most likely forecasts, which were unsupported by documentation.

3. Thorson and Brewer, "A Model to Estimate Commuter Airline Demand in Small Cities", 1978.
   a. DESCRIPTION - the study was the basis of an Iowa State recommended program to evaluate the role commuter air carriers and intercity express bus route service might play in a long-range transportation plan to enhance personal mobility. This research effort represented the means of estimating the potential of a given community to utilize air carrier services.
   b. SCOPE - estimates of average daily passenger enplanements were calculated for 42 cities in Iowa considered to be candidates for expanded commuter air carrier service. Data was obtained from 58 cities in a six-state area having commuter air carrier service in 1974 and social and economic environments approximating Iowa cities.
   c. METHODOLOGY - various linear and non-linear regression equations were developed. Five explanatory variables were tested:

      - community population

      - percent of families with incomes at least $15,000

      - occupation (professional, technical, managerial only)

      - education

      - miles to the nearest FAA hub airport (measure of isolation)

      The dependent variable was the average daily passenger enplanements. A check on the appropriateness of these variables was obtained from an on-board commuter air carrier survey at Iowa stations. Each airline was sampled for three consecutive days during the summer. The final regression model was non-linear and included the product of only two variables: population and the measure of isolation.
   d. COMMENT - the final regression equation was a simple expression analogous to the concept of gravity model travel resistance formulae long accepted in trip distribution analyses. While it only explained 40 percent of the variance in the sample data, it represents a step in the right direction of being "behavioral"; that is, it attempted to describe the causal relationships between socioeconomic and transport system characteristics on the one hand and the number of passenger enplanements on the other.

4. Flight Transportation Associates, "Forecast Methodology and Model for Forecasting Commuter Airline Activity", 1975.
   a. DESCRIPTION - because very little effort has been devoted to forecasting the level of activity in the commuter air carrier industry, this report was written in response to an FAA request for a proposal to develop the necessary predictive tools for this industry.
   b. SCOPE - the intent here was to produce a ten-year forecast of commuter air carrier activity including passenger enplanements, revenue passenger-miles, aircraft operations, and type and mix of flight equipment. Econometric models were proposed to relate variations in these activities to relevant economic, demographic, and transportation service variables. The forecasts will be split among large-, medium-, and small-size hubs and non-hubs (less than 0.05% of total enplaned passengers) as contained in the FAA Terminal Area Classification.

c. METHODOLOGY - two specific econometric modes are described: a total
   industry model and a model to produce terminal area forecasts. The
   total industry model would be specified to forecast quarterly national
   traffic generated by the commuters. In particular, this model would
   produce the forecasts for enplanements, operations, fleet mix, and
   revenue passenger-miles. The single equation econometric model will
   be calibrated using the technique of multiple regression analysis.
   The two sets of independent variables proposed are: the socioeconomic
   (such as real GNP or income, and population); and the transport-related
   variables (level of service). However, given data constraints on
   the level-of-service factors, the following transport-related variables
   will be used instead:

   - the number of points served by the commuter air carriers

   - the average revenue per revenue passenger-mile (yield)

   - and the number of passenger enplanements on certificated
     air carriers

   The basic dependent variable would be enplanements. The forecast of
   industry enplanements will then be used to produce forecasts of operations
   (by converting enplanements into number of seats), fleet mix (by extrapo-
   lation of the percent of each type of aircraft in the total fleet),
   and revenue passenger-miles (by projections of average length of haul).

   The terminal area model applied is a separate single equation regression
   model applied to forecasting activities at each of the 728 FAA terminal
   area forecast airports. Once again, the principal forecast variable
   is enplanements, from which airport operations can be derived as in
   the total industry model above. RPM's and fleet mix, however, will
   not be forecast. Enplanements will be regressed against:

   - population in the airport's county

   - average family income

   - a business (production) index for the county

   - the estimated commuter enplanements as forecast by
     the total industry model

d. COMMENT - the proposed technique appeared to be quite reasonable in
   terms of modelling difficulty, intuitively correct, adequate for the
   purposes of individual airport forecasting, and represents the state-
   of-the-art. The "behavioral" approach allows for the description of
   the causal relationships between socioeconomic and transport system
   characteristics on the one hand, and the number of air passengers on
   the other.

5. SARC, "Forecast of Commuter Airlines Activity", 1977.
   a. DESCRIPTION - This report assesses the potential of the commuter airline
      industry including the identification of those short-haul low-density
      points that are likely prospects for future commuter service.
   b. SCOPE - the first section provides a national forecast of commuter
      airline enplanements, revenue passenger-miles, number of aircraft
      operations and composition of fleet for 1975 to 1988. The second part
      of the report describes a model developed to disaggregate the activity
      forecast to individual points with existing service or anticipated future

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service, and provides forecasts for those points.

c. METHODOLOGY - The basic methodology used for the national forecast was multiple regression analysis. The preliminary list of variables included:

- certificated carrier enplanements
- population
- Gross National Product
- consumer price index (transportation)
- total personal income
- per capita disposable personal income
- average household income
- index of industrial production
- total retail sales

Various combinations of the above factors were regressed against commuter enplanements, but the results were largely unsatisfactory. After reviewing the various models, and with serious reservations with respect to the applicability of a time-series model, it was felt that the most acceptable predictor of commuter enplanements was the relationship to certificated carrier enplanements. Certificated carrier enplanements were in turn linked to:

- civilian employment
- plant, equipment and other investment in the air transport industry
- price of air relative to other modes of transportation

Revenue passenger-miles were projected using time-series analysis. Projections for the commuter fleet and mix paralleled the equipment mix that obtains today. National commuter aircraft operations were then calculated as a function of forecast enplanements and average boardings per departure.

For the disaggregate activity forecasts it was not possible to construct a single model which could be used for predicting passenger enplanements at each point. Points were grouped on the basis of size and characteristics (e.g. large hubs, non-hubs, institutional, agricultural, and industrial). With respect to the hubs, a methodology was devised for predicting both the growth of this group and allocation to individual points. Using total personal income as the indicator, the group was allocated a share of the national enplanements forecast in 1988. This share was weighted for the ratio of its percentage share of traffic to income in the base year. After the group's enplanements are determined, the forecast for each point is computed by substituting the point for the group, and the group for the national data in the formula. A similar methodology as used for the hubs is employed in computing the forecast estimates for the non-hub points. Based on total personal income, each group was allocated a share of the national enplanements forecast in 1988.

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This share was weighted for the traffic-income relationship of the base year. Allocation to individual points within the non-hub group were done on the same basis, and with each points' economic/ isolation units (constructed from population, income and driving time to nearest air service center) substituted for income.

d. COMMENT - The report is evidence of the FAA's continuing effort to develop and improve its forecasting methodology. The econometric techniques that were used in both the national forecasts and in the individual points disaggregate forecasts were well documented, were quite adequate for the purposes of airport planning, and represents the state-of-the-art for commuter airline activity forecasts.

C. General Aviation

1. DOT-FAA "Aviation Forecasts - Fiscal Years 1978-1989", 1977.
   a. DESCRIPTION - see air carrier
   b. SCOPE - 10 year forecast of operations; fleet size, composition, and utilization; and aircraft production and air personnel.
   c. METHODOLOGY - The forecasts are derived from an econometric model. The independent exogenous variables, which come primarily from the Wharton Econometric Forecasting Model, are:

   - GNP

   - civilians employed

   - plant and equipment expenditures by the aerospace industry

   - general aviation cost index.

   General aviation activity measures not estimated by this model are generated from a time-series analysis. Forecasts of such variables as average hours flown per operation and average fuel consumption per hour are based on historical trends. These ratios are then applied to the operatons forecasts to predict hours flown and fuel consumed by general aviation.
   d. COMMENTS - see air carriers

2. Transplan, Inc. and S.S.V. and K.,Inc., "A Study for the Development of Stewart Airport", 1973.
   a. DESCRIPTION - the report was prepared for the Metropolitan Transportation Authority of New York to assist in undertaking the planning and development of Stewart Airport.
   b. SCOPE - A total of 23 tower airports in the Northeastern U.S. were selected to determine a general statement of general aviation airports. For each of these 23 airports a service area was determined, defined as countries located for the most part within one-half hour's driving time from the airport. Each service area was then profiled in terms of annual disposable income weighted by an index for average disposable income per household in that year.
   c. METHODOLOGY - In forecasting general aviation aircraft operations at Stewart several techniques were tested and rejected, including the most commonly used one: relationship of operations to numbers of based planes. Factors which will bear upon decisions by corporate and private aircraft owners to base their aircraft at an airport may include:

   - The ease of accesibility to the airport

   - The type of landing facilities available

   - The availability of hangars or tie-down space

   - The quality of service offered by the fixed base operators

   - The cost of leasing the aircraft at the airports

   - The cost of landing at the airport.

This technique, however, was rejected because of (1) wide variance among airports due to capacity constraints, training operations, and air carrier mixing and (2) erratic time series trends. Instead, regression analysis was employed to test the correlation between total general aviation operations at the 23 airports with the weighted number of high income households in the corresponding airport service areas. The final step was to break out operations between the itinerant and local. This was done based on the percentage of operations experienced at Dulles International Airport.

   d. COMMENT - The most commonly used technique of relating operations to numbers of based aircraft was rejected in this study primarily because a general statement about general aviation operations was desired, and this general statement was based on 23 other airports. The technique would have been applicable had individual airport forecasts been desired.

3. Haney, "St. Louis Aviation Forecast Study," 1975.
   a. DESCRIPTION - forecasts of aviation activity are developed for the St. Louis region.
   b. SCOPE - the forecasts of general aviation operations at Lambert-St. Louis airport include local and itinerant air taxi and commuters. Air carrier operations were forecast separately.
   c. METHODOLOGY - The basic approach was to (1) develop forecasts of based aircraft and aircraft operations for the St. Louis region; (2) use the regional picture as a background for assessing the conditions at Lambert; and (3) develop forecasts based on several major judgements, such as: a more intensive air carrier activity at Lambert which will put more pressure on general aviation activity at other airports, and an increase in itinerant operations by transient aircraft.
   For the based aircraft projections an attempt was made to correlate by multiple regression analysis active general aviation aircraft registrations in the St. Louis region with:

      • regional population

      • non-agricultural employment

      • personal income

   Unfortunately no reasonable equation could be found. So, the St. Louis historical regional share of the U.S. active based fleet was used in conjunction with a forecast of U.S. active based fleet to arrive at the corresponding forecast for the St. Louis region.
   For general aviation aircraft operations projections, the method entailed calculating the current ratio of operations per based aircraft, comparing the ratio with corresponding national figure, and projecting the ratio by factoring Aviation Advisory Commission forecast by 1.15.
   d. COMMENT - The forecasting methodology is not "behavioral" - that is, the relationships between socioeconomic variables, air transportation variables and the number of based aircraft or operations is not described. The forecast is based purely on the ratio analysis method and judgement.

4. Urban Systems Research and Engineering, "Models for Aviation Activity
   Forecasting", 1975.
   a. DESCRIPTION - this study analyzed historical patterns of aviation
      activity at FAA facilities and developed models for forecasting future
      levels of activity. General aviation forecasting models were trans-
      formed into computer-based forecasting systems for use by the FAA
      in its aviation forecasting activities.
   b. SCOPE - forecasts were made to the year 1987 of general aviation
      aircraft ownership, operations at airports with FAA-operated traffic
      control service, and activity at FAA air route traffic control centers.
      The end product of the research was to be a set of forecasting tools
      and procedures which could be used repeatedly over time and updated
      to incorporate the most recent trends in general aviation activity.
   c. METHODOLOGY - the basic strategy used in the forecasting approach
      was the following. First, the factors influencing general aviation
      activity levels were identified. These variables were grouped under
      the general headings of:

      - population

      - income

      - population density

      - general aviation facilities and support

      - general aviation flying costs

      - cost and supply of alternative transportation services

      - general aviation activity measurement system (air route
        traffic control centers and number of airports with
        FAA-operated traffic control service).

   Next, the mathematical relationship between GA activity and alternative
   determinants of this activity were estimated by econometric analysis,
   and the most attractive model forms were identified and tested. Finally,
   forecasts of the determinants of GA activity were input to the econo-
   metric activity models, and the forecasts of future GA activities were
   output.
   d. COMMENT - the econometric analysis revealed that state population,
      per capita income, population distribution, and the variable cost of
      GA flying were the most important of the seven determinants of state
      GA activity. For GA aircraft ownership, state population, per capita
      income, and state land area (which, when combined with population, is
      a measure of population density) were the important measures.

   The approach taken here adequately captures the interdependencies between
   the level of aviation activity and socioeconomic and transportation
   measures. The techniques were very well documented, represent the
   state-of-the-art in forecasting techniques, and were successful in
   explaining variations in GA activity levels for different states.
   The variables used in the analysis relate to the potential for GA
   activity in a direct and understandable fashion, and the derived
   coefficients for these variables conformed with prior expectations.
   The models developed performed well when tested for statistical sig-
   nificance and stability over the analysis period.

An appendix to the report presents a brief review of some of the more
significant prior studies of general aviation activity forecasting
and demand analysis. Of their eight reviews, four are also presented
here. They are: Baxter and Howrey (1968), Wood (1970), Ratchford
(1974), and Battelle (1973). Excerpts from the remaining four reviews
are presented here:
(1) R. Dixon Speas, The Magnitude and Economic Impact of General Aviation:
1978-1980, Aero House, 1970.
Forecasts of aircraft ownership, fleet composition, aircraft utilization,
aircraft movement, active airmen, and general aviation passengers
and cargo carried were developed and analyzed. Forecasts for general
aviation aircraft ownership were made on the national level for
the 50 states and for the 75 largest SMSA's. Aircraft ownership
was econometrically correlated to auto sales, number of cities
with populations greater than 100,000, the location (Northeast,
Midwest, etc.) of the region, and other socioeconomic variables.
(2) Arnold N. Schwartz, Estimating General Aviation Activity: An Econometric
Approach (Working Paper), May 1972.
Schwartz forecasts on a state-by-state level the number of eligible
general aviation aircraft, the number of itinerant operations, and
the number of local operations made by local general aviation aircraft.
Logarithmic multiple regression equations correlated aircraft counts
and operations to per capita income, state population, number of
airports with towers, and state land area.
(3) Daniel, Mann, Johnson, and Mendenhall, Phase One Report - California
Master Plan of Aviation, prepared for the State of California,
Department of Aeronautics and the California Aeronautics Board,
April 1973.
This state master planning document forecasts general aviation
activity to the county level and allocates general aviation demand
between airports within the counties. A linear regression equation
has as independent variables: population, income, an index of
the county's degree of urbanization, availability of air carrier
service within the county, a measure of the accessability to general
aviation facilities within the county, the total number of airports
within the county, and the relative income groups of the county.
(4) Systems Consultants, Inc., Development of a Non-Survey Method for
Estimating Traffic at Non-Towered Airports, prepared for the FAA,
April 1974.
This study evaluates air carrier and general aviation activity at
non-towered airports. It is not oriented towards forecasting but
is useful in pointing out the factors which do influence general
aviation activity. Annual itinerant operations and annual total
operations are linearly regressed against fuel storage, registered
GA aircraft in county, airport acreage, portion of student pilots
in the county attributed to the airport, air index of airport
facilities, and annual scheduled air carrier operations.

5. Baxter and Howrey, "The Determinants of General Aviation Activity: A Cross-
Sectional Analysis", 1968.
   a. DESCRIPTION - the paper is directed specifically at general aviation
      in a given locality.
   b. SCOPE - the article relates operations at general aviation airports to
      socioeconomic variables using cross-sectional data for 485 counties in
      the eastern U.S.

c. METHODOLOGY – not satisfied with either the time-series, survey, or
gravity and abstract route approaches to forecasting, demand equations
considered in this study are based primarily on the traditional theory
of consumer behavior. Logarithmic relationships were developed correlating
activity to:

- population

- per capita income

- the number of airports in a region

- the quality of services provided at the airport

- industrial characteristics of the region

Several quality-of-service variables were experimented with, including
the average inspection priority of the airports in the county, the
fraction of airports with runway lights, and the average runway lengths.
The one that was decided on is the fraction of airports in the county
with paved runways. Various indices of the industrial composition
were included in the operations equation. The indices represented
total employment and unemployment by type of industry.

d. COMMENT – Although the importance of general aviation in agricultural
communities, for example, is of interest, on balance the addition
of the variables on industrial structure added little to the explanation
of operations. In large part, this was due to the high correlation
between these variables and per capita income. It is interesting
to note that the authors forecast operations without using based aircraft
or some similar aircraft ownership variable.

6. Wood, "Analysis of General Aviation Activity", 1970.
   a. DESCRIPTION – this paper is based on cross-sectional analyses of general
   aviation activity in Wisconsin. It attempts to describe the results
   of applying known frameworks of analysis to a new body of data.
   b. SCOPE – the data which were analyzed were collected in several surveys
   conducted at 126 airports in Wisconsin in 1974. All Wisconsin general
   aviation aircraft owners and a sample of owners in five neighboring
   states were surveyed by mail and questions were asked concerning their
   flight activity in Wisconsin. Activity was defined as an aircraft
   takeoff, and the data were available for takeoffs both by planes based
   at each airport and by itinerant operations.
   c. METHODOLOGY – the author seeks to isolate the determinants of general
   aviation activity at individual airports. Variables examined include:

- the number of home-based aircraft

- population within 10-mile radius of airport

- resort and hotel rooms

- location of air carrier airports with respect to the
  county

- other socioeconomic variables such as employment and
  population

Wood examines a series of linear relationships for both counties and
individual airports.

d. COMMENT - one of the dangers of basing the analysis on survey results is that a survey is a relatively expensive research technique in relation to the amount of data collected and, except in very specific situations, resources are unlikely to extend to total coverage. Also, because the survey was only taken once, the change in traffic was being forecast, based on a one-time measurement. Hopefully, future surveys will develop more information concerning specific characteristics of trips, aircraft, and aircraft utilization.

One other noteworthy aspect of this paper is the level of detail in both the dependent and independent variables. Wood's independent variables include the number of takeoffs at each airport by class of aircraft, and a further distinction is made between operations of based and non-based aircraft at each airport.

7. Ratchford, "A Model for Estimating the Demand for General Aviation", 1974.
   a. DESCRIPTION - claiming that to date no one has estimated the effect of price or income on the demand for general aviation, Ratchford analyzes the elasticity of demand for aircraft activity with respect to disposable personal income and the price of aircraft operation.
   b. SCOPE - time series data from 1947 to 1971 were used. General aviation activity includes: business, personal, recreation, construction, crop dusting, and air taxi. This activity is measured at the national level by the variable: hours of total U.S. general aviation activity divided by U.S. population.
   c. METHODOLOGY - two econometric forms were developed: one linear and one logarithmic. A total of sixteen separate regression equations was fitted, relating general aviation activity with:

   - price index data for general aviation flying

   - disposable personal income

   - an index reflecting changes in the cost of commercial air carrier flying

   - and two dummy variables which correspond to periods of unusual changes in general aviation flying (pilot training associated with the G.I. Bill in 1947-48 and the Korean War from 1951-53).

   d. COMMENT - broad national forecasts of total general aviation activity are the easiest to make, achieve the best fit to the data, and are of little real use. To serve any planning purpose, they must be broken down to the level of individual airports and regions, and the processes for breaking these aggregate projections down into sub-totals by region or county usually are ad hoc and lack a solid basis.

   Ratchford's work is not a forecasting model in a strict sense of the word. He analyzed historical data and made references about the behavior of consumers of general aviation activity. However, his work is useful as a guide to future forecasting methodology.

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8. Systems Consultants, "General Aviation Forecasts: 1975-1987 State, Regional and National Operations", 1976.
   a. DESCRIPTION - this report provides annual state, regional and national forecasts of general aviation activity. In addition to the forecasts, the forecasting model and the rationale used in its development is identified. Also, alternative forecasting techniques, whose results verified the validity of the aggregate estimates, were developed and are described.
   b. SCOPE - the report presents yearly forecasts through 1987 of total (towered plus nontowered airports) general aviation activity in terms of total, local and itinerant aircraft operations.
   c. METHODOLOGY - the forecasting models developed in this report were based on a pooled time series and cross-section framework using data from the 48 contiguous states for the years 1972 and 1974. The resultant models for estimating total and local operations were derived using econometric techniques. The final models included two explanatory variables:

   • number of pilots or number of student pilots
   • number of general aviation active aircraft

   which were used at the state, regional and national level. These two explanatory variables were selected from other candidate exogenous variables:

   • state's wealth - bank assets, personal income, in-force insurance, savings and loan mortgages.
   • its people - total population, voting age population, college attended population, pilots and student pilots.
   • aeronautical factors - number of active aircraft, number of active aircraft less six years old, number of airports.
   • alternate transportation - auto registrations, miles of paved highway, land area.

   Alternate models were also explored in this report. One simplified approach that was initially investigated categorized airports into groups according to their estimated operations. These estimations were then scaled up and added together to produce national level results. A second more sophisticated technique was to modify an existing regression model which was a linear function of 4 applicable variables: land area (acres), number of single engine aircraft, number of registered aircraft per 100,000 population, number of hours flown. A third model calculated total operations directly from the number of hours flown, the number of hours per flight and the number of operations per flight. Finally, the fourth approach is to calculate usage rates (i.e. operations per based aircraft) from readily available operations data.
   d. COMMENT - the forecasting techniques that were investigated in this report as well as the final model that was used for the primary forecast were well documented and were adequate for the purpose of airport planning. Statistical tests were performed on the stability of the results, and alternative forecasting techniques were also developed to test the credibility of the econometric technique that was used for the primary forecast: the alternative methods yielded forecasts similar to the primary forecast.

9. Battelle - Columbus Laboratories, "General Aviation Dynamics" , 1977.
   a. DESCRIPTION - this report is the result of a series of research programs
      dealing with the cost impact effects on general aviation. During these
      studies, it became apparent that the complex nature of the general aviation
      system was not being adequately represented with a set of independent,
      log-linear regression equations. A method was needed which: focused
      on general aviation activity at the individual user or aircraft type
      categories; recognized the important causal interactions between pilots,
      aircraft, and annual hours flown; and has the ability to assess various
      policy alternatives quickly. The General Aviation Dynamics model was
      an attempt to satisfy the above objectives. Its methodology differs
      from previous forecasting techniques.
   b. SCOPE - the approach provides distinct forecasts for aviation activity
      within each significant user category/aircraft type subsegment. The
      primary activity measures are:

   - number of active aircraft by primary use

   - annual hours in service

   - pilots

   Seven distinct user categories were chosen (business, corporate, personal
   aerial application, instructional, air taxi, and other), and seven dif-
   ferent aircraft types were included (single-engine non-aerial application,
   single-engine aerial, multi-engine, turboprop, turbojet, piston-engine
   helicopter, turbine helicopter).

   The model is claimed to have the following capabilities: the ability to
   forecast baseline activity at the national level in the area of pilot
   supply, aircraft utilization, and aircraft demand; evaluation of alter-
   native policy actions; and sensitivity analysis.
   c. METHODOLOGY - throughout the report, discussion of the model is couched
      in the terminology of system dynamics. In essence, the technique consists
      of a set of non-linear, simultaneous, first-order difference equations.
      These difference equations explicitly describe the decision policies
      followed by users of general aviation. There are three major sectors
      representing the most important state variables in the model: pilot
      supply, aircraft utilization, and aircraft demand. The aircraft utiliza-
      tion and aircraft demand sectors are tied together by important negative
      feedback loops for some user category/aircraft type subsegments. In
      many cases, the demand for an active aircraft is derived from conditions
      within other sectors. The pilot supply sector exhibits a one-way causal
      influence on both numbers of active aircraft and annual hours flown.

   The pilot supply sector develops forecasts of the active pilot population
   by type of certificate and number of ratings. Relationships are estab-
   lished between the factors of three population age groups, student
   certificates issued, and cost of instructional flying. The aircraft
   utilization sector recognizes significant behavioral differences for
   each of the users. Finally, the aircraft demand sector has a functional
   section for each user category/aircraft type subsegment. For example,
   the demand for business or personal use is dependent on the supply of
   active pilots, the demand for air taxi and instructional use is dependent
   on utilization rates, and the demand for corporate use is based on
   national economic conditions like GNP.

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d. COMMENT – the general aviation model developed here analyzes the aggregate level of activity within the U.S. The authors caution at the time of writing that "it was not constructed for the purpose of forecasting activity on a regional basis; although it should be adaptable to regional studies."

The model represents a significant advance in the state of the art. It is better judged according to its overall structure which defines the causal interactions between various components of the entire general aviation system. According to the authors, some parts of the model are better understood than others. This is partly because of data availability and partly because of a more stable behavior of certain segments of the general aviation community. A complete assessment cannot be made without more experience using it.

D. Military Aviation

1. DOT -FAA "Aviation Forecasts - Fiscal Years 1978-1989", 1977.
   a. DESCRIPTION - see air carrier
   b. SCOPE - 10 year forecast of operations. Detailed military planning
      extends through 1983, and remaining year forecasts are projected at
      the 1983 level by the FAA. Basic military activity elements (aircraft
      and flying hours) are translated into expected FAA air traffic workloads.
   c. METHODOLOGY - All military aviation activity forecasts are based upon
      information provided by Department of Defense and the U.S. Coast Guard.
   d. COMMENTS - the forecasts assume operations to hold nearly constant
      throughout the planning period. Thus, the methodology is based
      purely on judgement.

2. Haney, "St. Louis Aviation Forecast Study," 1975.
   a. DESCRIPTION - forecasts of aviation activity are developed for the
      St. Louis area.
   b. SCOPE - forecasts of itinerant and local aircraft operations are
      made every 10 years through 1980.
   c. METHODOLOGY - discussions with Missouri-Air National Guard personnel
      revealed that there is no basis for forecasting a substantial change
      in the level of Air National Guard Activity.
   d. COMMENTS - methodology is purely judgemental.

3. DOT-FAA, "Military Aviation Forecasts Fiscal Years 1977-1988," 1974.
   a. DESCRIPTION - This report presents forecasts of military air traffic
      activity at facilities operated by the FAA. These data are required
      for proper planning to meet the demands which the U.S. military
      services will place on the National Aviation System.
   b. SCOPE - Data on the number of active military aircraft and hours
      flown were supplied by the Office of Secretary of Defense. Data
      covers the period fiscal years 1977-1983. The 1983 levels were
      then extended foreward for general planning guidance for 1984-1988.
   c. METHODOLOGY - Detailed planning information, supplied by the Department
      of Defense, goes through fiscal year 1983. The remaining years
      1984-1988 have been projected by the FAA at the 1983 levels using
      historic trend rates.
   d. COMMENT - the level of military activity is a function of national
      defense policy and, as such, it naturally does not lend itself to
      forecasting techniques like trend analysis or econometrics, which are
      a function of historic trends and variables relative to national
      defense. Thus, about all that can be expected is either to use the sort of
      methodology that the FAA has adopted here or to assume that the
      level of military activity will not change in the forecast period.

E. Air Cargo

1. DOT-FAA "Aviation Forecasts - Fiscal Years 1978-1989", 1977.
   a. DESCRIPTION - see air carrier
   b. SCOPE - Forecasts are made for freight, express and mail and are
      expressed as revenue ton-miles (RTMs).
   c. METHODOLOGY - Air cargo forecasts are made using econometric fore-
      casting techniques. Activity is assumed to be a function of the:

      • general economy of the U.S. and its world trading partners

      • growth in time-sensitive cargo shipments

      • differences in quality and prices for air and surface
        transportation modes.

      One model forecasts domestic RTMs while 12 other models forecast
      RTMs for imports from and exports to 6 world regions. The 12
      international models are based on a 10 year series of U.S. imports
      and exports by air as reported by the Department of Commerce, and
      on average revenue yields.
   d. COMMENTS - the air cargo econometric model is founded on the
      premise that no dramatic technological or sociopolitical changes
      will occur in the forecast time frame. The models also assume that
      shippers and receivers choose their transport mode based upon
      economies and time sensitivities, and that these choices will
      remain essentially unchanged in the future.

2. Haney, "St. Louis Aviation Forecast Study," 1974.
   a. DESCRIPTION - forecasts of aviation activity are developed for the
      St. Louis region.
   b. SCOPE - future freight and mail originations and enplanements were
      estimated through the year 2000 for Lambert-St. Louis based on
      1959-1969 data.
   c. METHODOLOGY - a number of multiple regression models were developed
      using historical freight and mail originations and their relationships
      to demographic, economic, and freight rate variables. The most
      attractive models, judged from theoretical and empirical rules, were
      those that related freight and mail solely to total personal income.
      Both linear and logarithmic models were tested.
   d. COMMENT - see air carrier.

3. Maio, Wang and Meltzer, "Forecasting Models for Air Freight Demand," 1977.
   a. DESCRIPTION - this report documents a method for projection of air
      cargo activity at all U.S. hub airports and provides a base projection
      of such activity at 25 large hubs. This project was conducted by
      the Transportation Systems Center for the FAA Office of Aviation
      Policy to support that office's periodic update of Aviation Forecasts
      and Terminal Area Forecasts.
   b. SCOPE - base projections for 1977, 1982, and 1987 are made for national
      aggregate cargo enplanements and a set of hub passenger enplanements
      which are translated into hub specific enplanements in passenger
      flight lower holds, enplanements in freighters, and into freighter
      operations. Projections are produced for domestic services and

for U.S. international services for each of the three forecast years and each air hub specified. Any number of hubs may be included in the current base forecast.

c. METHODOLOGY - four major steps are involved in the forecast procedure. Step 1: allocation of the long-term national air freight (including express) and air mail demand forecasts to cargo tonnage enplaned by hub. Econometric models were used to forecast aggregate domestic revenue ton-miles and international export and import tons based primarily on the following two explanatory variables:

- an aggregate measure of economic activity, like GNP;

- average revenue yields.

Allocation of this aggregate demand to the air hubs was in proportion to their respective historical shares of the total (shares assumed constant throughout the forecast). Step 2: estimation of the passenger fleet usable lower hold capacity for each hub by analyzing the growth trend of the size of the aircraft. Step 3: projected cargo tonnage is allocated to the estimated lower holds by market group out of each hub until the capacity is exhausted. A computer program handles this assignment. Step 4: having allocated the total demand to lower holds until the capacity is exhausted, any residual demand is assigned to freighters. Application of projected average employment load factors to projected average aircraft capacity produced the average enplanement measured in tons per departure which can be expected for each market group out of each hub. Dividing the projected residual demand for lift capacity for each group out of each hub by the projected average tons per departure produces the estimates of projected annual freighter departures for each hub.

d. COMMENT - the technique presented here is at the state-of-the-art in econometric traffic forecasting. The "behavioral" approach allows for the description of the causal relationships between socioeconomic and transport system characteristics on the one hand and the number of air passengers on the other. However, because of the lack of supply (or level of service) variables and policy variables, the forecast presented here is founded on the premise that no dramatic technological or socio/political changes will occur in the forecast time. Given the available data, significant improvements in the accuracy or precision of the forecasts can occur through individual forecasts of specific commodities, through more credible modal split models, and more precise modelling of the price and levels of service factors.

4. Cohen, "Planning for Air Cargo Development", 1974.
   a. DESCRIPTION - the essence of Cohen's paper is forecasting domestic scheduled air cargo traffic in such a way that it attempts to stimulate the "cause and effect" mechanisms of demand generation. With a basic understanding of economic, technological, demographic, and regulatory factors that affect the demand for a product or service, a model can be constructed which provides a more tenable basis for demand forecasting than do the prior methods of trend extrapolation and executive judgment.
   b. SCOPE - the forecasts are given in ton-miles of domestic scheduled air cargo for freight, express, air mail, non-priority mail, and total cargo from 1973 to 1985. These aggregate forecasts do not

propose to indicate potential demand. Rather, the research was dedicated to predicting only the "satisfied" cargo demand, given certain levels of price, inventory, and economic activity.

c. METHODOLOGY – the technique of econometric modelling is applied to supply the analytic foundation for the national forecast of scheduled air cargo traffic. Cohen provides a list of some of the determinants of air cargo demand:

- economic activity

- rates

- technological change

- military situations (airlift support)

- service characteristics such as schedule convenience, flight frequency, on-time reliability, and the probability of ground handling damage, and/or pilferage

- operational performance of competing modes

- shipper awareness of the total distribution cost concept

- airline promotion of air freight service

- excess capacity

- regulatory actions

However, the past magnitudes of several of them are not easily measurable, and their future magnitudes are not easily forecasted. As a result, Cohen formulates the air freight model with GNP, price, and some dummy variables for seasonality; the air express model included GNP, seasonality, and an "urgency of need" indicator (such as the level of non-durable goods inventories of retail stores); and the air mail and first class models include GNP, seasonality, and U.S. mail traffic in the preceding quarter (lagged). All four models were calibrated with quarterly data from the years 1958 to 1970.

d. COMMENT – the approach is fairly typical: the author begins with a detailed analysis of the determinants of air cargo demand and develops a long list of these variables, but only ends up including the usual aggregate measures--GNP and price. In addition, broad national forecasts of total ton-miles are the easiest to make and are of little real use until they are broken down to the level of individual airports or regions. Usually, the process for breaking these aggregate projections down is ad hoc and lacks a solid basis. In Cohen's paper, the suggested conversion process is based on extrapolation of historical data and on judgment.

5. Wilson, "Policy Analysis and Forecasting Models for U.S. Domestic Air Cargo Movements", 1977.
   a. DESCRIPTION – this study describes the modification and extension to air cargo of a new disaggregate simulation freight demand analysis model developed at the MIT Center for Transportation Studies. This effort was in response to a lack of substantive demand analysis at the disaggregate shipper level. While some logistics cost models have been developed by manufacturers for sales purposes, the author

claims that none has been applied systematically to a wide range of
shippers and commodities. The industry has had to rely on aggregate
level forecasts.

b. SCOPE - using a 10 percent sample of 1974 air bills collected by the
CAB for use in the <u>Domestic Air Freight Rate Investigation</u>, statistical
expressions are estimated which relate shipment rates to character-
istics of the shipment and attributes of the commodity shipped, such
as weight, length of haul, number of pieces, density, value per pound,
interlining and directionality. Its principal outputs are freight
modal share estimates by commodity group, supplemented by the logistics
cost components and choice of mode and shipment size for each individual
commodity and shipper.

c. METHODOLOGY - the modelling approach used in this study is based upon
a classical inventory theory approach toward logistics decisions.
Firms are assumed to minimize "total logistics cost," including storage,
capital carrying, and stockout costs as well as transport charges,
in making modal choice decisions. The results of these individual
decisions are accumulated and used to develop modal share estimates,
which can then be used in preparing aggregate forecasts of modal flows.

d. COMMENT - according to the author, the ideal type of modelling approach
for air cargo demand is one which allows for the analysis of new tech-
nology options under a range of different assumptions about the regulatory
and management actions which will shape the future air cargo environment.
Current models are neither sufficiently policy-sensitive nor detailed
enough to be of real use. Certainly, in these respects, the approach
taken here represents a substantial improvement. It is behaviorally
oriented, and based on individual shippers' modal choice decisions.
It also represents the most advanced technique currently available
for forecasting domestic city-pair air cargo movements.

IV.   REVIEW OF 1973 MASSACHUSETTS STATE SYSTEM PLAN FORECAST

a. PREPARED BY - Arthur D. Little, Inc., December 1973.

b. SCOPE - the forecasts included based aircraft, annual operations (local and itinerant), aircraft mix, and peak activity.

c. FORECAST TIME FRAME - 1972, 1977, 1982 and 1992.

d. METHODOLOGY - the forecasts began with developing projections for based aircraft at each of the State's airports.   Forecasts of aviation activity were then developed as a function of the based aircraft predictions.   Based aircraft were estimated using the following procedure. The first step was to develop projections of based aircraft for the State as a whole using a simple regression analysis of based aircraft counts against population 25 years old or older, population 25 years or older with some college education, and per capita income.   Each of the socioeconomic variables (population, education and income) were converted to indices to facilitate the manipulation of data at the Regional Planning Area (RPA) level based on a state estimate of the variables. This conversion was done because they felt that the reliability of the estimate was better at the State level than at the RPA level.   The second task was to project the share of each of the RPA's based aircraft to the state's total by using a least squares analysis of 1960-1970 historical based aircraft data compiled from 5010-1 forms.   Finally, the projected shares for each airport in an RPA were also obtained from a least squares analysis of the 1960-1970 historical record.   Some projections were later revised by a judgmental weighting procedure, such as whether an airport would (1) service the public instead of being strictly military, or (2) have a limited capacity due to geographical reasons.   As far as the consultant can determine, the judgmental process did not give additional consideration to localized socioeconomic factors within an RPA.   All other aviation activity projections, such as local vs. itinerant and peak activity, were developed using historical trend rates.

e. COMMENT - the approach taken here is the classical one.   Based aircraft are first projected and then aircraft activity is estimated from these volumes.   Basically, it appears to be reasonable on inspection and intuitively correct.   However, there is an imbalance in the sophistication of the techniques applied to each task.   Based aircraft projections utilize a fairly sophisticated regression approach which adequately captures the effects of changes in the socioeconomic factors (population, education, and income).   But the conversion of these estimates to aircraft operations relied simply on historical trends and judgment. Such an approach is inadequate to effectively capture the interrelationships between the socioeconomic, technological and institutional (such as fuel, noise and regulation) factors on the one hand, and aviation activity on the other.

V. REVIEW OF INDIVIDUAL MASSACHUSETTS AIRPORTS MASTER PLANS

1. Bedford (Hanscom Field)
   a. PREPARED BY - R. Dixon Speas and Bolt, Beranek and Newman, June 1977.
   b. SCOPE - the primary forecast element was eligible registered aircraft, which served as a basis of forecasting general aviation aircraft operations. Usage included: executive, business, personal, aerial application, instructional, air taxi - FAR 135 non-scheduled, industrial/special, and "other". Forecasts also include local and itinerant operations, instrument approaches and estimates of peak-hour activity.
   c. FORECAST TIME FRAME - 20 year, 1975-1995.
   d. METHODOLOGY - total approach is best illustrated in outline form:
      1. define study area or region of forecast.
      2. forecast U.S. general aviation aircraft registrations by a regression on GNP (lagged one year) and population greater than 16 years.
      3. break-down this macro-forecast into regional based aircraft using the historical ratio trend.
      4. develop another micro-forecast of study area registrations by a multivariate regression on regional population, employment and per capita income.
      5. evaluate and consolidate both the macro and micro forecasts to produce a practical and realistic regional forecast of based aircraft.
      6. aircraft movements were calculated by applying results of a survey and historical trends to based aircraft projections.
      7. the aircraft movements forecasts were compared to FAA and State System Plan forecasts to determine degree of reasonableness.
      The proportion of local-to-itinerant operations were described using historical trends. Peak-hour activity was calibrated using FAA supplied curves from a report entitled, "Air Traffic Relationships".
   e. COMMENT - the approach taken here is the classical one. Based aircraft are first projected and then aircraft operations are estimated from these volumes. In this study the projections of based aircraft utilized sophisticated regression techniques, but the conversion process of based aircraft into aircraft operations was based simply on historical ratios and results obtained from a survey.

2. Beverly
   a. PREPARED BY - Edwards and Kelcey, Inc.; Aerospace Systems, Inc.; W.J. Cavanaugh and L.G. Copley; November 1973.
   b. SCOPE - the basic part of the master plan is the analysis and projection of both based aircraft and total general aviation operations. These forecasts are then translated into peak aviation demands.
   c. FORECAST TIME FRAME - 20 year, 1972-1992.
   d. METHODOLOGY - projections of the number of based aircraft were calculated using two methods: a straight line trend relationship with population (over 25), and an estimated share of Beverly to statewide estimates provided by the FAA. The average number of operations per based aircraft were then predicted using a trend relationship of the number of based aircraft (forecasted using the above 2 techniques). A certain amount of judgment was also used in adjusting these forecasts to reflect actual field surveys, national trends, and data provided by the commission. These forecasts were translated into peak aviation demand in terms of peak-day or busy-hour operations.

Note: FAA defines busy-hour operations as the total number that are
expected to occur at an airport, averaged for two adjacent peak hours
of a typical high activity day (using the 37th high activity day of
the year).

   e. COMMENT - their approach is poorly documented and seems to rely
      mostly on past historical trends and judgment. Such an approach is
      not sufficiently "behavioral" to allow for impacts of changes in
      socioeconomic, technological or institutional (such as fuel, noise
      and regulatory) policy.

3. Boston (Logan)
   a. PREPARED BY - Massport, September 1975.
   b. SCOPE - projections are given for: air carrier passenger demand and
      aircraft operations, general aviation operations, military operations,
      ground access demand, runway usage, high-speed rail diversion, and
      night passenger operations.
   c. FORECAST TIME FRAME - yearly from 1975 to 1985.
   d. METHODOLOGY - purely judgmental. From a number of socioeconomic
      factors as well as factors related to the cost and convenience of
      flying, growth rates are estimated and applied to growth in traffic
      and operations. The approach is "bottom-up" in the sense that a
      rate of growth is assumed and then applied to the base year.
   e. COMMENT - the methodology is poorly documented and projections rely
      entirely on assumed growth rates. Such a judgmental approach is not
      behavioral enough to allow for relationships between the number of
      aircraft operations or enplaned passengers on the one hand and
      socioeconomic and air transportation variables on the other. This
      methodology is inadequate.

4. Chatham
   a. PREPARED BY - Edwards and Kelcey, Inc.; Aerospace Systems, Inc.;
      W.J. Cavanaugh and L.G. Copley; January 1973.
   b. SCOPE - estimates of based aircraft and total aviation activity are
      given, and are also translated into peak-day and busy-hour operations --
      which provide the most accurate measure of the types of facilities
      that will be needed. Seasonal variations also measured.
   c. FORECAST TIME FRAME - projections given for 1977, 1982, and 1992.
   d. METHODOLOGY - the number of based aircraft were estimated using a
      trend relationship with population (over 25), and an estimated share
      of Chatham to statewide estimates provided by the FAA. Aircraft
      operations were then predicted based on a relationship to the based
      aircraft counts and checked against yearly town reports, operators,
      the FAA, national averages and actual field counts. These forecasts
      were then translated into peak aviation demand in terms of peak-day
      or busy-hour operations.
   e. COMMENT - their approach is poorly documented and seems to rely mostly
      on historical growth rates and judgment. Such an approach is not
      sufficiently "behavioral" to allow for impacts of changes in
      socioeconomic, technological or institutional (such as fuel, noise
      and regulatory) policy.

5. Hyannis (Barnstable Municipal)
   a. PREPARED BY - Arthur D. Little, Inc., January 1974.
   b. SCOPE - for the commercial operations the report presents projections
      of scheduled, flight instruction and charter activity. For general
      aviation, the number of based aircraft were estimated and both local
      and itinerant operations were forecast.

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c. FORECAST TIME FRAME - forecasts given for 1977, 1982 and 1992.
d. METHODOLOGY - two projections of year-round private use based aircraft
were given. For a high-range, aircraft ownership was related to
population growth. For the low-range the rate was based on aircraft
ownership growth rates for the state. Commercial aviation activity
(scheduled, instructional flying and charter operations) were projected
using historical trends (growth rates). General aviation forecasts
(local and itinerant) were based on judgment and were compared to FAA
Terminal Area Forecasts and Massachusetts State Plan growth rates.
e. COMMENT - the approach relied mostly on historical growth rates and
judgment. The authors point out that prior attempts to derive
forecasting models for the whole country, culling out such factors
as growth in income, changes in demographics, the geography of the
region or modal accessibility, have generally produced mixed results.
For relatively small regions, the effort is even less useful.
Therefore, they decided not to construct a complicated model, but
rather to derive ratios based on growth trends.

6. Lawrence
a. PREPARED BY - Arthur D. Little, Inc., January 1974.
b. SCOPE - projections include aircraft ownership and aircraft
operations.
c. FORECAST TIME FRAME - forecasts given for 1977, 1982 and 1992.
d. METHODOLOGY - the FAA claims that there is a definite positive
relationship between population, income and the number of based
general aviation aircraft. The authors, however, maintain that these
relationships are viable for determining aviation demand in large
areas, and that such macro average approaches are only minimally
useful at specific airports like Lawrence. According to Arthur D.
Little, aircraft ownership is growing faster than population in a
manner that looks similar to a normal growth, or Gompertz, curve.
Thus, this growth rate was assumed for based aircraft projections at
Lawrence. Their forecast of airport operations was based upon their
knowledge of surrounding airports. Here, they undertook their own
counts and utilized the seasonality of Norwood and Hanscom to develop
a slightly greater seasonality factor for Lawrence.
e. COMMENT - see Hyannis.

7. Marshfield
a. PREPARED BY - Hoyle, Tanner and Associates, March 1975.
b. SCOPE - forecasts are limited to general aviation activity. This
includes: charter, recreational, instructional, pleasure, flying
clubs, private business and similar activity. The forecasts encompass:
based aircraft counts, annual operations, peak-hour operations, and night
operations. Aircraft operations are further segmented into local
and itinerant.
c. FORECAST TIME FRAME - there are three planning periods: short range
(1972-1977), intermediate (1978-1982) and long range (1983-1992).
d. METHODOLOGY - the consultants used the forecasting methodology designed
by Arthur D. Little for the Massachusetts Airport System Study.
This study began with developing projections for based aircraft.
Forecasts of annual operations, peak month and peak hour operations,
itinerant vs. local operations, etc., were then developed as a
function of the based aircraft projections. Based aircraft were

estimated using the following procedure:(1) projections of based aircraft for the state as a whole were developed by a simple regression analysis of based aircraft against time, population, population over 25, and per capita personal income; (2) projections of the share of each of the regional planning areas (RPA's) based aircraft to the state's total by a least squares analysis of historical based aircraft; and (3) projections of these shares to each airport in the RPA by least squares analysis. Total annual operations were forecast from a historical ratio of operations per based aircraft and an assumed growth rate. Local vs. itinerant operations forecasts were developed from assuming prior percentage split between the two. Peak month operations were estimated from historical percentages and judgment. Peak hour operations were computed from average daily operations (peak month divided by 31) in accordance with FAA criteria as given in the advisory circular "Airport Capacity Criteria Used in Preparing the National Airport Plan."

    e. COMMENT - the approach taken here is the classical one. Based aircraft are first projected and then aircraft operations are estimated from these volumes. As usual, the projections of based aircraft utilize sophisticated regression techniques, but the conversion process of based aircraft to operations relies simply on historical trends and judgment.

8. Nantucket

    a. PREPARED BY - Transplan, Inc., June 1973.

    b. SCOPE - forecasts encompass: passenger demands (accounting for seasonality, peak-day and peak-hour counts); aircraft operations for air commuters, general aviation and total; number of based aircraft; and aircraft mix.

    c. FORECAST TIME FRAME - forecasts given for 1977, 1982 and 1992.

    d. METHODOLOGY - the consultants claim that the most authoritative forecasts of aviation activity are those of the FAA. Thus, all estimates are based on FAA supplied growth rates.

    e. COMMENT - the approach relies entirely on historical and FAA supplied growth rates and on judgment. Such an approach is not sufficiently "behavioral" to allow for impacts of changes in socioeconomic, technological or institutional (such as fuel, noise and regulatory) policy.

9. New Bedford

    a. PREPARED BY - C.E. Maguire, Inc., 1975.

    b. SCOPE - forecasts are given for air carrier, military, general aviation and cargo operations.

    c. FORECAST TIME FRAME - there are three planning periods: short range (1975-1980), intermediate (1980-1985) and long range (1985-1995).

    d. METHODOLOGY - air carrier and military operations were projected using assumed growth rates. The general aviation operations forecast used an average of six regressions: the first correlation is between operations and population; the second is a correlation with income; the third is a correlation with per capita income; the fourth, fifth and sixth are simply a linear least-squares regression against time for various base years. For the cargo forecasts, the historical growth rate was applied to the base year for projections out to 1980, then a constant 10 percent was applied from 1980-1995.

    e. COMMENT - with the exception of the general aviation forecasts, which use econometric techniques, the approach relies mainly on judgment

about the rates of growth. For general aviation activity, the
consultants state that a preferred methodology would be first to
forecast based aircraft and then to forecast the number of landings
and take-offs, i.e. operations. However, to forecast based
aircraft one needs an accurate time series (history) of based
aircraft, and in the case of New Bedford such a record does not exist.
For this reason, the technique of averaging 6 regressions was
applied. It appears that 6 separate regressions were used instead
of one so as to avoid collinearity among the explanatory variables.
In other words, if both income and income per capita were included
in the regression equation, then the correlation between these two
variables will affect the accuracy of the forecast.

10. Norwood
    a. PREPARED BY - Fay, Spofford and Thorndike, Inc., September 1975.
    b. SCOPE - forecast includes based aircraft, aircraft mix, enplaned
       passengers, and annual and peak operations. Both local and
       itinerant operations are estimated.
    c. FORECAST TIME FRAME - intervals of 5, 10 and 20 years from 1972 to
       1992.
    d. METHODOLOGY - basically, the consultants used the forecasting
       methodology developed by the FAA in the report "Aviation Demand and
       Airport Facility Requirement Forecast for Medium Air Transport Hubs
       through 1980." In addition, forecasts based on socioeconomic activity
       of the region as performed by Arthur D. Little were available for
       comparison. Forecasts of based aircraft were estimated from growth
       rates of the Eastern section of the U.S. as suggested by the FAA, but
       adjusted downward to account for slower growth at Norwood. Forecasts
       of annual operations were also determined in accordance to FAA
       prescribed growth trends.
    e. COMMENT - the approach, adopted from the FAA, relied entirely upon
       historical growth rates and judgment. Such an approach is not
       sufficiently behavioral to allow for impacts of changes in socioeconomic,
       technological or institutional policy.

11. Plymouth
    a. PREPARED BY - Fay, Spofford and Thorndike, Inc., December 1973.
    b. SCOPE - forecast includes based aircraft, annual operations (local
       and itinerant), aircraft mix, enplaned passengers, and peak
       operations.
    c. FORECAST TIME FRAME - 1972 to 1992 at 5 year intervals.
    d. METHODOLOGY - because of the uncertainty involved in forecasting,
       three different methods used to predict number of based aircraft and
       operations: methods 1 and 2 are based on growth trends and shares;
       method 3 is a standard procedure recommended by the FAA. Methods 1
       and 2 differ in the estimation of the number of based aircraft.
       In method 1 the growth is simply that forecasted by extrapolation.
       In method 2 the growth is based on the average of growth trends for
       the nation, state and county. Here, growth trends are expressed in
       terms of population-to-based-aircraft ratios. All three method
       estimates were averaged. The number of operations that will occur were

calculated by multiplying Plymouth's share of based aircraft as estimated from above by the ratio of number of operations per based aircraft (estimated at county level). Implication here is that Plymouth activity is similar to county as a whole.

e. COMMENT - the difficulty of forecasting at non-towered airports, such as Plymouth, is the accuracy and consistency of the data. One can use national, state and county trends in aviation growth which tend to minimize or average out any errors at the individual airport level. Here, the consultants chose to average out the error by using three methods. For forecasting, such an approach is intuitively correct but is not sufficiently policy-sensitive.

12. Provincetown

a. PREPARED BY - C.E. Maguire, Inc., Philip B. Herr and Associates, 1972.

b. SCOPE - projections are given for passenger movements, scheduled air taxi movements, general aviation operations, based aircraft, aircraft mix, and peak hour operations.

c. FORECAST TIME FRAME - 1972 to 1992 at 5 year intervals.

d. METHODOLOGY - various techniques were used depending on the variable to be forecast: for passenger movements a ratio was computed of passengers enplaned and deplaned to a weighted employment index; scheduled air taxi activity was based on passenger enplanements and estimated seating capacities; general aviation operations were obtained from FAA supplied growth rates; peak hour operations were calculated from FAA criteria in "Airport Capacity Criteria Used in Preparing National Airport Plan"; aircraft mix was assumed to remain the same; and the number of based aircraft were estimated using judgment.

e. COMMENT - the approach relies entirely on historical and FAA supplied growth rates and on judgment. Such an approach is not sufficiently "behavioral" to allow for impacts of changes in socioeconomic, technological or instititutional (such as fuel, noise and regulatory) policy.

13. Southbridge

a. PREPARED BY - Edwards and Kelcey, Inc.; Aerospace Systems, Inc.; W.J. Cavanaugh and L.G. Copley, March 1973.

NOTE: the scope, forecast time frame and methodology are exactly the same as for the Beverly forecast.

14. Taunton

a. PREPARED BY - Edwards and Kelcey, Inc.; Aerospace Systems, Inc.; W.J. Cavanaugh and L.G. Copley, January 1973.

NOTE: the scope, forecast time frame and methodology are exactly the same as for the Beverly forecast.

15. Turners Falls

a. PREPARED BY - C.E. Maguire, Inc., May 1976.

b. SCOPE - forecasts included based aircraft, annual operations (both local and itinerant), busy hour and peak hour operations, and passenger movements.

c. FORECAST TIME FRAME - 20 years, 1975 to 1995 in 5 year intervals.

d. METHODOLOGY - In this study the basic parameter of air traffic demand was the number of based aircraft. All other projections were dependent on the ratio of based aircraft to income per capita. To complete the various forecasts where it was determined that data was lacking, state-wide or FAA national trends and norms for similar airports were used to supplement the Turners Falls data. The technique of forecasting based aircraft was not stated, although a combination of using historical trends and judgment was suspected.

Per capita income was applied as an indicator upon which to base
projected aviation activity, but its exact application is not
documented.
   e. COMMENT – their approach is poorly documented and relies mostly on
      historical trends and judgment. Such an approach is inadequate for
      policy analysis.
16. Westfield (Barnes)
   a. PREPARED BY – Conlon Associates, United Aircraft Research
      Laboratories, December 1972.
   b. SCOPE – projections include general aviation operations (both local
      and itinerant), military activity and limited scheduled air carrier
      service. Latter analysis made in considerable detail, including
      forecasts for enplaned passengers to specific locations. Air freight
      demand was also examined.
   c. FORECAST TIME FRAME – projections given for 1977, 1982 and 1992.
   d. METHODOLOGY – general aviation activity is keyed to based aircraft.
      Average annual growth rates were assembled from the state and FAA
      (Medium Hub Forecast)from which a composite forecast was constructed.
      The Westfield airport is a potential location for a limited scheduled
      carrier network. An analysis of this potential consisted of:
      (1) a projection of the origins and destinations of all travelers to/
      from SMSA's in Western Mass. and Northern Conn., using a "gravity"
      model; (2) a projection of the share of those trips traveling by
      air, using a "disutility" model (the "disutility" is the total
      apparent "cost" of transportation); and (3) a selection was made of
      some candidate destinations of the scheduled service by careful
      judgmental screening of all U.S. and Canadian SMSA's. Forecasts for
      air cargo were prepared to correspond to growth in the scheduled
      passenger service, the historical tonnage of mail and freight
      enplaned at nearby Bradley field, and historical scheduled air cargo
      service at Bradley. Judgment was exercised for the military aviation
      projections.
   e. COMMENT – considerable effort and detail went into the scheduled air
      carrier forecasts, incorporating such techniques as "gravity" models
      and "disutility" functions, but the other activity projections relied
      mainly on judgment and some knowledge of historical growth trends.
      Particularly noteworthy is the fact that, historically, there is no
      scheduled air carrier activity at Westport. Such an imbalance in
      the sophistication of the applied techniques can be justified only
      if scheduled air carrier activity represents the major fraction of
      total operations; otherwise, the forecasts are inadequate.
17. Worcester
   a. PREPARED BY – R. Dixon Speas Associates, August 1973.
   b. SCOPE – projections include airline passenger demands, air freight
      movements, air carrier aircraft activity, aircraft mix, general
      aviation activity (for both local and itinerant operations) and peak
      day and busy hour activity.
   c. FORECAST TIME FRAME – 1977, 1982, 1987, and 1992.
   d. METHODOLOGY – airline passenger demand is only a small fraction of
      the total demand potential of the area, so that simple extrapolation
      of past data can not furnish meaningful indication of potential
      demand. Thus, the consultants sought to define potential demand
      based on an econometric model of U.S. population, per capita personal

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consumption expenditure, yield and passenger length of haul. Air
freight growth rates were derived from a national forecast prepared
by Speas for a DOT/NASA-sponsored Civil Aviation Study. Air carrier
movements were obtained by converting enplaned passenger forecasts
using estimates of average seating capacity and load factors. The
growth in general aviation was based on a "top-down" method, wherein
the relationship between the study area and total U.S. aircraft was
extrapolated on the basis of a comparison of relative growth rates
for various socioeconomic indicators. Several regressions were
developed (population was the only variable mentioned) and a consensus
adopted through subjective evaluation. Aircraft mix was based on
national trends. Local vs. itinerant activity projections were
developed from historical proportions. Forecasts of total aircraft
movements were estimated by applying a movements-per-aircraft-hour
ratio to the average number of hours flown in a year by each type of
aircraft. This utilization forecast is based on past trends. Peak
activity was calibrated from two curves: peak day percentage of average
day plotted against annual volume, and busy hour percentage of peak
day plotted against annual volume.

   e. COMMENT - the forecasting techniques that were used were fairly well
      documented (compared to other master plans), were quite adequate for
      the purposes of airport planning, and represents the state-of-the-art
      for individual airport forecasts. However, it should be noted that
      this "state-of-the-art" technique produced the highest forecast error
      (the Worcester forecast was nearly 48% higher than reported total
      aircraft operations. See Table 7, page 7) of any master plan study
      in Massachusetts. Sophistication is no substitute for accuracy!

18. Westover Air Force Base
   a. PREPARED BY - Simat, Helliesen and Eichner; Transplan, December 1976.
   b. SCOPE - the report was written to assess the potential joint use of
      Westover as a civil and military airfield. The forecast includes
      air carrier activity, commuter activity, passenger and cargo demand,
      supplemental and international carrier demand, general aviation
      operations, and military activity.
   c. FORECAST TIME FRAME - 1977 to 1992.
   d. METHODOLOGY - SH&E developed a mail survey for distribution in an
      area encompassing 4 counties and 215 firms selected from 1974-1975
      Mass. Industrial Directory. Potential demand forecasts were based
      on relationships developed by the survey, but these relationships were
      not clearly stated. Reference was made to the Stewart Airport (New
      York) study and the multi-airport model constructed for that project;
      but, because of the broader scope of the Westover feasibility study,
      the data compiled for Stewart was not used.
   e. COMMENT - the use of a survey to gather information about potential
      operations is intuitively correct. The technique appeared to be
      reasonable on inspection, but it was very poorly documented.

The aviation forecasts which have been reviewed in this report represent a wide selection of variables to explain the variation in the level of aviation activity.   The following table outlines these variables in a form which reflects the type of influence each variable exerts on aviation activity.

Type of Variable	Variable	Application
Size and spending ability of market	Population	All types of forecasts
	Population density	General aviation
	Land area	General aviation
	Employment	All types of forecasts
	Investment by air transport industry	Air carrier, air cargo, commuter
	Industrial production	Air cargo
	GNP or Gross Domestic Product	All types of forecasts
	Income	All types of forecasts
	Personal consumption expenditure	All types of forecasts
	Total personal expenditure on travel and recreation	Air carrier and commuter
	Average number of business telephone calls	Air carrier and commuter
	Education	Air carrier, commuter, general aviation
	Retail sales	Air carrier, air cargo
	Registered based aircraft	General aviation
	Pilot certificates issued	General aviation
	Military aircraft support	Air carrier and air cargo
Cost of using air transport services	Fares	Air carrier and commuter
	Rates	Air cargo
	Yields	Air carrier, air cargo, commuter
	Travel time	Commuter, general aviation
	Value of time	Commuter, general aviation

[*]This table is analogous to Table 1 of "Manual on Air Traffic Forecasting," International Civil Aviation Organization, DOC 8991-AT/722, 1972, pp. 15-17.

Table (continued)

Type of Variable	Variable	Application
Cost of using air transport services (continued)	Marginal cost, variable cost, fixed cost	Air carrier and commuter
	Cost of oil and fuel consumption	All types of forecasts
	Landing fees	General aviation
Airport access	Distance or transport time between airports	Commuter, general aviation
	Landing facilities, hangar space, other services	General aviation
	Number of towered airports	General aviation
	Resort and hotel rooms	Air carrier, commuter and general aviation
Schedule convenience	Load factor	Air carrier
	Frequency, capacity, speed and other quality of service	Air carrier, commuter, air cargo
Competition	Percent of traffic carried by 2nd largest carrier in market	Air carrier
	Cost of alternate modes	All types of forecasts
	Competition among alternate modes	All types of forecasts

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VII. CONCLUSIONS

Throughout this report, in the brief survey of forecasting techniques, in the review of prior forecasts and in the appraisal of Massachusetts airport master plans, one key point required of a good forecast was repeatedly emphasized: a forecasting model should be both sufficiently policy-sensitive and detailed enough to be updated and revised in a timely manner as conditions change. This point is especially true of airport planning, where long lead times are required to plan for the introduction of new systems and where, because of high average annual growths, slight variations in the rates of growth can produce marked differences in the absolute levels of traffic available.

The need for a policy-oriented model cannot be stressed too strongly. To allow for the impacts of changes in socioeconomic, technological and institutional (fuel, noise and regulatory) factors affecting the level of demand, the relationships between these factors and aviation activity must be clearly stated. If a model predicts a certain percentage increase in air carrier activity for a region or an airport, it would be difficult to change this forecast if, for example, a short or long run energy conservation rule is promulgated or the regulatory reform or noise bills pass through Congress. In other words, the explanatory variables should be under control of the planner so that the effects of policies can be gauged.

Detail is required in a forecast for similar reasons. Typically, a forecast may use national growth trends to predict a certain percentage increase in local activity, but such an approach fails to provide details related to this growth. What types of activity make up this increase? Local? Itinerant? What really caused the shift?

To begin with, there is a need to question the scale at which forecasts

are made. Frequently, forecasts are made at a macro-level, also termed "top-down", where nation-wide or state-wide projections are made, and estimates are given for a region, planning area or airport based upon historical share trends. Here, everything is reduced by generalizations and assumptions or judgment. There is little attempt to determine the cause of the change in the estimating process. Broad national forecasts are the easiest to make as individual hub anomalies will tend to balance out, but because of their broadness they are of little real use. To serve any planning purpose they must be broken down to the level of individual airports or regions, and the process for breaking these aggregate projections down into sub-totals is usually ad hoc and lacks a solid basis.

On the other hand, the success of micro-level approaches, or the "bottom-up" techniques, for an individual airport or region, depends upon the availability of information and the sensitivity of the forecast to changes in local policy, socioeconomics and technological factors. Such techniques, therefore, are, by nature, more costly and more difficult to develop and tend to be avoided. It is an approach which requires more professional judgment with respect to the techniques selected and the explanatory variables included, and one which is more open to criticism.

Regardless of the scale with which projections are made, forecasters are generally in agreement that three basic steps are required for any airport planning forecast. These must be performed sequentially, as the outputs from one become the inputs to the next. In chronological order as given by Fisher (7), they are:

  1. annual projections of basic demand parameters, such as passengers, cargo and mail;

2. the translation of these basic demand components into the units of aircraft movement;

3. based on the distribution of aircraft movements, the establishment of peak aviation demand parameters – those parameters which directly impinge on facilities design.

A variety of techniques have been suggested by Fisher and others for developing these forecasts. Each of these techniques has already been reviewed earlier in this report, so they will only be briefly mentioned here.

For the first step, the basic demand projections, the methodologies that have been employed are: judgmental estimation, historical trend projection, econometrics, surveys and spatial equilibrium models (of the "gravity" model type). The important point to keep in mind here is that methods such as judgment and trend analysis are based upon the unreliable but convenient premise that what has happened in the past has some relevance for what is going to happen in the future. If the trend changes, then the forecast will be inaccurate. More reasonable alternatives which provide a cause and effect relationship between air traffic and base conditions can be found in econometrics and "gravity" type models. Surveys tend to be relatively expensive in relation to the amount of data collected.

The second step, translating demand into aircraft movements, unfortunately, is where most approaches that have been reviewed in this report have failed. The planners spend considerable effort developing a sophisticated methodology for predicting basic demand components, such as numbers of passengers, but resort to judgmental estimation or projections based on historical share trends to convert this demand into aircraft movements, which is the key item needed for facilities planning. The key difficulty is the progression from

passengers to units of demand measured in terms of aircraft. Instead of developing relationships between capacity and load factor on the one hand, and socioeconomics, local policy and technological factors on the other, the planners simply resorted to good judgment or historical growth rates to estimate the number of passengers per enplanement.

Finally, in the third step, establishment of peak demand, forecasts have generally been approached in an intuitively correct and sound manner. Most planners calibrate peak-day and busy-hour operations in accordance with FAA criteria as given in Appendix 2 of the advisory circular, "Airport Capacity Criteria Used in Preparing the National Airport Plan" (38). This criterion establishes peak hour operation as a percent of peak daily operations (calibrated separately). Such parameters are the most critical to airport planners as they directly affect facility sizing. Surprisingly, however, most effort is spent on development of models for basic demand projections, which have little direct relationship to the airport planning, rather than on estimating peak period activity.

It seems pertinent at this point to state some conclusions regarding the forecasting process at the level of each aviation activity. In the case of scheduled air carrier and commuter airline activity, airport planners are well along in their attempts to reliably and accurately forecast operations. The approaches taken generally employ econometrics which adequately capture those all too important cause and effect relationships mentioned throughout this report. Of course, much of the success in forecasting this activity is attributable to the availability of reliable and consistent historical data. Nevertheless, the key to the success of any forecast is to locate a historical data base of sufficient accuracy and time scope, even if it entails conducting

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a market analysis. Alternatively, one tries to correlate the activity or demand to some other parameter for which a substantial and reliable historical record does exist.

In the case of general aviation activity, historical records, such as based aircraft and annual operations, do exist; but the reliability of this data is considered to be poor unless totaled and/or averaged for a large area such as a state or a regional planning area to negate individual airport errors. To be at all reliable, forecasting for a specific airport must reflect consideration of very localized conditions. Thus, the application of national measures of general aviation growth rates to historical data for a specific small airport would be apt to produce very unreliable results. Recognizing the inadequacies of information, most general aviation forecasting methods reviewed in this report have sought to relate general aviation activity to such socioeconomic variables as population, age distribution of the population, level of education of the population, per capita personal income, or median family income. The approach to general aviation forecasting begins with projections for based aircraft at each of the state's airports. Forecasts of annual operations, peak-day and peak-hour operations, itinerant vs. local activity, etc., are then developed as a function of the based aircraft projections.

The problem of forecasting air cargo development has long consumed the energies of a multitude of competent analysts. Unfortunately, the rapidly changing picture presented by air cargo has made even short-term projections little more than educated conjecture. Many forecasts were derived either by simple trend extrapolation or by executive judgment. The inherent failure of such methods, since they do not deal explicitly with the determinants of demand, means that they cannot be used to disclose the influence on future

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air cargo traffic of changes that are occurring (e.g. deregulation) or are likely to occur in the marketplace and in air transport service characteristics. Accordingly, a reliable forecast of air cargo demand should employ methodologies, such as econometric modelling, which convey a basic understanding of economic, technological, demographic, and regulatory factors that affect the demand for the product or service. Such policy-sensitive forecasts afford the airport planner a framework within which all future determinations of air cargo space requirements, of facility and labor needs, of freighter movements, and of the implications of airport policy scenarios (night curfews, peak-hour movement limitations, off-airport satellite cargo depots, etc.) are conducted.

The level of military activity is a function of national defense policy and, as such, it does not lend itself to forecasting techniques like trend analysis or econometrics, which are a function of historic trends and variables relative to national defense. Thus, about all that can be expected is either to use the detailed planning information supplied by the Department of Defense, or to assume that the level of military activity will not change in the forecast period.

In conclusion, despite the growing sophistication of the techniques that are available, predicting future airport activity remains hazardous and often unreliable. Given the problems of data collection and the stability of trends, this view is wholly understandable. However, in some ways it is unfortunate that the industry has not experienced some marked change in its rate of development causing it to review its methods of forecasting.

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