TRANSPORTATION RESEARCH
E-CIRCULAR
Number E-C040 August 2002

Aviation Demand Forecasting

A Survey of Methodologies

TRANSPORTATION RESEARCH BOARD / NATIONAL RESEARCH COUNCIL

TRANSPORTATION
RESEARCH
E-CIRCULAR

Number E-C040, August 2002
ISSN 0097-8515

Aviation Demand Forecasting

A Survey of Methodologies

COMMITTEE ON AVIATION ECONOMICS AND FORECASTING (A1J02)

Gerald W. Bernstein, *Chairman*

David Ballard
Alan R. Bender
Bengt B. M. Bostrom
Robert L. Bowles
Charles R. Chambers
Jaap G. De Wit
Mark Diamond
John W. Fischer
Louis P. Gialloreto
Richard S. Golaszewski
Billie W. Jones
Derrick J. Maple
Francis P. Mulvey
Kevin Neels
Kazuhiro Ohta
Sasha N. Page
Michael W. Pustay
Jojo Quayson
Joseph P. Schwieterman
Anne Strauss-Wieder
William W. Trigeiro
Pierre Vilain
Leopold E. Wetula
Margaret R. Young

COMMITTEE ON LIGHT COMMERCIAL AND GENERAL AVIATION (A1J03)

Gerald S. McDougall, *Chairman*

Andreas Aastad
Douglas E. Abbey
Brandon Battles
Andrew Broom
Michael D. Chase
Steven Davis-Mendelow
R. Steven Hines
John Hyden
Tulinda Larsen
David S. Lawrence
Matthew Liu
Deborah C. McElroy
Molly Martin Pearce
James R. Potts
Kenneth E. Roberts
Mari A. Stark
Rudolf P. Winter
David Scott Worrells
Jack P. Wiegand

Joseph A. Breen, *TRB Representative*

TRB website:
www.TRB.org

Transportation Research Board
National Research Council
2101 Constitution Avenue, NW
Washington, DC 20418

Foreword

This Circular was prepared during the first half of 2002 by members of TRB's Committee on Aviation Economics and Forecasting (A1J02) and Committee on Light Commercial and General Aviation (A1J03) with substantial assistance from friends and associates who are not formal committee members. The objective of this Circular is to provide examples of the diversity of techniques used to forecast the many measures used in aviation system and market analyses.

By intent, almost all examples provided herein illustrate methodologies or approaches to forecasting used by private sector manufacturers and consultants. Forecast methodologies employed by the FAA and the International Civil Aviation Organization are documented in existing publicly available technical reports and manuals. Some manufacturers, most notably Boeing and Airbus, also provide documentation of their forecasts to the public. But while these forecasts and their related documentation are all helpful to aviation analysts, they comprise only a small fraction of the various forecast methodologies in current use.

The examples provided in this Circular illustrate approaches to aviation forecasting that receive less public attention. Yet these approaches provide equally valid insights into how to think about aviation activity measurement and future outlooks.

Most of these forecasts are quantitative, but not all are econometric. Some require extensive computer modeling; others require minimal computer capability. Some are descriptions of commercially available products, while the complete details of others are corporate confidential. The descriptions are provided using a common format to facilitate comparison, but the content varies with the individual and firm that prepared the description.

Preparation of this Circular was assisted by several persons. Mr. Saleh Mumayiz (Illgen/BAe Systems) was helpful in conceptualizing the kinds of approaches and issues to seek; Ms. Peg Young (Bureau of Transportation Statistics) assisted in converting papers into a reader-friendly style and format. The Board of the Air Transportation Research Forum helped disseminate the request for descriptions to its members.

My thanks to these persons and to those who submitted descriptions for supporting this effort to broaden public awareness of the diversity of approaches to air transportation forecasting.

Gerald W. Bernstein
Managing Director
Stanford Transportation Group
Chairman, Committee on Aviation Economics and Forecasting (A1J02)

Contents

Forecasts at a Single Location

Air passenger demand is related to such factors as the number of persons in a region and their motivation to travel ("propensity to travel"), socioeconomic activities and measures that support travel, and the availability of service and infrastructure. Forecasting at the local level should ideally take all of these influences into consideration.

A major assumption underlying most forecasts is that there exists a correlation between demand and generating factors derived on the basis of historical data, and that this correlation is (to varying degrees) applicable for the forecasting horizon. Numerous assumptions related to expected future environments are made and used as input to the forecasting process. These assumptions are most likely to be a set of other forecasts derived independently, (e.g., future fare level, future service, future gross national product, and the like). It is the logic used and methodology applied to predict the relationship between the factors that creates variations among demand forecasts. For major airports, the relation between connecting (transfer) passengers and local origination or destination (O-D) traffic needs to be specified.

The following six examples illustrate a variety of airport-specific forecast situations. The first two illustrate approaches to forecasting both annual passenger traffic and aircraft movements at larger (urban or international) airports. At these locations, ample data is usually available at the local level. In the third example, identification of passenger or aircraft movements at "peak" or "busy" times can be estimated for facility sizing purposes when annual volumes are not appropriate.

The latter three examples illustrate approaches to forecasting when detailed or historical data is not as readily available. These include the problems of forecasting passenger traffic and aircraft movements outside of major urban areas, problems associated with the forecasting of general aviation (GA) activity only (a completely distinct problem from forecasting commercial aviation traffic), and the unique problems and challenges when forecasting in developing regions where data (or even prior demand) may be scant or non-existent.

URBAN AIRPORT PASSENGER AND AIRCRAFT MOVEMENT FORECASTS

Patrick Kennon
HNTB Corporation

Purpose

Urban airport forecasts are not an end to themselves, but are a part of a greater purpose. HNTB uses forecasts to guide the planning of new or expanded facilities, the mitigation of noise impacts, determination of financial feasibility, or the development of a strategic plan. Typically, forecasts are part of a formal master plan, which also includes a demand/capacity analysis, estimates of facility requirements, airport development concepts, and a financial plan. At times, more detailed market-by-market and flight-by-flight forecasts are required for airfield or terminal simulation.

Methodology and Approach

The appropriate forecasting technique depends on the history, environment, and role of the airport. Most airports serving large urban areas are large enough to warrant sufficient competition so that activity is demand driven—that is the airlines will provide enough capacity to accommodate the demand. The balance between demand and capacity will be mediated by the fare levels. At highly competitive "spoke" markets, fares tend to be low. Fares tend to be higher at connecting hubs dominated by a single airline and at smaller, less competitive airports.

Demand-driven markets lend themselves to certain forecasting techniques, such as regression analysis. Typically, a forecasting model based on regression analysis specifies passenger origination (the dependent variable) as a function of one or more independent variables representing the regional economy such as employment, income, or gross domestic product (GDP), a price variable such as average fare level or yield (airline revenue per passenger mile), and sometimes an air service variable.

Regression models require a large amount of historical data in a consistent format. More importantly, a forecasting model based on regression analysis requires that the future relationship between passenger origination and the independent variables remain similar to what they were for the historical period for which the regression data was collected. If there is a change in this relationship, whether it results from a new airport site, a change in regulations, or a fundamental change in the structure of the economy, this relationship will no longer hold true.

Accurate projections of the independent variables are also critical. HNTB typically uses socioeconomic projections from local planning agencies, or a private vendor such as Woods & Poole or DRI-WEFA. FAA yield projections, adjusted for local circumstances using airline input, are used to estimate future levels of the price variable.

When budget and schedule allow, HNTB projects traffic on a market-by-market basis. Market-by-market originating traffic is also estimated using regression equations which incorporate destination market socioeconomic variables in addition to the independent variables previously cited.

At airline hubs, connecting traffic is typically estimated as a percentage of originating traffic. When possible, the airline is contacted regarding future networking strategy and possible implications for the connecting ratio. When doing a market-by-market analysis, individual connecting traffic trends can be isolated, and connecting traffic from potential new non-stop markets can be added. Recently, market-by-market breakouts have been very useful in estimating the impact of regional jet (RJ) operations on overall traffic.

Dividing total enplanements (the sum of originating and connecting passengers) by load factor yields an estimate of seat departures. Load factor projections are typically obtained from FAA national forecasts and adjusted by input from airline surveys. Dividing seat departures by average seats per aircraft (again obtained from FAA national forecasts and adjusted with input from airline surveys) yields a forecast of passenger aircraft departures.

When performing a market-by-market forecast, the seat departure projections can be used, in conjunction with information on the existing bank structure at the O-D airports and the fleet acquisition plans of the airlines serving that route, to forecast flight frequency and fleet mix for that market. The resulting aircraft departure forecast then much better reflects the network characteristics of the airlines serving an airport. This is a particularly useful way of estimating the extent to which RJs will penetrate a particular market.

Forecast scenarios are a way of addressing the uncertainty inherent in any forecast. They incorporate "what-ifs" such as oil embargoes, economic recessions, changes in airline strategies, the introduction of low-cost carrier service, or competition to air transportation such as high-speed rail or teleconferencing. They are superior to simple high- and low-range forecasts because the impact of higher or lower than expected activity on airport facilities is often uneven. For example, the introduction of Southwest service will increase passenger traffic, but will increase gate requirements much less because of their high gate utilization and will likely decrease regional carrier activity because they have no regional partners.

Observations and Comments

The outlined methodology is not intended to be a substitute for professional judgment in forecasting passenger traffic at urban airports. It does, however, provide a framework within which insights of both the forecaster and the user can be applied. The approach has been sufficiently detailed to provide for planning needs and sufficiently flexible to accommodate unforeseen circumstances. HNTB has used the above approach on over 40 studies, including 5 that were carried to a market-by-market level of detail.

INTERNATIONAL AIRPORT PASSENGER AND AIRCRAFT MOVEMENT FORECASTS

Catherine Harmel-Tourneur
International Air Transport Association

Purpose

In the increasingly competitive environment in which airports have to operate, a key factor for airport management is to ensure that their operations are financially healthy while providing the appropriate infrastructure to cope with growth in traffic. This description presents a brief outline of International Air Transport Association (IATA) databases and methodologies typically used to produce long-term annual passenger forecasts.

Methodology and Approach

Data Compilation

Passenger traffic statistics typically made available are based on "coupon" O-D. This means that traffic figures relate to the first destination of the passenger covered by the flight coupon processed at the airport (not necessarily the "true" O-D). The source of data for such analysis is the passenger booking made through computer reservation systems (CRSs) by travel agencies throughout the world. These passenger bookings are compiled in Market Information Data Tapes (MIDT) and cover the full itinerary of passengers which means that we can determine the full composition of traffic in each route area split by

- Passengers originating from a selected airport and using direct services (and vice versa);
- Passengers originating from the selected airport and going through any other intermediate airport (and vice versa) to reach their final destination; and
- Passengers originating from a foreign airport and connecting through the selected airport to reach a final destination.

In some instances we can use the IATA Billing Settlement Plan (BSP) database that contains all airline tickets issued by travel agencies in a country. BSP data has the same level of detail as the MIDT data, but relates to actual tickets sold and not just bookings.

MIDT or BSP data is then calibrated to come up with total annual estimates of the major traffic components splitting true O-D, coupon-O-D, and transfer traffic.

Forecast Methodologies

IATA forecasts do not rely entirely on the use of econometric models in estimating annual demand due to the weakness inherent to this methodology. Instead, IATA generally uses a combination of several methods.

Computerized Regression Analyses Computerised regression analyses covering to/from the airports associated with the major socioeconomic variables.

IATA Worldwide Traffic Forecast Survey The IATA worldwide traffic forecast survey is undertaken every year in August–September which covers all traffic flows around the world (generally covering nearly 2,000 unduplicated country-pairs). This survey reflects the opinion of all IATA member airlines serving these country-pairs on the likely future development of passenger and cargo traffic during the next 15 years. The survey takes into account not only the major economic variables but also airline strategies to respond to future demand.

Special Survey-Based Forecasts Produced Specifically for an Airport IATA typically will survey key airlines and tour operators to seek their opinion on likely future changes.

Judgmental Forecast This method permits a wide range of information to be brought to bear on the forecast (national trends, political situations, etc.). It is especially useful in conjunction with the other methods, where there are a large number of variables for which little information is available, or where non-quantifiable factors are expected to play a major role.

The combination of the various approaches described above can be put into two groups. The first group refers to the top-down approach. In this case, passenger traffic is driven by econometric models using GDP, yields, etc., as drivers. The second group—termed the bottom-up forecast—refers to variations in traffic growth by route area. This detailed approach enables us to differentiate growth rates on a route basis using the world-side airline traffic forecast survey as a guideline, but complementing these results with the examination of variation in economic growth between the various traffic generating countries, etc. Of course, both forecast methodologies have to be reconciled.

The passenger forecast covers total coupon O-D, true O-D, and transfer passengers. From the passenger forecast, IATA then forecasts aircraft movements which, by route area, cover the following parameters: passenger load factors, average aircraft size, passenger aircraft movements by aircraft size category, and maximum take-off weight (MTOW) by aircraft size category.

For the production of aircraft movement forecasts, a link is established between annual passenger traffic and passenger aircraft movements by projecting the likely future evolution of the passenger load factor and the average aircraft size. This link enables us to derive a projection of aircraft movement to and from the selected airport by route area and by aircraft size category. Aircraft movements cover total commercial scheduled and charter services and are also forecast by aircraft category. Categories are determined on the basis of aircraft MTOW.

Observations and Comments

This methodology is highly flexible. It has been applied to domestic and international routes, to small and large airports, and to all world regions. It has been used for airports with as few as 2 million annual passengers and as large as 25 million.

When seeking to derive a profile of passenger travel *within* a region, other sources of data need to be employed. Market trends constructed on the basis of coupon statistics are inadequate when the objective is to assess the real size of the local market versus the transfer market which may be a key distinction for an airport.

INTERNATIONAL AIRPORT BUSY DAY PASSENGER AND AIRCRAFT MOVEMENT FORECASTS

Catherine Harmel-Tourneur
International Air Transport Association

Purpose

A key factor for airport management is to ensure that their operations are financially healthy while providing the appropriate infrastructure to cope with growth in traffic. Annual activity forecasts (and the financial forecasts that derive from them) are one essential consideration. For facility planning and staffing, however, busy or peak-day forecasts are also required. This description provides a summary of the IATA forecast methodology used to produce long-term busy day forecasts.

IATA has a very specific definition of the busy day that needs to be evaluated for airport capacity requirement determination. A busy day is defined as the second busiest day in an average week during the peak month. An average weekly pattern of passenger traffic is calculated for that month. Peaks associated with special events such as religious festivals, trade fairs and conventions, and sport events, are excluded. This single-day analysis assesses:

- Operational suitability of an aircraft type for a given route structure;
- Aircraft rotations compatible with high level of utilization;
- Use of commercially feasible arrival and departure timings throughout the route structure; and
- Airport curfews and other limitations.

Methodology and Approach

Determination of Passenger Traffic Volumes During a Typical Busy Day for the Base Year

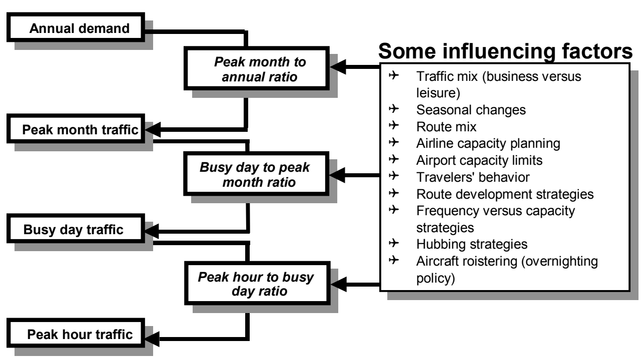
The busy day data for the base year is based on data that comes in part from the airport tower log and which is sometimes supplemented by other sources. This data file covers each aircraft movement during the busy day with an indication of such factors as airline name, flight number, aircraft type, aircraft registration, seating capacity, origin of flight, arrival time, terminal used, passengers deplaning, direct transit passengers (if applicable), departure time, destination of flight, and enplaning passengers.

A computer model has been developed to incorporate this data and display the flow of traffic (aircraft movements and passengers) by time of the day in order to identify the peak hour. It also identifies variations in load factors by time of the day and by route area.

Projections of Busy Day Traffic

The busy day methodology enables us to forecast aircraft movements, passenger flows, and aircraft gate (stand) requirements; each are forecast by route area using a detailed bottom-up approach.

The projection of total passenger traffic for a typical busy day is developed first by determining the historical ratio of busy day traffic to total annual traffic and second by applying this calculation to the projection of annual traffic as shown in the illustration below. The relationship of busy day to annual traffic depends on seasonal variations and passenger characteristics. This relationship is projected separately for each route.



Projection of Hourly Profile of the Busy Day

Once total passenger traffic is projected for the busy day, the next step is to redistribute this traffic by time of the day in order to determine the future evolution of the peak level of incoming and outgoing traffic. The following factors are examined in the projected hourly distribution of traffic.

- Flight duration: short flights tend to have quicker turnaround times.
- Connecting traffic: arrivals and departures are grouped at certain times of the day to enable passenger connection.
- Aircraft size: small aircraft operating numerous frequencies spread traffic more evenly throughout the day than large aircraft with fewer frequencies.

- Route network: transiting flights are subject to more constraints on arrival/departure times than originating/terminating flights.
- Curfews: constrain arrival/departure times at the airport of origin as well as at a destination.
- Local times: difference in local times condition the hourly pattern of intercontinental flights.
- Commercial considerations: acceptability of arrival/departure times from both an airline and airport point of view.

Airlines can meet growing demand in a number of ways such as by increasing frequencies without changing capacity, maintaining frequencies and using larger aircraft, eliminating intermediate stops, introducing direct routes to regional airports, and replacing transit flights with turn-around flights. The chosen pattern is affected by the airline's policy of developing or minimizing sixth freedom (connecting) traffic, and by the national government's policy on development of fifth freedom rights (favoring transit flights).

For each route area, knowing how many additional flights are required for each aircraft category to cope with traffic growth, and the airline and national influences, we then build up a probability distribution of when (and what time) these flights are likely to take place during the day.

Observations and Comments

The model provides forecast results in a level of detail suitable to both the business plan and the airport master plan.

NON-URBAN AIRPORT PASSENGER AND AIRCRAFT MOVEMENT FORECASTS

Patrick Kennon
HNTB Corporation

Purpose

Non-urban airport forecasts are not an end to themselves, but are a part of a greater purpose. HNTB uses forecasts to guide the planning of new or expanded facilities, the mitigation of noise impacts, determination of financial feasibility, or the development of a strategic plan. Typically, forecasts are part of a formal master plan, which also includes a demand/capacity analysis, estimates of facility requirements, airport development concepts, and a financial plan.

Methodology and Approach

The appropriate forecasting technique depends on the history, environment, and role of the airport. Most non-urban airports serve markets that are too small to warrant significant competition. Consequently activity tends to be supply driven, that is, the amount of passenger traffic depends on the air service available to accommodate it. Often, the decision to provide service rests with factors other than the existence of passenger demand, such as the cost of providing the service, the availability of appropriate aircraft equipment, the airport's geographic location with respect to airline networks, and the availability of subsidies.

Non-urban markets usually share several characteristics. Except for those satellite communities immediately adjacent to metropolitan areas, their economies are slow growing and they often have declining populations. Household incomes are usually lower than average, and people have a lower propensity to fly even after adjustment for the income differential. Business that are dependent on air travel do not locate in these communities and therefore there is little business-related air travel. Those residents who do fly often drive long distances to a larger airport to take advantage of non-stop flights, higher frequencies, more reliable service, and larger aircraft. This "leakage" is significant and often well over 50%.

Supply-driven markets do not lend themselves to traditional large airport modeling techniques such as regression analysis. The recommended forecasting approach depends on the forecasting budget, which is often limited for small airports.

The simplest approach, suitable for extremely low budgets, is to identify the historical trend in the airport share of national passenger traffic (typically declining), then project that decline to continue at the historical rate, and apply the projected decline in share to the FAA forecast of national enplanements.

When more resources are available, HNTB's approach is to identify and project the factors affecting an airline's decision to maintain or add service. Since data on these factors is spotty, a large amount of professional judgment is required. Some of the data can be supplemented with airline interviews, but their outlook typically does not extend to the 20 years required for a master plan forecast. The factors considered are:

- Cost of the service. Aircraft operating costs are available from U.S. Department of Transportation (USDOT) filings but estimates of fixed costs such as station costs also need to be included.
- Availability of appropriate equipment. Carrier fleet plans are used as a guide. Since many carriers are eliminating 19-seat aircraft from their fleets, the threshold of passenger traffic required for profitability is increasing. In some very small markets this may lead to a projected elimination of service.
- Geographic location with respect to airline networks. This involves elements of air service analysis, in which the traffic (including connecting traffic) that could be sent from the airport to a candidate airline's hub is estimated, and a determination is made as to whether that traffic is sufficient to generate a profit for the airline.
- Subsidies. This involves evaluating the community's standing or potential standing with the Essential Air Service program or state programs in some cases.

In this approach, air service (operations) are first estimated and then forecasts of passenger traffic are derived from the operations forecasts, opposite to the urban airport forecasting approach in which operations are derived from passenger forecasts.

Forecast scenarios are a useful way of addressing the uncertainty inherent in any forecast, especially with small non-urban airports. They incorporate "what-ifs" such as changes in airline strategies, changes in subsidy programs, or the introduction of low-cost carrier service to a nearby airport. They are superior to simple high- and low-range forecasts because the impact of higher or lower than expected activity on airport facilities is often uneven. For example, the size of aircraft used may have a more significant impact on peak activity and airport facility requirements than total passenger traffic.

Observations and Comments

The methodologies outlined above are sensitive to the whims of airline strategies, which will change many times over the course of a 20-year planning horizon. The scenario approach is particularly useful in providing a range of potential activity so that the resulting airport master plan is sufficiently flexible to accommodate these contingencies if and when they emerge. HNTB has used the above approaches on more than two dozen studies involving individual non-urban airports or state systems of non-urban airports.

SMALL GENERAL AVIATION AIRPORT OPERATIONS FORECAST

David Ballard
GRA, Inc.

Purpose

It is typically difficult and time consuming to develop traffic counts for small non-towered airports that serve only GA traffic. Some states have supported counting efforts at a sample of such airports, making use of a variety of techniques. In a project undertaken for the FAA Office of Aviation Policy and Plans, GRA developed an estimating model for GA operations at small airports that is based on the relationship between demographic characteristics of the area surrounding the airport, some airport measures such as based aircraft (BA) and the GA aviation activity at the airport.

The purpose of this project was twofold: 1) to identify common characteristics among a group of towered GA airports and 2) to use these characteristics to construct models of airport activity at non-towered GA airports which are less closely observed and monitored. While not a substitute for actual activity counts, the model provides information that can be useful for the allocation of GA airport and aviation infrastructure resources within states and within the nation.

It is important to note that the model does not generate forecasts of future activity; rather it is an estimating model that uses available information about an airport and its surroundings to estimate the number of operations that can reasonably be believed to occur over the course of a year. While the model developed in this project is not a forecasting model per se, it could be combined with forecasts of the independent variables to develop GA activity forecasts.

Methodology and Approach

The methodology used in this model is based on the assumption that the GA aircraft activity at GA airports is related to demographic features of the area surrounding the airport along with other characteristics of the airport. These demographic features are relatively easy to itemize, and the data for them are readily available, compared to explicit aviation activity data which are not rigorously collected for small non-towered airports in general. The data set used to estimate the model contains 127 small towered GA airports, for which accurate tower counts exist, and 105 non-towered GA airports for which activity estimates have been made by state aviation authorities using various methods of sampling and extrapolation to a full year of data. For these airports the following data items were developed from U.S. Census Bureau data and other sources:

- Based aircraft: BA (+)
- Square of BA: BA^2 (–)
- Airport's percentage of BA within 100 mi: %in100mi (–)
- Number of Part 141 certificated flight schools at airport: VITFSnum (+)
- Population within 100 mi of airport: Pop100 (+)
- Airport in states of California, Oregon, Washington, or Alaska?: WACAORAK (–)
- Ratio of population within 25 mi to population within 100 mi (+)
- Tower at airport?: TOWDUM (+)

The estimating equation, based on data from the 232 small towered and non-towered GA airports and using the variables above, is shown below. In the list, the plus or minus with each data item indicates if the estimated parameter has a positive or negative effect on an airport's estimated GA activity (as shown in the equation). For example, having a tower at an airport adds, on average, 13,674 GA operations annually.

Some model relationships are counterintuitive at first glance. In particular, the negative sign on the coefficient for "airport prominence" (the airport's percentage of BA among all airports within 100 mi) indicates that the more important an airport is to GA operators in the area, the smaller is the airport (in terms of annual GA operations). This result is taken to mean that an area that has a single highly prominent airport is likely to be sparsely populated and to support relatively little GA activity in absolute terms. In a sense, the "regionally prominent" GA airport tends to be the "big frog in a small pond." Other coefficients appear intuitively reasonable.

$$\mathbf{GAOPS} = \underset{(-0.25)}{-571} + \underset{(8.41)}{355}\,\mathbf{BA} - \underset{(-3.83)}{0.46}\,\mathbf{BA^2} - \underset{(-2.79)}{40{,}510}\,\mathbf{\%in100mi} + \underset{(1.87)}{3{,}795}\,\mathbf{VITFSnum} + \underset{(3.48)}{0.001}\,\mathbf{Pop100}$$

$$\underset{(-3.61)}{-8{,}587}\,\mathbf{WACAORAK} + \underset{(2.67)}{24{,}102}\,\mathbf{Pop25/100} + \underset{(6.44)}{13{,}674}\,\mathbf{TOWDUM} \qquad R^2 = 0.743$$

t-score in parentheses

Model stability and robustness was tested by using out-of-sample methods in which the model was re-estimated using a portion of the sample data. The estimates for the remaining airports in the sample were then compared to actual activity at these airports. In general, these comparisons proved satisfactory. Once a reliable model structure had been specified, comparable demographic data were collected for nearly 3,000 other small GA airports in the United States. Each of these non-towered airports reports an annual activity estimate on Form 5010, which is submitted to the airport's FAA district office.

Form 5010 data is regarded by many as unreliable, especially for non-towered airports that have neither the resources nor the infrastructure to actively monitor GA activity. The model's estimate of airport annual GA activity was compared with the 5010 filing for each of these 2,789 airports. The comparison between the 5010 estimates submitted by the airports and the model's estimates can be found in the research paper underlying this model at the FAA website at http://api.hq.faa.gov/Contracts/GAModel 3F.doc. For these non-towered GA airports, the percentage difference between an airport's 5010 activity estimate and the model's estimate tends to be smaller as the 5010 activity estimate grows. For the 2,469 airports reporting 2,000 or more annual GA operations, the absolute percentage difference between the 5010 estimate and the model estimate is 50%. In addition, the model tends to underestimate airport activity (relative to the 5010 estimate) for the most active of these non-towered GA airports.

Observations and Comments

The GA activity estimating methodology developed in this model can provide valuable new information to state or regional planning organizations with an interest in GA. It provides a direct connection between the level of activity data at a small GA airport and the demographic features of the airport's environs.

AIRPORT DEMAND FORECASTING IN DEVELOPING NATIONS

Bengt Bostrom

Purpose

Aviation demand forecasting in developing countries is needed for a variety of reasons, but also presents unique challenges. As in developed nations, most of the requirements for forecasting aviation demand are related to identifying infrastructure requirements (airports, ground aids, and air traffic management). Many forecasts are related to future medium- to long-range investment requirements either connected to foreign financing or to concessions of all or part of the services provided to the airlines and other airport users. The forecasts are normally needed to plan and assess investments of long duration (10 to 25 years) and for master plans for airports to meet demand for many years. While some of the future needs are directly related to aircraft movements, these in turn are largely derived from passenger travel and air cargo movements. A second use of such forecasts is for domestic passenger traffic volume (and revenue) analysis.

The main difference between forecasting in developing and developed countries is that the background data upon which aviation forecasts can be based, including at times the aviation industry information itself, may not be available to predict future demand. This limitation is most serious in the case of the demand assessment of completely new services and/or new airport locations. Despite the unique challenges, a few rules and observations can be identified.

Methodology and Approach

Local Economic Analysis

Fortunately the aviation industry normally has a good base of homogenous traffic data compared to other transport modes. This situation also applies in most developing countries. Analysis of past traffic trends is therefore possible for most countries to assist in the prediction of future demand. Extrapolation of previous traffic development is therefore feasible in most cases. This may provide a degree of accuracy adequate for certain purposes such as revenue projections and identifying general trends for manpower requirements.

A typical first step is an economic analysis of the effects of underlying factors on the historic aggregate demands for passenger and freight traffic in a country or region. For master plans and major investment assessments this would reduce the degree of uncertainty and considerably improve the quality of the resultant forecasts. Efforts to use and improve econometric models are worthwhile wherever feasible such as by assessments of likely population and economic growth (such as GDP), changes in world trade, changes in average passenger and freight yields, and linking these to traffic. International or regional traffic forecasts are often developed using these methods and relationships. The challenge, however, is to get information on economic developments specific to the area of influence of the airport or air system and relate this to the traffic information. For smaller countries this may be possible by using economic information for the whole country and applying it to the dominant airport since the area around this airport may account for a major share of the economy; trade information may be dealt with in a similar way. The computing power of personal computers makes it relatively easy to test correlation between variables.

To the extent data permits, the assessment should also include the comparison of individual parameters such as price elasticity for yield, income elasticity for GDP, or other national income parameters. However, the accuracy of some of these data (such as airline yields) is often so poor that it would not be advisable to rely much on these added measures. Elasticity to time gains is also of similar questionable value. One way to get around these problems would be to relate air traffic to parameters such as the GDP over several years to generate a multiplier that may be used to forecast future traffic. This multiplier would then reflect both the effects of income elasticity and price elasticity. Detailed breakdowns of passengers between purpose of travel or origin of travelers is often not available or accurate either. To use such information for traffic projections can therefore be difficult, but may still be necessary where different categories have very different growth patterns. Seasonal tourism, pilgrim traffic, and different types of air cargo are examples of situations where separate projections may be necessary.

Information from Other Regions

Developing country analysis can be informed by an analysis of other countries or markets in a similar economic situation. Experience elsewhere could be applied in cases where a drastic change is foreseen such as in opening up of new major resort areas for tourism, exploration of new mining or oil resources. For the first case, assessments of average tourism stay, hotel occupancy rates, and regional tourism growth rates would be needed. For the second case, regional comparisons of air travel in relation to GDP or GDP per capita could be of assistance.

User Involvement

Despite good supporting data over several years (10 years or more) it is essential that a good dialogue with main users is undertaken concerning their own assessments. One needs to be alert, however, to the bias from the users' perceptions and the fact their concerns are often focused on the immediate future. Anticipation of changes, such as rising load factors used in the determination of aircraft movement forecasts, are often found not to change very much from current levels. The effects of deregulation will also be very difficult to predict.

Peak demand forecasts are often necessary as is an assessment of the scope for future changes. Here, too, a dialogue with main users (airlines, tour operators, freight agents) is essential. Historic trends may be unavailable and a good distinction between on-board loads and local O-D traffic may need special surveys. Yet again, changes in peak patterns may not be dramatic due to current curfews and limitations at airports in O-D countries.

Observations and Comments

While domestic information for developing countries on population and economic trends is not readily available and is less accurate than information in the developed countries, a good deal of information and guidance is available from a number of international sources. These include

International Civil Aviation Organization (ICAO) (Manual of Air Traffic Forecasting, regional forecasting groups, and periodically an Outlook for Air Transport), IATA, organizations like Airports Council International, and some of the aircraft manufacturers such as Boeing and Airbus (with information on Internet on future regional traffic trends). Economic information is available for most countries from institutions such as the International Monetary Fund (monthly), World Bank (annual atlas), and regional development banks.

Forecasts for a Multi-Airport Region

The three approaches to forecasting described in the following examples could all be applied to developing forecasts at a single airport. However, as these examples provide further insight into the travelers' choice of airport when alternatives are available, the methodologies are separately described.

In keeping with this distinction, the three approaches described require more detailed information on a variety of influences than do the forecasts previously described. The methodologies in this section typically require greater specification of such measures as:

- Local population and employment distributions based on some geographic (zone) distribution,
- Social and economic characteristics by analysis zone,
- Travel time from population and employment zones to the airport(s),
- Other travel-related costs such as parking and tolls, and
- Airline service measures for each airport, including frequency, aircraft type, and fares by market.

These models not only forecast total demand in a region, but allocate this demand to its point of origin and to individual airports within the analysis region.

One major distinction between these three approaches is the amount of background effort and time needed to construct the models. Those used by the Port Authority of New York and New Jersey (PANYNJ) and the Southern California Association of Governments (SCAG) require extensive survey and computer resources to calibrate and to exercise. Community air-service analysis (CASA) can be applied to smaller regions and permits a more simplified data collection and analysis procedure.

PORT AUTHORITY OF NEW YORK AND NEW JERSEY

Jojo Quayson and **Charlie Saunders**
Port Authority of New York & New Jersey

Purpose

PANYNJ currently operates four airports in the New York/New Jersey Region: Kennedy International and LaGuardia in New York, and Newark International and Teterboro (TEB) in New Jersey. TEB is a GA airport with no scheduled service. The PANYNJ air passenger forecast provides 10-year passenger estimates by market (domestic and international) and terminal building for the three airports with scheduled service. The forecast is further segmented into monthly estimates of activity for the first 2 years of the forecast. These forecasts are used for internal budgeting, financial projections, airport planning, and as input for other forecasts of airport activity.

Methodology and Approach

PANYNJ's passenger forecast model utilizes a top-down process that estimates passengers by market for the region. Forecasts of airport and terminal activity are derived from these aggregates using a combination of historical factor shares, airport and terminal specific developments, and airline schedules. These numbers are further combined with X-11 factors to produce monthly estimates. The X-11 factors are produced using the Census II method, a seasonal decomposition process developed by the U.S. Census Bureau. This technique can decompose a time series into trend, seasonal, and irregular components.

The forecast process involves three interactive phases including data collection, model estimation, and the disaggregation process. Phase 1 consists of data collection. Data comes from a multitude of sources including internal sources, Immigration and Naturalization Service (INS), Official Airline Guide (OAG), the FAA/USDOT, and DRI-WEFA.

Phase II is the model specification and estimation stage. Two, sometimes three, types of models are used and the results reconciled. Phase II utilizes time series techniques, in the form of single equation exponential smoothing models. Estimates of passenger activity are made separately for domestic and international markets.

The structure of the exponential model is as follows:

$$Pax_{t+1} = \beta Pax_t + (1-\beta)\, PPax_t$$

Where

Pax_{t+1} = Forecast of next year's passengers
Pax_t = Actual value for current passengers
β = Smoothing constant
$PPax_t$ = Forecast value of current period's passengers

This model progressively weighs values from the most to the least recent. Data from the current period is weighed by β. Data for t–1 is weighed by $\beta(1-\beta)$ and data for t–2 is weighed by $\beta(1-\beta)^2$. Before estimation an extrapolation technique is employed to smooth aberrations like the Persian Gulf War of 1993. Though exponential models are ideally suited for short-term forecasting, this model is used to provide a first approximation of passenger growth. At this stage we remember Professor C. L. Jain of St. John's University, New York, who advised "Forecasting with a time series model is like driving a car with the windshield glass completely blackened out, and the driver drives it looking out the rearview window. If you happen to be driving on a highway full of curves, this is a prescription for disaster." Time series models are quick and easy but for the above reason we use them only as guide to set the stage for a more in-depth modeling effort.

The forecast process proceeds with an econometric model. This is also a regional model. Passenger levels are dependent on real GDP and real yields. Dummy variables are used to allow for special events. This model is specified as follows:

$$\text{Log } Pax_t = \phi_0 + \phi_1 \text{Log RealGDP}(_{-1}) - \phi_2 \text{Log RealYield} + D_{1973} + E_t$$

Where

Pax_{t+1} = Next year's passenger levels
D_{1973} = Dummy variable, 1993 = 1 (Persian Gulf War), 0 otherwise,
ϕ_1 = Income elasticity,
ϕ_2 = Price elasticity, and
E_t = Error term

Estimates are again separately made for domestic and international passengers. The international modeling process is divided into residential and non-residential models, each with its own exogenous drivers. As always, variations of the above specifications are estimated before settling on final specifications. The final choice is based on several factors including diagnostics (MAPE, DW, R^2), coefficient signs and magnitude, and actual ex-post testing. The results of the two efforts are reconciled and estimates are made for regional levels of domestic and international passengers.

On occasion we approach the forecast from a third perspective and directly specify national passenger models using GDP and yields. The results of this model are then used against share models to produce forecasts for the region. These share models postulate that the region's share of traffic is dependent upon the region's share of income and the relationship between regional yields and national yields. When these three approaches are used all the results are reconciled before final decisions are made on forecast levels.

Phase III involves the disaggregation of the systemwide domestic and international passenger forecasts into airport specific forecasts. The guiding variables used to calibrate share-down factors are airport specific development, terminal expansion plans, new entrant plans and prospects, carrier plans, and advanced schedules. Terminal-specific and carrier-specific information at each airport is used to divide the airport forecast into terminal forecasts. Census X-11 factors are derived and used to disaggregate the annual forecast into monthly forecasts.

Observations and Comments

The PANYNJ models have performed reasonably well over the years as we constantly strive to challenge underlying assumptions, evaluate forecast performance, and adapt to new techniques. We always kept the following in mind when forecasting with models.

- The forecast must be updated periodically as new data becomes available.
- Choose simplicity over complexity. Sophisticated and complex models do not necessarily translate into results that are more accurate.
- Forecasting is a process; always crosscheck results with different approaches including judgmental ones.
- Changing market dynamics may cause models that work well historically to loose relevance.
- No matter how the forecast was derived, there should always be a coherent common sense story that motivates the forecast.

SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS

Michael Armstrong
Southern California Association of Governments

Purpose

The Regional Airport Demand Allocation Model (RADAM) is a state-of-the-art multinomial logit (MNL) model that generates and allocates current and forecast air passenger and cargo demand to airports. It was originally developed by the consultant firm Advanced Transportation Systems for the SCAG's 1994 Southern California Military Air Base Study in order to estimate the potential of closed or downsized military air bases in the region to attract air passenger demand as commercial airports. It was designed to significantly improve upon the level of accuracy that is obtainable in assessing the allocation of passenger demand between competing airports in complex multi-airport systems using more conventional gravity or MNL models. SCAG aviation staff's disappointing experience with simple gravity models in previous system studies led to the conclusion that a new and innovative analytical tool such as RADAM was needed to accurately assess the impacts of major capacity expansion proposals on the multifaceted Los Angeles regional aviation system. A more sophisticated methodology was needed that was capable of testing a range of airport system scenarios that are differentiated by a wide variety of discreet variables.

Methodology and Approach

The RADAM model is a bottoms-up model, generating air passenger and cargo demand by a geographically based zonal system (i.e., RADAM zones) that are compilations of SCAG transportation analysis zones. Socioeconomic data by RADAM zone is used in combination with airport choice criteria to generate passenger forecasts and allocations in terms of baseline, catalytic, and total air passenger demand for airports in actual or theoretical airport systems.

Demand generation is the first step in the RADAM methodology. Current and forecast air passenger demand is forecast for 100 RADAM aviation zones in the region, as well as additional zones in Santa Barbara and San Diego counties. For current demand, available airport O-D data is used. For forecast demand, the correlated data are applied to SCAG's forecast socioeconomic data for each RADAM zone. A variety of socioeconomic factors are used in the correlation process, including total population, total employment, retail employment, high-tech employment, median household income, disposable income, household size, number of households, and licensed drivers per household.

The demand generation process also includes the calculation of "catalytic" (or "induced") demand. This represents the increased propensity to fly (over baseline conditions) due to the more convenient provision of airport services, such as when a nearby military air base is converted to commercial use, or when an airport adds more frequent and/or less expensive flights. Because of the addition of this type of demand to baseline demand, the regional demand total is a variable that depends on the amount and distribution of airport capacity and quality of service around the region, and is not a fixed and independent parameter.

SCAG's surveys identified a number of variables which most influence the airport choices of air passengers. These variables were calibrated for different categories of air passengers using a sophisticated curve fit program. The categories of passengers (not mutually exclusive) include short-, medium-, and long-haul passengers, international passengers (with subsets of Pacific Rim, Europe, Latin America, and Canada/Mexico passengers), and business, pleasure, and exclusive tour passengers. The primary airport choice variables that are calibrated by the RADAM model for the various passenger groups noted include (as example) total number of flights, frequency of flights, nonstop destinations served, number of discount airlines, travel time from home and work, travel time from hotel/convention center, ground access congestion, air fare, terminal congestion and convenience, parking costs, and convenience and airport mode choice options. Most of these primary choice variables are comprised of smaller support modules with additional subvariables. In addition, a part of the RADAM calibration or weighting process is to determine the cross-elasticities between the variables. In short, this means replicating how the different passenger groups make implicit tradeoffs between the choice criteria in deciding which airport to choose.

The next step is that of demand allocation. Demand allocation is based on a process of matching major airport attributes (available flights, air fares, ground travel time, etc.) with the primary airport choice factors identified and calibrated for the different passenger categories (business, pleasure, and all-inclusive tours) in each RADAM zone. The number of air passengers allocated to a particular airport from a particular zone is determined by how many of those passengers have their travel needs best met by the particular set of attributes at that airport. A series of MNL equations evaluate a myriad of airport attributes and airport choice factors to calculate the degree of matching. This is typically done through a series of four to six iterations for each alternative evaluated. The result is a percentage allocation of passengers from each passenger category in each zone to each existing or hypothetical airport, producing a total passenger allocation to each airport. Note that passengers can be distributed to several airports from a zone.

After the first iteration, typical fleet mixes and passenger load factors are drawn into the analysis for each haul type, and flight frequencies are adjusted to be consistent with different combinations of demand, aircraft capacity, and load factors. During the last iteration, the number of flights is adjusted until load factors do not decrease below a set percentage that is considered to be consistent with what is economically acceptable. Generally speaking, the iterations continue until only minor changes occur and a point of equilibrium is reached.

The iteration process replicates how the entire regional airport system adjusts to significant changes, such as the addition of a major new airport that diverts passengers from other existing airports. This diversion of passengers in turn makes those airports more desirable for certain passengers because they are less congested, which is reflected in subsequent iterations through a partial return of lost passengers back to those airports. RADAM computer simulations offer the advantage of taking place in “real time” that is much quicker than the actual lag time required for adjustments in human behavior to be made.

Observations and Comments

Besides the 1994 study of military air bases, RADAM has also been employed in SCAG’s 1996 George Air Force Base (AFB) Air Quality Conformity Study, 1997 March AFB Joint Use Feasibility Study, and 1998 Aviation System/Regional Transportation Plan (RTP) Study. It has been used in the Los Angeles International Airport (LAX) and Marine Corps Air Station El Toro master plan studies as well as the agency’s 2001 LAX to March AFB and 2002 LAX to Palmdale high-speed rail studies. The RADAM methodology is in a continual state of refinement, and was most recently refined and updated for SCAG’s 2001 Aviation System/RTP Study. Although developed for SCAG, the model itself is owned by Citigroup Technologies.

COMMUNITY AIR SERVICE ANALYSIS

Edward MacNeal
Edward MacNeal Associates

Purpose

CASA is a full repertoire of community air service analytical methods that derived initially from the MacNeal Air Service Scale (MASS). CASA methods can answer many air passenger- and site-related questions at a fraction of the cost of other methods. For example, what will be the effect of a new airport on passenger traffic volumes at existing airports? What is the likely passenger traffic that will occur if the present airport is closed and a new one opened? What change in passenger traffic volumes will occur if two airports are consolidated at one site? (Such questions are answered for *all* possible sites in contour maps, thereby permitting informed judgments to be made before any really expensive site selection work is undertaken.) What effect will removing a bridge or tunnel toll have on passenger traffic? What effect will it have on passenger traffic volumes if the parking fees or the distance of the lots from the airport are changed? What system of commercial passenger airports for a given state or region will maximize passenger convenience? What effect will it have on passenger traffic volumes if faster subsonic aircraft come into service?

MASS was developed in 1963, and has since been tested in thousands of markets, undergoing gradual refinement as indicated by such tests. One can use MASS to determine the *quality* of service actually provided by air carriers in response to varying volumes of passenger traffic. (In general, up to a point, the more passengers, the *better* the service, but after that point only *more* service occurs.) Using the findings as a standard, one can then ask and answer the basic normative question. What services (quality of service by city-pair market) *should* be provided at a given airport? What are the most important additions needed to an airport's existing service? What is the *minimum* number of flights (by time of day by market) that could meet all of the service requirements (for any given year)?

These are just sample questions that have been asked. Most have been answered many times for many different communities. However, MASS and CASA can answer almost any question that involves the interplay of passenger traffic, schedules, fares, airport accessibility, underlying demand, and its geographic distribution.

Methodology

MASS is a unique scale of numerical values that can represent the quality of round-trip air service in any given city-pair market. Lower values represent better service; higher values represent poorer service. The scale measures service from the most frequent nonstop pattern (level –3 if shuttle service, level –2 if reservations are required) through various qualities of single plane service (levels –1, 0, 1 or higher, depending on distance) and connections (today usually levels 2 through 7). The scale measures the pattern of round-trip service versus desired departure times, taking equipment type, stops, connections, connection time, circuity, and distance into account. Number of flights (frequency) and seats (capacity), as such, are ignored. Odd as these exclusions may at first appear, they are absolutely necessary to avoid the automatic correlation between seats and passengers that invalidates other city-pair air service scales.

The changes in passenger traffic that correlate with changes in quality of service on the MASS have been calibrated logarithmically so that a change of one step anywhere on the scale produces the same percentage change in traffic (typically about 15% for the city-pair markets of an ordinary independent airport). The effect on passenger traffic of changes in fares and airport accessibility have been calibrated to the same scale. This reveals quantitatively how changes in service, fares, and accessibility either reinforce or offset each other. Then, with relatively simple analytical techniques and standard factors (such as population distributed by income and geographic area) one can apply CASA to any airport situation.

Specifics of the CASA depend on the issue to be addressed. In the case of analyzing service distribution between multiple airports in a region, for example, the method proceeds in three broad and logical steps. First, the air service areas (the local regions from and to which air passengers using each facility come or go) of the present airports are calculated (without need for any field survey). Second, the underlying relative demand for air service is computed for each zone in each air service area. This relative demand is typically a product of the zone population by income group and the propensity to travel by income group (although other factors, such as employment and lodgings, may also be used). Third, the relative demand is converted to an estimate of realized demand through consideration of such influences as airport accessibility to the population, the level of air service available (MASS rating) at each airport, and the fare levels. If the location of an airport is to be changed (for example), the effect on conversion of underlying to realized demand is calculated, and the regional benefits (or inconveniences) can be determined.

It might reasonably be said that the MASS measures the effect of changes in schedules on passenger traffic whereas a quality of service index-type (QSI) of scale measures the effect of changes in passenger traffic on the number of seats. This is a critical difference in the foundation on which to build a system of CASA.

MASS directly measures air service *quality* as seen by prospective passengers making trip decisions, not *quantity* of seats provided by schedulers trying to fit the market demand. For example, in the MASS, once there is jet service in a market at any given time of day, neither a variation in the size of the plane nor the provision of additional flights near that time affects the score. Hence, unlike the traditional QSI measure, the MASS does not automatically regard more seats as better service. Further, the MASS measures all city-pair markets, including all types of connecting service, on one continuous scale. Yet, despite its having much greater freedom than the QSI to vary from existing traffic, changes in the MASS correlate even better with changes in passenger traffic than do changes in the QSI. The better correlation apparently stems from the fact that the MASS studies the pattern of round-trip service rather than the number of seats, thereby giving weight to the complete trip scheduling factors that influence actual trip decisions but are completely missing from the QSI and other methods.

Observations and Comments

Both the scale and the analytical methods were developed by Edward MacNeal (originally at James C. Buckley, Inc., then in association with Landrum and Brown, then independently, and since 1969 as Edward MacNeal Associates). These methods have been employed for airports and regions, large and small, located in more than half of the 50 states. Calibration of the models to within a few percent of current traffic distributions on the first trial typically provides a high confidence in their predictive capabilities. The analyses are remarkably transparent and, therefore, easy to review, to understand, and to apply.

Traffic Flow Forecasts and Market Shares

At times, the appropriate perspective for forecasting aviation demand is that of the volume of traffic flowing between regions rather than from the local (airport) perspective. Such a perspective would be appropriate in support of airline service or air traffic control facility analyses (as examples). The following five examples illustrate approaches to the problem of forecasting overall passenger traffic and cargo between regions, and means for allocating passenger traffic to competing airlines serving these markets.

A variety of socioeconomic measures and model formulations are described to forecast the overall flow between countries or regions. As always, data can be a limiting factor. One paper describes the ability to combine several public databases to improve the accuracy and relevance of O-D data commonly reported.

Two papers directly address the problem of allocating the overall demand (measured or forecast) to competing airlines. Though both utilize measures of service quality, they illustrate differences of emphasis on various competitive attributes.

INTERNATIONAL PASSENGER TRAFFIC FORECASTING

Claire Starry
TDS Economics

Purpose

In projects conducted for aviation associations (e.g., IATA), the FAA, and corporate clients, the staff at TDS Economics has developed forecasts of international aviation activity, including flights, enplanements, and similar variables by O-D pair, and for overall international aviation activity within a country. Our approach is based on econometric/statistical analyses that rely on time series or cross-sectional data from publicly available and proprietary sources. Clients use these forecasts to evaluate the impacts and benefits of aviation activity and also for policy making, airport planning, marketing, investment decision making, and so forth.

Methodology and Approach

Although the method used to forecast international aviation activity varies from assignment to assignment, most analyses include the following steps.

- Identification of the forecast objectives, including the selection of dependent variables, the level of detail, and the forecast horizon.
- Collection of cross-sectional or time series data on flights or passengers carried between specific O-D pairs (which can be at a region-to-region, country-to-country, or airport-to-airport level). Data sources include government and international entities (e.g., FAA, ICAO), associations [e.g., IATA, Association of European Airports (AEA)], airports, and published schedules as well as proprietary sources supplied by the client.
- Collection of economic and demographic data that influence the demand for aviation. These variables include GDP, population, prices, interest rates, and fuel costs. These data are available from economic forecasting services such as DRI-WEFA, or from a variety of government sources.

- Development of a model to analyze and forecast international aviation activity. The model will depend on the objectives of the assignment and specific variables to be forecast.
- Analysis and adjustment of forecasts based on workshops or other peer review.

A single-equation econometric model is often used to develop country-level international forecasts. The dependent variable is functionally related to a series of independent or explanatory variables, such as real (inflation adjusted) GDP, yields, business profits, fuel costs, and aircraft operating costs. This type of modeling requires sufficient data to develop reasonable equations. A model may take the form of:

$$\text{Dependent variable} = \alpha + \beta\ \text{GDP} + \gamma\ \text{Yield} + \varphi\ \text{GDP Other Countries} + \text{Other Explanatory Variables}$$

or

$$\text{Dependent variable} = \alpha + \beta\ \text{GDP/Population} + \gamma\ \text{Population} + \lambda\text{Yield} + \varphi\ \text{GDP Other Countries} + \text{Other Explanatory Variables}$$

The inclusion of population and GDP per capita in the equations can add to their predictive power, especially if a rapid growth in GDP per capita is expected. This inclusion reflects the strong correlation between the number of airline trips per capita and GDP per capita.

Time series data for a period of 12 to 20 years is generally used to estimate these equations, especially if the forecast horizon is 10 to 20 years. The minimum number of observations needed depends on the number of explanatory variables in the equation and forecasts horizon. If seasonal adjustments are included, seasonal data must be collected and seasonal adjustment variables included in the equation. The models are usually estimated in linear or log-linear form, depending on the equation form that best fits the data. The estimated coefficients of the explanatory variables in log-linear equations are also the elasticities of demand.

Models that are designed to forecast airport-to-airport or country-to-country operations often take the form of:

$$\text{Dependent Variable} = \alpha + \beta\ \text{GDP1} + \gamma\ \text{GDP2} + \lambda\ \text{Yield} + \text{Other Explanatory Variables}$$

where GDP1 and GDP2 represent regional or country income or other measure of economic activity. This type of model requires extensive data on an O-D basis, sufficient to develop separate models for each O-D pair evaluated. However, once the models are estimated, it is relatively easy to forecast flights, enplanements, or other dependent variables using the demand elasticities from the equations. This approach was used by staff of TDS Economics to forecast country-pair aviation activity within Europe using elasticities of demand from models previously estimated by the AEA. Using a starting value for each dependent variable (e.g., number of flights between a country-pair), forecasts were generated using the relevant elasticities multiplied by the rates of change in key independent variables, in this case yields, and country GDPs.

Observations and Comments

As with many forecasting endeavors, international aviation forecasts often rely on econometric and other statistical approaches. Data availability and the cost of collecting and organizing it are among the major difficulties in developing international aviation forecasting models. Specific data may not be publicly available, and unless proprietary data can be found, the model needs to be adjusted to fit the available data.

With any of the above forecasting methods, it is always useful to evaluate and adjust the models based on peer or committee review. Often changes occur that are not picked up in historical data that should be judgmentally incorporated into the final forecasts. Also, some level of sensitivity analysis is usually warranted, and this is conducted through a range of forecast values for the independent variables, such as GDP or yields. Sensitivity analyses are particularly useful when evaluating policies implications.

INTERNATIONAL PASSENGER TRAFFIC FORECASTING: TRUE O-D

Barry Clark
Travel Insights, Inc.

Purpose

Travel Insights, Inc.® has developed an international route forecasting model in a Microsoft Access environment that provides for preparation of detailed passenger traffic forecasts for international air services. The model allows the analyst or researcher to build a detailed forecast that takes account of every possible passenger flow over an international route at any U.S. gateway airport.

The database is unique in that it reports the volume and destination distribution of international air passengers by beginning and ending geographic area; it does *not* report traffic at an airport as the end point. This approach permits an airport, airline, political jurisdiction, or related businesses to identify the true volume of international traffic from any geographic area. Thus, the database ties the passenger O-D to a geographic location rather than to the airports in an airline ticket itinerary.

O-D locations in the United States are defined by counties while overseas locations are defined by community names. The geographic O-D locations can be related to airports by linking each U.S. county or foreign community with the most easily accessible local airport. With the geographic definition of catchment areas it is possible for the first time to establish definitive relationships between international airline traffic and the economic/demographic characteristics of an airport's catchment area.

Methodology and Approach

The forecasting process is a simple interactive procedure in which the user edits data lists that are generated within the model. There are six basic steps to the procedure.

- Identify the O-D for the nonstop flight.
- Define the states whose traffic could flow over the nonstop segment on connecting services.
- Define the catchment area countries beyond the foreign gateway to which traffic could connect.

- Identify the markets which the target carrier and/or alliance partners serve behind the U.S. gateway and beyond the foreign gateway.
- Establish maximum and minimum growth rate limits for different categories of city-pair markets.
- Establish stimulation assumptions as necessary.

The forecast model is based on Travel Insights' proprietary international O-D database. In addition to the detailed passenger O-D data, the database contains information on both U.S. and foreign gateways used for the trip and on the citizenship of passengers (either U.S. or foreign). There are no constraints on the use of the database or model because it is developed from sources that, unlike the USDOT O-D Survey, have no confidentiality restrictions.

The database covers the period from 1991 through 2001 and is updated annually. It was developed by integrating INS Statistics with the International Trade Administration's Survey of International Airline Passengers. The resulting traffic data is identically consistent with INS statistics at the segment and citizenship level. Internally the database is also identically consistent with the INS data at the carrier flag level. The database, which includes 10 years of historical data, is unique for U.S. international traffic because it includes the true O-D of all traffic on both U.S. flag and foreign flag airlines and provides a complete picture of the traffic flows beyond the initial foreign gateway. An important and unique feature is that the passenger origin is established from the passenger's place of residence, rather than being tied to the airline itinerary.

The 10-year time series of historical data allows the model to generate growth rates internally for every individual market. However, since some of the city-pairs are usually very small and tend to be somewhat volatile on a year-over-year basis, growth rates in markets that would require two connections are aggregated into regional or national groups such as "Mountain States–France." The model uses a conservative market growth algorithm as default, but allows the user to establish upper and lower bounds on the growth rates.

Stimulation estimates can also be entered by the user of the model for a number of different categories of routes. Since the underlying traffic database includes U.S. and foreign gateways for the passenger traffic flows, it is possible to develop data to support stimulation assumptions by identifying a comparable route (or routes) from the historical period and preparing an analysis based on the routes initiated by the target carrier or by making comparisons to routes with similar competitive characteristics.

This same approach can be used for market share assumptions. This provides a much more rational and supportable basis for market shares, in our view, than a rote application of techniques such as the QSI. The QSI approach implicitly assumes that all services can be effectively compared using mathematical values for various different characteristics of the itinerary. We do not believe that this is appropriate, especially given the fact that the Travel Insights' database has some unique characteristics that give it greater value for analysis than is provided by more common air traffic-only data sources.

Comments/Observations

The use of the passenger place-of-residence as origin has a number of major benefits. Many passengers travel significant distances to their gateway airport by surface transport or by using a separate unrelated airline ticket. In the Travel Insights' database, unlike other sources such as the USDOT O-D Survey, these passengers are reported where their journey really begins. For example Dusseldorf residents may drive to Amsterdam for a transatlantic flight and would be reported as

Amsterdam passengers, but Travel Insights reports their journey begins in Dusseldorf. In other areas across Europe many passengers use high-speed trains to go from their homes to distant airports but the data reports them as beginning the journey from home rather than from the airport. (Transatlantic, transpacific, and Latin American markets can be assessed.) This, we believe, provides an inherently more reliable basis for traffic forecasts. The residence-as-origin approach also overcomes problems that arise from split ticketing, whereby a passenger uses two separate tickets for a complete journey. Split ticketing is an increasing problem as major travel outlets buy blocks of space and then re-sell the space for their own account.

INTERNATIONAL AIR CARGO FORECASTS

Paul Bingham and **Robert West**
Global Trade & Transportation

Purpose

Huge volumes of higher-value goods are shipped throughout the world by air. Sometimes the physical distance and required short transit times are the determining factors to select air over water. In other cases, air is chosen for even short distances if the value of the goods is high enough.

DRI-WEFA has developed an approach to forecasting of international air cargo volumes that tackles one of the most difficult aspects of the problem—how to maintain consistency of the cargo forecast with the general economic environments.

The output from these models is used to assist private airlines in planning their long-term routing structures, assisting in the purchase decisions of new aircraft, helping to determine the potential international air cargo volumes for new airport facilities, etc. DRI-WEFA has used these models in consulting assignments in many countries and has worked with both private airlines and local governments.

Methodology and Approach

The approach taken by the DRI-WEFA team is to focus on 77 commodity categories, which, in total, constitute total international merchandise trade. There are clearly many commodities that never move by air, such as coal, grains, etc. Other commodities, typically of intermediate unit value, are shipped by air some of the time but not all of the time—these have "air penetration factors" that are greater than 0 but less than 100. Finally, there are high-value goods, such as computers or scientific equipment, for which the air penetration factors are quite high.

But the world is not uniform. A commodity that might move by air between Singapore and the West Coast of the United States, may, in fact, be transported by ship if it is shipped from Brazil to the U.S. East Coast. The selection of air as the preferred transportation mode depends, in other words, on both the commodity and the route; this is another way of saying that the local infrastructure for handling the air cargo differs greatly from one part of the world to another.

The guiding principles behind the DRI-WEFA air cargo forecasting methodology is to link the cargo movements to economic indicators from the O-D of each commodity. The overall demand for each commodity in question is first estimated using a pooled cross-sectional time series approach, based on extensive historical data as well as country-specific information. However, with the exception of the United States, the United Kingdom, and a few other countries, commodity tonnage figures are typically available only for total tonnage, regardless of mode. The challenge then is to identify meaningful air factors to apply against the total commodity tons, in order to estimate the volume of air cargo.

DRI-WEFA uses actual, reported air cargo tons from two key parts of the world: the United States and the United Kingdom. Over time, other country-reported air cargo tons figures will be added to the system in order to enrich the air factors and to improve the estimation procedure by O-D pair and by commodity.

Data Inputs

In addition to country-specific merchandise trade statistics, such as the all-methods data series from the U.S. Census Bureau, DRI-WEFA uses annual United Nations and Organization for Economic Cooperation and Development trade statistics to provide comprehensive coverage of global commodity movements by O-D country and commodity.

Linking Air Cargo to Economic Forecasts

In order to forecast air cargo volumes, DRI-WEFA uses its own macroeconomic forecasts, developed by a large staff of professional country economists who work with individual country models and who manage their regular re-estimation and solution-producing forecasts updated several times per year, to incorporate the latest economic and political developments. These macroeconomic models, covering over 125 nations, provide critical inputs to the air cargo forecasting models, such as real GDP, incomes, consumption, investment, prices, population, employment, share of goods traded, and so forth.

Each commodity group has its own global forecasting model. For each route in the model, the historical variables are used and weighted using statistical techniques. Once the relationships are established and the air penetration factors are applied, the forecasts are developed using the macroeconomic inputs (annual projections that are constructed over a 20-year time frame).

If there is some additional knowledge that might indicate a growing volume of air cargo on a particular route, such as the development of new air cargo handling facilities, or a new airport, then the air penetration factors are modified to reflect the expected change in flows.

Observations and Comments

From experience, we have found these models are very useful for long-term infrastructure planning and policy analysis. The annual forecasts produced provide an excellent baseline defining the underlying market demand for airborne commodities shipped on a route-specific basis. These air cargo demand forecasts are especially useful where an ability to explain why a particular change in future air cargo activity will occur, or where sizing the fundamental demand for goods is important. Using these models, it is also possible to test the impacts of changes in the value to volume relationship on future air cargo demand.

NETWORK SIMULATION MODELS

Mark Diamond
SH&E

Purpose

Passenger airlines are increasingly employing sophisticated network simulation models to test the feasibility of proposed service changes and optimize their network profitability. SH&E developed its NetWorks desktop software system for this purpose.

Such models are used by airline planners to quantify the impact on traffic, revenue, and profitability of "what if" network scenarios. In practice, simulation models have many potential uses in evaluating proposed network changes, including testing the impact of schedule or route changes, capacity changes, fleet changes, major network restructuring (such as the creation of new hubs), code-shares and alliances, or synergies from proposed airline mergers or acquisitions. The models can also be used to "game" competitor actions and responses.

Methodology and Approach

Modern network simulation models are loosely based on QSI methodology, which was developed in the 1950s by the U.S. Civil Aeronautics Board (CAB) as a means of forecasting an airline's market share, traffic, and operating results. QSI-based models work by estimating an airline's market share in a given O-D city-pair market, based on the characteristics of the carrier's service offerings relative to its competitors. This estimated share is then applied to the known total passenger traffic in the market, in order to project the number of passengers that the subject airline is likely to attract. Today's computerized simulation models are able to estimate share and allocate traffic across an airline's entire network—which may consist of thousands of O-D markets—in a matter of minutes.

Data Inputs

Network simulation models such as SH&E's NetWorks employ as inputs O-D market traffic data, fare data, and airline schedule data. A "market file" is constructed, with total true O-D passenger traffic data—summed across all carriers in the market—for each of the thousands of city-pairs under consideration. Sources of this data include the USDOT's O-D Survey or MIDT data downloaded from airline CRSs. The market file also includes fare information for each city-pair market obtained from airline records or ticket lift samples such as the O-D Survey. In addition, SH&E's NetWorks model utilizes detailed airline schedule data offered by provider services such as the OAG or *Innovata*. To ensure that *all* potential service offerings are considered in each city-pair market under review, the model will automatically construct connecting services according to specified service criteria, including minimum/maximum connecting times and permitted trip circuity.

Estimating Share

SH&E's NetWorks model takes into consideration seven separate service parameters in order to establish values for all airline services offered in each O-D city-pair market, including

1. Weekly service frequency,
2. Number of stops enroute,
3. Number of connections enroute,

4. Type of connections (online, interline, or code-share/alliance),
5. Aircraft capacity,
6. Elapsed time from origin to destination, and
7. Time-of-day and day-of-week departure preference factors.

These parameters generally reflect the major service attributes that airline customers consider in making service selection decisions, as well as the relationship between capacity offered (frequency and aircraft size) and traffic demand. Each of the service parameters is given a numerical weight, established by iteration in an initial calibration phase. The model then calculates a CSI value (competitive service index) for each competing service offering in each of the O-D city-pair markets under consideration. Where w_x represents the weight associated with a particular parameter, the CSI value for a given air service is calculated as

$$w_1 \times w_2 \times w_3 \times w_4 \times w_5 \times w_6 \times w_7$$

Where

w_1 = Number of weekly services,
w_2 = Number of stops,
w_3 = Number of connections,
w_4 = Type of connection,
w_5 = Aircraft capacity,
w_6 = Elapsed time, and
w_7 = Time/day preference factor.

Other preference factors can be added as well to reflect competitive variables such as passenger fare elasticity, loyalty program (frequent flyer) effects, or carrier market presence (S-curve effects). The final CSI values for each airline participating in the market are then used to calculate an entitlement share for each carrier. An airline's estimated entitlement share in any given O-D city-pair market is its CSI value divided by the sum of all carriers' CSI values.

Allocating Traffic and Calculating Revenue and Profitability

Once entitlement share estimates are derived, they are applied to the total true O-D traffic in each city-pair market, to obtain an estimate of the number of passengers allocated to each airline in the market. SH&E's NetWorks model also contains a spill function that will, if necessary, iteratively displace passengers onto alternative airline services in high-demand markets, ensuring that the number of passengers uplifted does not exceed the number of seats offered by each carrier on a given route segment.

Carrier revenue estimates are derived from the allocated traffic and fares in each O-D city-pair market. Operating cost, contribution, and profitability estimates can then be obtained by applying unit cost data to the carrier's known activity levels. Financial results, as well as a variety of traffic and activity statistics, can be segmented by flight, by route, by station, by aircraft type, or for the airline's network as a whole.

Observations and Comments

The complexity of network simulation models requires extremely careful preparation of input data and assumptions and astute interpretation of results to ensure that results are realistic and unbiased. When used properly, such models offer an opportunity to evaluate multiple proposed airline network strategies quickly, precisely, and with little risk. Designed as a tool to improve airline decision making, network simulation models can also be used to address broader industry, policy, or forecast issues, including competitive implications of industry capacity trends, proposed alliances, or potential consolidations.

NETWORK PLANNING MODELS

William Spitz
GRA, Inc.

Purpose

GRA develops passenger revenue and traffic projections in a variety of settings for airlines, airports, and other clients. These analyses range from the very small (a new start-up carrier beginning service from a single home airport) to the very large (mergers, alliances, or other forms of cooperation between multiple large carriers, each of whom may serve thousands of city-pair markets).

While the focus may be quite different in each case, GRA utilizes a systematic approach across the board through use of its GRACE network planning model. The model can be used to project carrier passenger traffic and revenues on a city-pair market-by-market basis, and can trace levels of connecting and local traffic. At the other end, aggregated results at the regional, national, or international level also can be easily obtained.

Methodology and Approach

Many airline industry analysts have developed spreadsheet or database models to project market or carrier traffic shares at varying degrees of aggregation. At the one end are micro-oriented QSI or econometric models that typically are employed to analyze service offers market by market in a small number of O-D city-pairs. In principle one would prefer to perform all analyses at this detailed city-pair level since this is where passenger decisions about carrier and route choices are made. On the other hand, analysis of mega-carrier mergers or alliances often requires analysts to forego city-pair detail; in these cases more aggregate measures of competition (e.g., seat shares between the United States and Europe) are often employed.

The GRACE model provides a unified approach regardless of the size of the problem. At the micro level every city-pair market is analyzed in a QSI framework where market shares are projected based on the number and type of service offers (nonstops versus one stops versus two stops, online versus code share versus interline, widebody versus narrowbody versus RJ, etc.). Maximum flexibility is provided so that GRA can respond quickly to requests to investigate the effect of changing various parameters that influence the competitive environment.

The key to this approach is a model interface that allows GRA to easily define which markets to analyze, which schedules to use, and how to treat potential or existing carrier alliances. The user does not need to worry about specifying every O-D market or providing data on what connection possibilities are available; this is all handled internally by the GRACE model.

The model itself is divided into two parts: generating connections and creating reports. To find connections, one first specifies a set of airline schedules and city-pair markets (or, more simply, a set of points served by each carrier to be analyzed); GRACE then finds all possible non-stop, one-stop, and (if desired) two-stop services utilizing the flight schedules, user-specified time, and circuitry criteria. Two user-definable cases are considered: base and scenario. Service offers found by the model may apply to either or both cases.

After all possible connections are found, one can specify various parameters to characterize the competitive environment in the base and scenario cases. For example, one can specify relevant code share alliances or agreements that are to apply to each case. A typical use of the program would be to set up the base case to represent the current state of the world, and then to add in a prospective alliance and/or a new set of flight offers under the scenario case.

As mentioned earlier, GRACE utilizes a QSI approach to project shares within each O-D market. In addition, information about fares and market sizes (including any demand effects induced by changes in service offers between the two cases) is utilized to project overall passenger and revenue totals for each carrier in each market. One such option is the ability to specify traffic stimulation by way of user-specified elasticity.

When these computations are finished, a variety of reports (in Microsoft Excel format) can be produced to portray the results. These include

- Market shares,
- Average elapsed (traveler) times,
- Service details (type and number of service offers by carrier),
- Revenues (segment or O-D),
- Traffic (segment or O-D),
- Segment load factors, and
- Airport terminal passenger flows.

Observations and Comments

GRACE is a sophisticated PC-based planning tool that can quickly assess the impacts of airline service changes and how they propagate through domestic and international markets. GRA has used the model successfully to assess the impacts of new carrier startup proposals, major airline mergers, and proposed codeshare alliances on affected parties including individual airlines, airports and alliance partners. GRACE is a proprietary tool that GRA uses in-house only; it’s not licensed or sold to outside users.

Aircraft Production and Fleet Forecasts

Extensive aircraft demand forecast capabilities have been developed by airframe manufacturers, major component and system suppliers, financial brokerage firms and market analysts. In many cases, the overall structure of the models are similar in that they anticipate the growth in a fleet, retirements, and the new deliveries needed to accommodate growth and replacement of retired aircraft. An alternative approach is to forecast deliveries directly based on (forecast) changes in customer needs and general economic conditions. Examples of both approaches can be found in the following descriptions.

Differences in data availability and accuracy have also influenced the development of forecasting methodologies. Large commercial transport capacity and demand have been quantified for over 50 years with information compiled by such entities as the USDOT (including such predecessor organizations as the CAB), IATA, and ICAO. Airline reporting is extensive, and the resultant data has enabled detailed analyses to be undertaken and models developed to characterize commercial air transport demand. Numerous commercial sources regularly track changes in aircraft utilization, fleet composition, and aircraft ownership.

At the other extreme, in relative terms, little public data exists for rotorcraft. In the United States, utilization statistics are publicly reported at an aggregate level and are frequently questioned by industry participants who have proprietary data. Even the count of rotorcraft in active civil service is uncertain and subject to debate.

And between these extremes are found regional and business aircraft fleets; availability of capacity and demand data are mixed for these uses. The resultant approaches to forecasting reflect these distinctions.

Finally, across all these types of aircraft is the question of determining value at various times during their life cycle. Assessing and forecasting value introduces an entirely different set of considerations and data requirements. A description of this process is provided.

LARGE COMMERCIAL TRANSPORT DELIVERY AND FLEET FORECASTS

Edmund S. Greenslet
ESG Aviation Services

Purpose

The Airline Monitor is a monthly trade magazine that, among other things, projects worldwide demand for commercial jet transport aircraft. A completely new forecast is published in the July issue each year and is updated in the subsequent January/February issue. The time frame of the forecast is approximately 20 years, the main determinant being to overlap the time period of similar forecasts prepared by Boeing and Airbus. Those forecasts project the market in terms of airplane size class, i.e., 120 to 150 seats, 150 to 200 seats, etc. The *Monitor* forecasts project demand by specific airplane type, i.e. 737-700, 737-800, A-319, A-320, etc. The objective is to give users who may supply products to or provide financing for some programs, but not others, specific information that applies to their particular needs. In addition, all of the formulas used to build the forecast are published so that any users can substitute their own assumptions to create a model reflecting their own opinions of the market outlook.

Methodology and Approach

There are, in effect, two models. One is a macro approach based on a world traffic and airplane retirement forecast while the other employs a micro approach of building up demand for each individual airplane type on fleet trends and the backlog of orders and options.

Macro Model

A traffic forecast is prepared for each major region of the world: United States, Europe, Asia/Pacific, and an all-other group that consists of Canada, Latin America, Middle East, and Africa. The key driver is the near and long-term expectation for the growth rate of GDP measured in real constant-dollar terms. Airline traffic for the region is assumed to be a multiplier of this real GDP growth rate and that multiplier ranges from 1.2 times in the United States to 2 times in the less-developed sectors of the world. In addition, for the most developed sectors (United States and Europe) it is assumed that the price of air travel is also a major driver of demand, so a multiplier is applied to the percentage change in real yield. Thus the traffic formula for the U.S. becomes:

(Real GDP percentage growth × 1.2) – (real yield percentage growth × 0.7)

Putting numbers to this we get, as an example,

$(3.0 \times 1.2) - (1.0 \times 0.7) = 4.3\%$ traffic growth

Notice that real yield is entered as a minus because only when real yield declines does it stimulate more traffic, and the 0.7 factor for yield is a number that has been used for about 60 years as it dates back to the days when fares were regulated. The resulting number of revenue passenger miles (or kilometers if the user prefers) each year in each region is summed to obtain a world traffic number for each year of the forecast period.

Once an annual traffic figure is obtained a load factor must be assumed to determine capacity as denominated in the number of available seat miles (ASMs) (kilometers). At this point a capacity equation is applied to convert ASMs into the number of airplanes required to carry the projected traffic in each year of the forecast period. This capacity formula is

ASMs ÷ 365 = ASMs per day for the year

Then

ASMs per day ÷ (utilization in hours per day × speed per hour × seats per aircraft) = Number of Passenger Aircraft in the World Fleet

To this must be added a forecast for cargo aircraft to get the total expected airline fleet. It is the year-to-year change in that fleet that produces most of the expected number of annual deliveries. Clearly future utilization, speed, and seats must be estimated. For the first two this is done by looking at past trends and extending them into the future. The average number of seat per aircraft in the fleet depends on the mix of airplane types so this is the place where the macro and micro models (we will get to the micro model later) are joined.

The other major component of annual aircraft demand is retirements. The only statistical way to deal with this is to use airplane age although in the past actual retirements have not followed any age driven curve very closely and accidents can cause even young airplanes to retire. The assumption is that airplanes begin to retire once they are 25 to 30 years old (for cargo aircraft the beginning point is 45 years) and we assume that 20% of the airplanes reaching the targeted threshold are retired in each of the next 5 years. Thus if 100 aircraft become 30 years old this year, 20 are retired next year, 20 in the following year, etc. Doing this for all types in the fleet produces an annual number of retirements which is then added to the estimated growth in the active fleet to obtain an annual delivery number.

Micro Model

For the first 2 years or so of the forecast the number of airplanes of each type to be delivered is essentially driven by the announced plans of the manufacturers. These plans may result in a total that deviates significantly from the number of aircraft needed by the market as determined by the macro model, and this difference becomes the basis for judging that there is a surplus or shortage of capacity in the system. Beyond the first 2 years the macro model determines how many airplanes are needed.

Spreading that need over all available types is largely a judgment process based on the known mix of types over the last few years, the number of orders and options outstanding for each type, and the need to produce the number of annual ASMs indicated in the macro model from a defined total number of airplanes. The unit projection by airplane type should be accompanied by a calculation of the number of ASMs and seats produced by these deliveries. It is also necessary to combine the deliveries and retirements by type, ASMs, and seats into an annual forecast of the total fleet. This provides a cross check against the macro model and often leads to adjustments in some components of that work.

Observations and Comments

The one unknown is what new airplane types may be developed, and this question is particularly relevant when we are working 10 to 20 years into the future. Any such developments would clearly have a significant impact on existing models but the only way to deal with it is to redo the forecast frequently. (But when in doubt fall back on the basic adage of forecasters: forecast frequently, but never about the future!)

REGIONAL AIRCRAFT DELIVERY AND FLEET FORECASTS

Ameet Sareen
Bombardier Aerospace

Purpose

Bombardier Aerospace forecasts the world fleet and delivery demand for regional aircraft for the purpose of supporting its manufacturing and new product development activities. The forecast is segmented into various categories including: geographical region, seat category, and engine-type. The forecast is then used for internal product planning (to support investment decisions) and for external marketing/communication activities. The results of the forecast are published annually as Bombardier's Regional Market Outlook.

Methodology and Approach

The forecast is a merged top-down and bottom-up view of the market. The top-down forecast is driven by macro-economic models while the bottom-up forecast is based on detail, micro airline-by-airline analysis of the market.

The econometric model is primarily GDP-driven and based on historical aviation trends and regional economic inputs. This model predicts growth rates for the market and, when combined with existing fleets and retirement assumptions, produces a seat demand requirement. Regional seat split models are employed to forecast units by capacity segment.

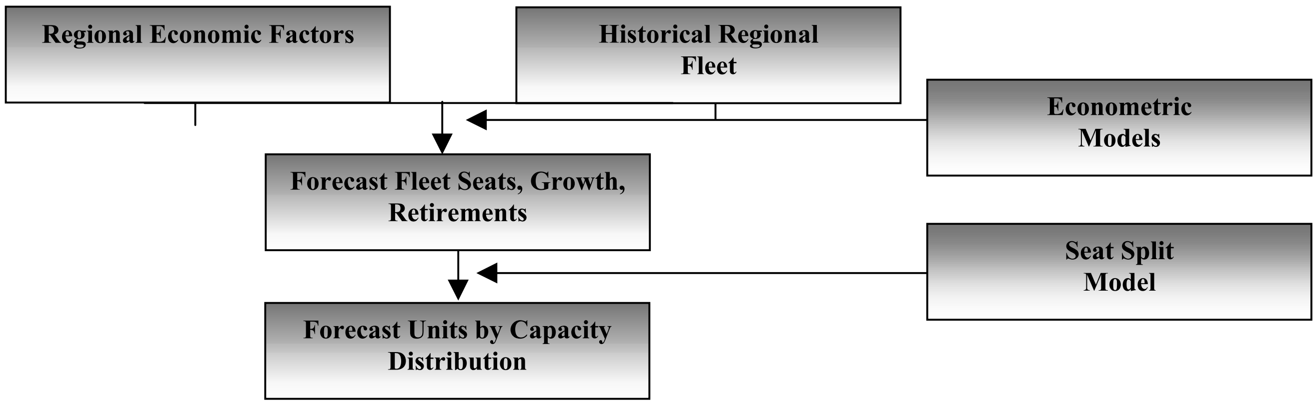
The results of the top-down econometric model are then tested against nearer term anticipated fleet decisions by individual airlines. This bottom-up check is more useful in the near term and may result in a shift forward or backwards of the expected timing of deliveries predicted by the top-down model.

Although a 20-year GDP-driven forecast is presented for each region, we do not attempt to forecast business cycles. Rather, our long-term GDP forecasts are based on a blend of two approaches: 1) a forecast of short-run macroeconomic fluctuations, projections that primarily involve forecasting changes in the level of aggregate demand, and 2) a forecast of aggregate supply—i.e., the rate of expansion of the resource and technology base of the economy, which is the focus of long-run economic growth. In the first few years of each regional forecast, the results are dominated by aggregate demand projections, since both the resource and technology bases are relatively constant in the short term. Thereafter, the forecast is dominated by supply factors such as population growth, labor participation, and productivity growth. In addition, fiscal policy, monetary policy, regional trade, and the projected degree of international economic integration are incorporated into the long-term forecast.

The demand for regional aircraft capacity requirements is derived fundamentally by using a fleet seat forecast methodology.

- Historical fleet seat growth, as a measure of capacity is an excellent surrogate for passenger growth.
- Fleet seat data, particularity for the regional airline segment, is available worldwide on a consistent basis.
- Productivity effects are inherently included.
- Covers all major market segments:
  - Engine type: jets and turboprops, and
  - Geography: the total market demand is calculated by assessing each of the eight major geographical regions that, combined, make up Bombardier's estimate of the potential for regional aircraft. These regions include the United States, Europe, Canada, China, Asia and the Pacific, Latin America, Africa, and the Middle East. The forecast currently excludes Russia and countries of the former U.S.S.R.
  - Capacity segments: this market is segmented into four capacity groups: 20 to 39 seats, 40 to 59 seats, 60 to 79 seats, and 80 to 99 seats.

A diagram of the forecasting process is provided below.



BUSINESS JET DELIVERY AND FLEET FORECASTS: VALUE-BASED ANALYSIS

Jim Potts
Honeywell

Purpose

Honeywell develops forecasts for deliveries of numerous aircraft types in support of its manufacturing activities and new product development efforts. The company's approach to market forecasting is systematic, yet tailored to the unique attributes of each respective market segment (i.e., business aviation, commercial transports, regional transports, and military aircraft). The company's business jet forecast provides a 10-year outlook of total world deliveries by model by year, and a fleet forecast for analysis of aftermarket potential. It combines econometric models with user and industry analyst perspectives. These forecasts are used for internal production and program planning. The part of the business jet forecast publicly released (typically during the third quarter of the year) summarizes the 10-year delivery outlook into eight aircraft size categories.

Methodology and Approach

Honeywell's approach to business jet forecasting follows several steps. First, basic product and economic data are compiled. In parallel with this, market-specific workshops are held and aircraft operator surveys conducted. Information from these sources are combined with output from value analysis and econometric models; these results are then used as input to a later round of workshops that focus on company-specific applications of the forecast findings.

Product information is used to develop the supply side Business Jet Value Index component of our model. This information includes specifics as to the speed, cabin volume, range, runway performance, and price of competing (existing and proposed) aircraft models.

Economic forecast data is acquired from established sources such as DRI-WEFA. In this case, the data includes such factors as corporate profitability, GDP, inflation, industrial production, and consumption of transportation services. This data, along with government/defense budget and procurement levels (when applicable), are used to construct baseline global economic scenarios for all four market segments, which in turn drive the econometric forecasting models and force structure models used in the aircraft market assessments.

The market-specific workshops are hosted with recognized independent industry experts invited to discuss business trends, environmental/regulatory constraints, and emerging technology impacts including substitutes. These workshops include discussion of new program starts and timing with the goal of establishing an independent cross check and consensus to internal Honeywell views. The results of the workshops are synthesized into a few key "market drivers" and assumptions which are applied to the economic scenarios and econometric demand models.

The econometric models are run using this consensus input. Some of these models anticipate the dollar expenditures for business aircraft purchases by year through the forecast period. The resultant top line demand projections establish the boundaries of the overall market forecast. For business jets, we do not utilize separate econometric models for each world region.

Next, for the business aviation segment, independent surveys of corporate flight departments and other business aircraft purchasers are performed annually to establish projected purchase expectations over the next 5 years. This independent survey approach not only validates the total (modeled and projected) market levels, but also establishes a cross-check on internal market segmentation dynamics (i.e., trends toward larger aircraft, emergence of new buyer segments, etc). This survey is conducted in all world regions; the results are tabulated and extrapolated by world region. Hypothetical aircraft can also be tested with end users to corroborate the internal competitive or value assessments.

Following the surveys, a second round of program forecasting workshops are convened for each market area. These workshops utilize the new program start and timing data previously gathered as well as the latest production plan input from key original equipment manfacturer (OEM) customers supplied by the company's global network of field sales representatives. The group develops a consensus as to market "winners" and "losers" using aircraft/product value versus market pricing analysis, as well as insight into political or OEM specific strengths. It fits individual program details into the overall top line demand projections. Another way of describing the process is that it resembles a simulated competition on a program-by-program basis for the available demand.

The resulting new business aircraft forecasts are aggregated with current active fleets to construct projected fleets, segmented by Honeywell systems content (for example, turbofan engines, auxiliary power units, avionics, etc.). Combined with the economic scenarios described earlier, usage estimates are generated (flying hour rates, cycles, etc.) which define overall aftermarket potential for subsystems by market areas. Detailed historical replacement rate and product utilization data is maintained as a matter of course on all Honeywell-powered aircraft and is employed in the buildup of the projections.

The final step in the internal process is a set of detailed management and financial reviews. In these, any internal issues such as inventory investment, research and development, budget levels, or procurement/lead time constraints that might impact the business forecast are addressed. The forecasts developed for each aircraft market segment (business aircraft, commercial transports, regional/commuter aircraft, military aviation, etc.) are subsequently published internally and are used to link internal business planning in a consistent fashion across Honeywell aerospace enterprises.

Observations and Comments

The business aviation forecasting process combining empirical models with operator surveys and OEM inputs has evolved at Honeywell over the past 20 years. We have found its overall accuracy to be excellent. It has been particularly effective in calling market turning points well in advance and predicting success of new business jet models.

BUSINESS JET DELIVERY AND FLEET FORECASTS: UNIT-BASED ANALYSIS

Gerald W. Bernstein
Stanford Transportation Group

Purpose

The Stanford Transportation Group and predecessor companies have been forecasting world business jet demand since the mid-1980s. The methodology that has evolved is based on findings from surveys and analysis of drivers and trends in this market, as well as scenario development workshops undertaken with several client companies in this industry. The results have been used to identify airframe and major system business opportunities with 10- and 20-year time horizons.

Methodology

Our approach to forecasting business jet deliveries proceeds in five logical steps. In effect, we forecast the world fleet and derive annual sales from changes in the fleet (new additions plus replacement for aircraft that are retired or scrapped). The steps are described individually as follows.

In the first step, historic fleet and delivery information is compiled by size category and by world region. Several of our data files go back to the first dedicated business jet deliveries in the early 1960s. Sales data can be grouped into any number of categories. However we find the larger the number of categories (and the fewer the number of models in each category) the greater the year-to-year variability in the data due to the fluctuations in volume that occur when new models are introduced. Geographic data can be aggregated into as few as two world regions (North America and rest-of-the-world) or into as many as seven regions (Africa, Asia, Middle East, Latin America, Europe, North America, and Oceania). We typically use the latter.

The trend in fleet acquisition by each world region is reviewed from the perspective of the three major drivers of business aviation: corporate (or government) willingness and ability to purchase, government influence on business aviation in general, and changes in competitive alternatives. For example, in the United States, corporate profitability (undistributed corporate profits) is a (perhaps *the*) major driver of business aircraft sales. Growth in certain economic sectors tends to favor corporate aircraft acquisition more than others. In world regions where some of this data is not available, we substitute an assessment of overall economic trends and forecasts when preparing our outlook. Government influence shows itself through such actions as tax policies (investment tax credits), spending on airport and airway expansion, and (adversely) access restrictions. Competitive alternatives can include the quality of airline service, new model introductions, and means of operating business aircraft at reduced costs (such as fractional ownership programs). Each of these three drivers is assessed within each world region for the historic period and as they are expected to develop in the future. From these assessments, a forecast is made of the fleet expected in each region. At the completion of this second step, the world fleet forecast is computed by summing the regional fleet forecasts.

The third step in our process is to compute the number of aircraft expected to be retired from the world fleet through attrition or by accident. The formula for this is based on an analysis of fleet of a variety of out-of-production business aircraft. With minor variations reflecting popularity, a given year's production of business jets can be seen to be fully retired from the fleet in about 40 years, with about 50% of the given year's production out-of-service in about 33 years. This observation enables us to compute retirement rates for each year. We can then calculate the number of retirements from the fleet (by size category) in each year of the forecast period.

Combining the new growth calculation and the estimate of retirements enables us to compute a baseline delivery forecast as our fourth step. This baseline then needs to be modified to reflect economic cycles, known or expected new model introductions, production constraints, and other year-to-year influences on demand. The resultant adjusted delivery forecast should total the same number of units as the baseline over the forecast period, although it will vary by year.

In the fifth step, we allocate the delivery estimate of new deliveries to each world region by size category. This allocation takes into account historic trends in new aircraft deliveries by region, as well as other regional-specific factors identified during the second step (analysis of fleet demand). Since only the trend in new aircraft deliveries are assessed, used transactions need not be taken into account. The delivery forecast can then be aggregated by size category and by region.

Information on used (pre-owned) aircraft transactions can be obtained from a number of commercial vendors, from U.S. government trade statistics, or can be estimated from changes in world fleet composition by region by model. Relationships between used and new sales can be identified by region, and used sales forecasts.

Observations

The approach used has anticipated growth in business aircraft deliveries with reasonable accuracy for many years. At times of change, however, such as during the dramatic rise in fractional ownership programs, it has required careful attention by the analyst to identify the new sources of demand, their magnitude, and to add the incremental new demand to the underlying demand for these aircraft. One of the major strengths of this approach is that the assumptions as to future conditions are large in number and small in magnitude; thus the overall results are not highly sensitive to a single (key) assumption that might not prove correct as events unfold.

CIVIL ROTORCRAFT DELIVERY AND FLEET FORECASTS

Dave Lawrence
Aviation Market Research, LLC

Purpose

Aviation Market Research (AMR) maintains a historical and current data base of civil rotorcraft deliveries by market segment, estimates of worldwide civil rotorcraft fleets by geographical region and end use, and characteristics of helicopter models, based on data available from field research, the FAA, trade publications, and commercial sources. These data along with economic projections from generally acknowledged sources are used to drive models of market share, delivery projections, and competitive scenario analyses, which form the bases of a variety of studies performed to specific client requirements.

Delivery forecasts as such are not generally released publicly except as an anonymous component of the annual forecast of the TRB's Rotorcraft Subcommittee.

Methodology and Approach

The basis of AMR's delivery forecasts is a top-down parametric demand analysis (with pragmatic adjustments in recognition of current market intelligence) and a bottom-up corroboration that projects the strength and supply of each aircraft model in future markets.

The first step in the demand analysis is segmentation of rotorcraft markets by aircraft size and the end uses to which they are put. Weight segments are those used by TRB: piston-powered (all weights), single turbine-powered [under 6,000 lbs maximum gross weight (MGW)], light twin turbines (under 6,000 lbs), intermediate turbines (6,000-15,000 lbs), and large turbines (over 15,000 lbs). The segment breaks are less significant now than previously in terms of regulatory considerations, but they are still most generally used in studies of civil rotorcraft.

AMR's methodology recognizes three distinctive market segments for rotorcraft, each with its own demand parameters; these include corporate/personal uses, revenue producing operations, and heavy lift work. Each of these segments has shown clearly identifiable equipment preferences, reflecting unique groupings of acquisition parameters. There is very little crossover in equipment preference between segments.

The lower end of the corporate/personal market, which favors piston-powered and light, single turbine-powered aircraft, is significantly price-elastic and is not particularly sensitive to such performance benefits as high speed or long-range capabilities. The higher end of this segment is relatively inelastic and requires the speed and range available in twin turbines up to about 15,000 lbs MGW. But both of these subsegments are sensitive to economic factors; turning points in personal/corporate rotorcraft deliveries tend to follow turning points in GDP by about 1 year. The growth projections in these classes are thus adjusted in accordance with independent forecasts of general economic conditions.

End users who conduct revenue-producing operations are less sensitive to acquisition costs than to operating costs, as this strongly affects their competitiveness. Within the for-hire business, air taxi markets attract intermediate and large rotorcraft and work in a financial, operational, and regulatory environment similar to that of regional airlines. While the costs and capabilities of specific models determine market shares within these segments, overall demand for helicopter services is derived from the needs of ultimate end users. Thus, for example, the demand of offshore service operators for new aircraft cannot be assessed without first projecting the demand of oil companies for offshore transportation, which in turn is based on outside projections of fossil fuel demand and prices, and off-shore exploration and production activity, as well as the macroeconomy. Other for-hire markets—airmedical and charter for example—use lighter helicopters, but their demand for aircraft is similarly derived from the needs of their clientele. The forecasts are further massaged empirically to reflect projected trends in the operation of these businesses that might affect the transportation function (such as the policy of insurance companies to support medivac flights).

Heavy lift work—including logging, firefighting, agriculture, and construction—accounts for the largest share of the worldwide helicopter fleet, but these operators generally utilize pre-owned aircraft and are not significant in projections of new aircraft deliveries.

Thus, the approach to an industrywide forecast begins with projections of the overall economy and of growth in each of the industries that utilize helicopters. The top-down forecast is essentially an extrapolation of the previous 5 years' growth, segmented by end use, and adjusted upwards or downwards on the basis of economic and user-industry forecasts.

The bottom-up corroboration is an estimate of the sales of each extant or anticipated helicopter model, based on its cost, capabilities, suitability to its intended missions and production constraints (if any). These data are developed by field research and parametric market-share analysis. The final forecast, the sum of the segment forecasts, is a result of iteration between the top-down and bottom-up projections until the two are mutually consistent.

Observations and Comments

The sector approach to forecasting has been shown to be a more intuitive and logical approach than broader econometric techniques. Attempts to develop econometric-based forecasts of rotorcraft markets have typically resulted in poor correlation.

AVIATION ASSET VALUATION

Bryson P. Monteleone
Morten Beyer & Agnew

Purpose

The role of the appraisal has now more than ever taken a front seat in asset value determination, financial analysis, and forecasting residual value. With risk and exposure limits at the forefront of any financial analysis, the valuation of any asset, especially in an investment environment, becomes the benchmark for any investment strategy.

Methodology and Approach

Not until the early 1990s did Morten Beyer & Agnew (MBA) start to take a different approach with aircraft values. With the invention of base value (defined as the intrinsic baseline value of an asset from original manufacture to its retirement for scrap) came a need for a substantial methodology to address the fluctuation of values in a cyclical market. Aircraft values, more than others, are easily affected by the turbulent times in any given region or external factor, and can be very market-specific. As was seen in the late 1990s with the Asian recession, large widebody aircraft saw the biggest drop in market value, whereas the market for narrowbody aircraft remained relatively intact. Taking this into consideration, it then becomes important to look at aircraft values on both micro and macro levels. What once was a simple benchmark of historical transactions and incorporation of standard data points, has now become a multilevel approach including regression analysis supplemented by consideration of several variables to determine the underlying value of an aircraft.

Micro Approach

MBA has continuously evaluated its methodology to capture as many data points as possible. As the need for more exact information is required it has become incumbent upon us to provide a multitude of scenarios for a varying degree of situations. MBA has identified the following factors as those most important when determining both the base and market value of an aircraft.

- Historical value. MBA analyzes historical value trends to better interpret and forecast the future values of aircraft and related aircraft types. Historical values are subjected to indexing and regression analysis to identify long term value trending.
- Current transactions. Current transactions within the second tier markets allow for the best data points. Current transactions provide the backbone to the formulation of market values and are crucial indices to base value trends.
- Upgrade of model/type. In some cases aircraft have been introduced only to be superceded by an upgraded model, perhaps with an increased gross weight or newer powerplant. In many cases these newer upgraded aircraft are more popular and render earlier models obsolete. In these cases MBA takes this factor under advisement when determining current and residual values.
- Aircraft model/type segmented by gross weight/capacity. Similar to the aforementioned category, this factor takes into consideration aircraft types that are popular overall but due to increased/decreased gross weight/capacity have created market segmentations that sometimes result in value deterioration.
- Aircraft economic life. Although many aircraft lives are similar, MBA finds it important to review each individual aircraft's life and its revenue earning potential in secondary passenger and cargo markets, as all aircraft are not built alike.
- Tertiary economic value (TEV). MBA believes that aircraft, as they age, will eventually reach a value that is based solely on its use in revenue service. Each aircraft will reach a point as it nears the end of its economic life that it is only sustained by its current use, and the value of the asset itself is only worth its scrap value, or close to it—known as TEV.
- Imposed regulations. Regulations imposed by a government or international aviation body that restrict registration or certification can be detrimental to the life or operation of an aircraft. These regulations include age, environmental, and noise rules, as well as regulations that restrict registration of specific aircraft.
- "Orphan" syndrome. This effect can occur when a manufacturer stops production of an aircraft model, or when the manufacturer ceases operation altogether. Significant to the magnitude of the effect is the after-production support provided, as well as OEM supplies. Airworthiness directives (ADs). Significant ADs which MBA considers in base value changes are ones that can have long-term increased cost added to the operations of the

aircraft or one that changes or restricts operational use of procedures which materially affects the use or competitive position of the aircraft. Examples are the CPCP AD for certain aircraft, the weight restriction of cargo floors, and the pending fuel tank restrictions.

- Ubiquity. The geographical diversity and breadth of operator base of an aircraft plays a major role in the liquidity of the asset in the marketplace. MBA takes this ubiquity factor into consideration when determining the current market and future base value of an aircraft.
- MBA economic model. The MBA economic model is a proprietary from the ground-up analysis that evaluates each of the cost drivers for a type of aircraft under a common operational condition to derive the most basic of industry cost indices—the cost per ASM. MBA uses this widely accepted industry value to compare it to other like aircraft to evaluate economic performance, or in some cases underperformance.

Macro Approach

However, when it comes to the analysis of base values, these factors are only the beginning. As base values represent an aircraft in a market of perfect equilibrium, there are some elements that can detract from the future viability of the aircraft when it comes to residual values. In that case, it is important to evaluate an aircraft's potential benchmarked against similar aircraft types. MBA has found that similarities emerge among aircraft values and types when aircraft models are tranched together and statistically analyzed on assumptions with regards to technology, historical values, and length and currency of production. This data allows for a better understanding of an aircraft's potential competitive position, especially when forecasting residual values.

In the big picture, when further looking at the life of an aircraft and its residual value, values can be enhanced when taking into consideration: the contribution the aircraft type makes to fleets worldwide, the anticipated production life, and the potential for future applications (such as cargo). If an aircraft cannot be converted to cargo either because of design or financial constraints, the ability for that aircraft to retain any strong residual value in the future is severely impaired outside what would be considered its anticipated life as a passenger aircraft.

Comments/Observations

While base values and market values both serve different purposes, it is important to view them with some degree of symmetry. MBA believes that the base value is the underlying value of which the market value is derived; therefore, it is only at crucial junctures during the economic life of an aircraft at which the value should be modified. It is expected that the market value of an aircraft will ebb and flow above and below the base value. However, when the base value is altered, it should only be modified when extreme market conditions are observed over consecutive periods of time and the current base value cannot be supported.

Author Contact Information

Michael Armstrong
Southern California Council of Governments
818 West Seventh St.
12th Floor
Los Angeles, Calif. 90017-3435
213-236-1914
armstron@scag.ca.gov

David Ballard
GRA, Inc.
115 West Ave., Suite 201
Jenkintown, Pa. 19046
215-884-7500
bdballard@gra-inc.com

Gerald W. Bernstein
Stanford Transportation Group
236 West Portal Ave., #359
San Francisco, Calif. 94127
415-242-9296
GBernstein@STG-LLC.com
http://www.STG-LLC.com

Paul Bingham
Global Trade & Transportation
1200 G St., NW, Suite 1000
Washington, D.C. 20005-3814
202-383-2000
paul.bingham@ DRI-WEFA.com

Bengt Bostrom
6924 Tyndale St.
McLean, Va. 22101
Phone/fax: 703-356-8503
Bengtbostrom@Compuserve.com

Barry Clark
Travel Insights, Inc.
230 Oak Hill Dr.
Roanoke, Tex. 76262
817-491-1999
hreclark@ix.netcom.com

Mark Diamond
SH&E
1 Main St.
Cambridge, Mass. 02142
617-225-2800
mdiamond@sh-e.com
www.sh-e.com

Edmund S. Greenslet
ESG Aviation Services
The Airline Monitor
P.O. Box 1781
Point Vedra Beach, Fla. 32004
904-249-4215
Fax: 904-249-5893

Catherine Harmel-Tourneur
International Air Transport Association
800 Place Victoria, P.O. Box 113
Montreal, Quebec
Canada H4Z 1M1
514-874-1779 ext. 3377
HarmelC@iata.org

Patrick Kennon
HNTB Corporation
99 Canal Center Plaza
Alexandria, Va. 22042
703-684-2700

Dave Lawrence
Aviation Market Research, LLC
P.O. Box 1439
Fairfield, Conn. 06432-6439
203-259-9500
davelawrence@att.net

Edward MacNeal
Edward MacNeal Associates
P.O. Box 249
Wayne, Pa. 19087
610-687-0442
macneal@erols.com
http://edwardmacneal.com/Air Service/AS-consulting.html

Bryson P. Monteleone
Morten Beyer & Agnew
2107 Wilson Blvd., Suite 750
Arlington, Va. 22201
703-276-3200; Fax 703-276-3201
Bmontele@mba-consulting.com
www.mba-consulting.com

Jim Potts
Commercial Aircraft Services
Honeywell
Torrance, Calif.
310-512-4192

Jojo Quayson
Port Authority of New York & New Jersey
One Madison Ave.
Room 144, 7th Floor
New York, N.Y. 10010
212-435-3738
JQuayson@panynj.gov

Ameet Sareen
Bombardier Aerospace
123 Garratt Blvd., N16-10
Downsview, Ontario
Canada M3K 1Y5
416-375-3946
Fax: 416-375-4125
asareen@dehavilland.ca

Charlie Saunders
Port Authority of New York & New Jersey
One Madison Ave.
Room 144, 7th Floor
New York, N.Y. 10010
212-435-3739
CSaunders@panynj.gov

William Spitz
GRA, Inc.
115 West Ave., Suite 201
Jenkintown, Pa. 19046
215-884-7500; Fax: 215-884-1385
bills@gra-inc.com

Claire Starry
TDS Economics
1259 El Camino Real, Suite 196
Menlo Park, Calif. 94025
650-364-5298

Robert West
Global Trade & Transportation
24 Hartwell Ave.
Lexington, Mass. 02421
781-860-6519
robert.west@DRI-WEFA.com

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

National Academy of Sciences
National Academy of Engineering
Institute of Medicine
National Research Council

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. William A. Wulf are chairman and vice chairman, respectively, of the National Research Council.

The **Transportation Research Board** is a division of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results. The Board's varied activities annually engage more than 4,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.