Abridgment

Cost-Effectiveness Models for Determining Priorities in State Aviation Systems

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Two major questions must be answered in developing a state aviation system plan: How should available funds be apportioned between new airports and improvement projects at existing airports? How can funds be utilized most efficiently within these two categories? To date, these questions have been answered on relatively subjective bases. The models we present provide a quantitative guide to the decision maker for the most effective use of funds within the two categories.

The two models discussed are the airport entry model and the improvement project model. The airport entry model analyzes candidate airports, both new and existing, that are considered for inclusion within a state aviation system. It provides a quantitative guide on which new airports should be constructed and which existing airports should be considered for inclusion in the airport system. The improvement project model performs a similar analysis of proposed improvement projects and provides a quantitative guide of the relative desirability of each improvement project. The two models are not designed to determine whether an airport or an improvement project is desirable or undesirable, but merely to quantitatively compare candidates with other airports or improvement projects.

EVALUATION FRAMEWORK

A consistent methodology should be used for determining whether an airport should be added to or deleted from a state aviation system plan or whether an improvement should be made on an existing system airport. Common evaluation criteria should be employed in specific decision models; the two sets of criteria (one for airports and one for improvement projects) should be derived consistently with one another, and the two models should have similar form. The criteria are developed with an emphasis on safety, economic justification, environmental impacts, and an equitable distribution of facilities to all segments of the state.

Although the two models manipulate similar criteria, the resulting index numbers they produce cannot be compared with one another. The entry model ranks airports with respect to their effects on the airport system and in relation to the community or communities they serve. In contrast, the improvement evaluation model measures the incremental benefit that an improvement project will have on a single airport.

EVALUATION CRITERIA

The evaluation criteria for both models are grouped by (a) safety, (b) efficiency, (c) environment, (d) economic development, and (e) cost. These specific criteria, although not necessarily the same for the two separate evaluations, utilize consistent logic and mathematical quantities for both evaluations.

Safety Criteria

Safety criteria are critical elements of the evaluation process because the aviation community emphasizes safety. Safety improvement criteria are divided into two categories: airport safety and aviation safety.

Airport safety criteria are included in both the entry and the improvement evaluations. The relative impact that each of 15 different types of improvement projects would have on an airport was assessed. Weightings quantify the safety impact of each project. The weightings were derived on the basis of combined judgments of airport planners and pilots and reflect the severity of an incident together with its probability of occurrence. Coupled with the safety weightings are safety ratings. The ratings emphasize projects that rectify serious safety defects or deemphasize projects for less serious safety defects.

In the improvement evaluation, the weighting of the project signifies its inherent desirability as a safety improvement. The greater the project's innate impact on a facility's safety is, the higher its weighting will be.

The safety rating emphasizes the magnitude of the benefits derived from a safety-related project. While the safety weighting indicates the inherent benefit of a certain type of project, the safety rating further defines the specific project and denotes the extent that project deviates from the norm.

An airport without safety problems has an airport safety factor of 1.0; otherwise, it receives a factor of 1.0 minus the effective safety factor of the improvement project that would correct the condition.

Establishing quantitative criteria for deciding whether an emergency landing strip is justified is difficult. Such decisions must be influenced by local pilots, who are familiar with weather conditions and topographical features in the state. When the need for an emergency landing strip is established, that should be sufficient to justify the construction and adequate maintenance of the strip. The emergency need should not compete with other airports on a quantitative rating basis. For this reason, decisions on establishing such airports should be made apart from the priority ranking of airport entry.

Efficiency Criteria

Efficiency criteria measure the extent to which a proposed change to a facility will increase or decrease its transportation efficiency. Three criteria are included in this set: (a) airport access savings, (b) operational efficiency, and (c) remote location.

The major quantifiable impact on efficiency to consider in adding an airport into a state aviation system is the effect of the addition on total user costs for airport ground access. A second factor, which actually measures system equity more than system efficiency, is included at this point in the model development as a matter of convenience. This is the remote location priority rating. This rating emphasizes airports serving remote communities to account for their greater reliance on air transportation to provide basic and emergency needs.

For airport improvement projects, two criteria relate to efficiency. The first is operational efficiency, indicating the extent that an improvement project will improve the capacity or capability of an airport. The second criterion, remote location priority rating, emphasizes improvements at remote locations to partially compensate for the low usage these locations generally exhibit.

By assuming that aircraft access trips emanate from the address of aircraft registration and terminate at the nearest airport, we can estimate airport access trip distances. Using these distances, together with access costs per kilometer by automobile and estimates of aircraft usage, we can estimate the total access costs to an airport. When any proposed change is made to the system, revised access costs are calculated. The change in access costs can be determined by comparing the revised costs with the original costs. This method of evaluation provides only an approximation of access costs, but does reflect the relative effects of airport additions and deletions and is useful as a planning tool for airports in most parts of the state. Major discrepancies arise, however, if the method is applied in a large metropolitan area. In such a locale, where several airports are located rather close to one another, users do not necessarily base their aircraft at the nearest airport.

The operational efficiency factors, used in the improvement evaluation only, evaluate projects on their ability to increase an airport's capacity or capability through physical improvement of the facility. These factors are similar to the safety improvement factors and include an efficiency weighting and an efficiency rating.

We defined 12 types of projects that improve operational efficiency of an airport and associated specific weightings with each. As with the airport safety weightings, most projects that increase airport effectiveness can be characterized by one of the 12 project types.

The efficiency rating is utilized in a manner similar to that of the safety rating; it emphasizes projects that have a strong effect on the airport's efficiency and de-emphasizes projects that have very little effect. The rating value should be 1.0, except in cases where a different value is clearly justified. The product of the efficiency rating and the efficiency weighting is the efficiency factor.

The remote location priority rating emphasizes locations that are distant from major and regional centers of commercial trade. At these locations, where the availability of many specialty items and services is low, the user may not merely desire adequate airport facilities, but may require them for reasonable access to trade centers. Since remote locations rely more heavily on air transportation on a per capita basis than do close-in urban areas and since the volume of traffic that a remote location is likely to generate may not be enough to justify economically an airport or an improvement project when compared to higher density areas, an additional factor in the entry and improvement project evaluations is necessary to provide the needed equity emphasis.

Environmental Criteria

The third criterion used in both evaluations is the environmental rating. This rating, in addition to the economic development rating, reflects airport impacts on the community as opposed to impacts on the user.

A rating of 1.0 is given to a proposed new airport if an opportunity area can be found in the region in which the airport is proposed. The opportunity area plotted on a map represents an area where no (or minimal) adverse environmental effects, no conflicts with current or projected future land use, and no potentially serious construction, clearance, or airport approach or departure problems are known.

When an existing airport is tested for entry into the system, an environmental rating of 1.0 is given when the airport is environmentally accepted in a community. Otherwise, a rating of less than 1.0, subjectively determined, should be assigned.

For airport improvement projects, known environmental considerations that would result in detrimental effects if the proposed project were completed should be described in as much detail as possible. However, no reduced environmental rating is given. The rationale for this procedure is that, when federal agencies or the courts make the final judgment, projects that have adverse environmental effects are either approved or disapproved.

Economic Development Criteria

The fourth criterion, economic development, is a tool for the planner to shape the growth of the state. If accelerated growth is desired in a specific area, providing complete and modern transportation facilities will tend to further the goal. Likewise, if a reduction in the rate of growth in another area is considered beneficial, reduced emphasis on transportation improvements would further this objective. The economic development rating allows the planner to increase or decrease the desirability of an airport or improvement project. Assigning a rating of greater than 1.0 boosts the project's desirability, while a rating of less than 1.0 would tend to suppress a project. As with environmental ratings, care must be taken in applying these ratings for they are prominent in the decision process and, therefore, must be used consistently on all projects.

Cost Criteria

Cost criteria provide the means for reflecting the magnitude of the project in the evaluation process. In the airport entry evaluation process, the cost is the annual capital cost, measured in one of two ways: For a new airport, it is the capital cost of building the airport; for an existing airport, it is the salvage value (taken as the resale price of the land) of the existing facility. In the improvement project evaluation process, the cost is the annual capital cost of the project.

THE MODELS

The entry and improvement models take the basic form of effectiveness cost models. They calculate, for each proposed airport entry or improvement project, an entry or improvement index for ranking the airports or projects within each evaluation process. The models combine the criteria previously set forth with all factors except the cost criteria in the numerator and cost criteria in the denominator of the model.

Space does not permit detailed discussion of the models, which are somewhat complex in their formulation. Separate formulas that use the variables described above are derived for airport entry and for airport improvement projects.

The entry model is used to test three cases:

1. Entry of existing airports,
2. Entry of new airports, and

3. Entry of a new airport to replace service provided by an existing airport.

Detailed procedures were formulated for developing the index numbers and for comparing the index numbers of the three cases above.

The resulting entry indexes range from large positive numbers to negative numbers. In general, the larger the positive index is, the more desirable the airport is. An airport with a negative index is undesirable. Exceptions to these rules exist, however. For proper interpretation of test results, these indexes should be fully understood.

The results of the improvement model are improvement indexes ranging from zero to large positive numbers. An absolute significance is not attached to these indexes, but rather a relative significance relates projects to each other. The decision maker makes the final decision of which projects are feasible and which are not.

MODEL RESULTS AND DECISION MAKING

The models result in rankings of airports and improvement projects that reflect the relative desirability to the user and the community of the airports or projects. These rankings, however, must be used in a subjective manner; the final decision of whether an airport should enter the system or a project should be undertaken rests with the decision maker. The rating indexes do not determine which projects are feasible or which airports should enter the system, but provide an indication to the decision maker of how the entities being analyzed relate to one another. These ratings must be viewed in conjunction with the budgets for improvement projects and new airports to arrive at a final plan.

These models represent an incremental, yet substantial, improvement over previous subjective methods of determining aviation system plans. In our models, many factors normally considered subjectively have been quantified and incorporated into theoretically sound and workable cost-effectiveness formulations.

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Dynamic Modeling of Airport Activity

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This paper discusses problems encountered in modeling airport activity and particularly emphasizes forward planning and policy making. It is concerned with the relations among airlines, airports, and users (passengers and freight). Three simple models of activity are indicated, dealing successively with capacity, investment, and pricing. A basic need is creating a workable typology of airports in which attributes other than size may be considered. A second requirement is considering the importance of fluctuations in airport output. We used multivariate analysis of data for the leading British airports in the period 1968 to 1972 to develop a successful typology, which is essentially applicable to other national airport systems. It stresses the differences between scheduled and nonscheduled activity. Correlations among definitive output variables are used as input to principal components and factor analysis to derive the typology. Output is then disaggregated by the use of a corrected moving mean to give seasonal and trend components. These are used for analyzing growth and growth variability and for studying the stability over time of seasonal variations. In addition, we note positive links between nonscheduled activity and output variability. The implications for planning are demonstrated, in particular the close association among nonscheduled activity, variability, and predictability. The variable associations also indicate possible investment scenarios for the airport manager and the airport modeler.

This paper considers a number of problems associated with building a fundamental dynamic system model of airport activity. At first sight, such activities as movements, passenger throughput, and financial turnover might appear to vary solely as a function of airport size. We examine this possibility, which would permit size variables to provide the basic structure of a simple system model, and also examine whether there is a valid alternative methodology for developing an activity-based system model. Moreover, we examine the amount of variability in the activity measures chosen for study, showing that the amounts are of significance for the forward planning of activity levels by airport management.

Although airports vary considerably in their size and scale of operation, they all fill the same operational function—providing a landing place for aircraft where users (both passenger and freight) can interchange to, from, and within the air mode. The basis of building an airport model is really one of synthesizing a typical airport, which is feasible only if airports are found to lie along some common operational continuum. An operational definition would constrain the analyst to consider airport output, making this appear as the continuum of greatest relevance. The question is, Are airports operationally similar, varying only in size? Were this so, other variations in the system might be expected to be of only minor importance. In fact, we discovered that the idea of the continuum is not strictly valid, that airports do appear to have structural differences in activity patterns based on function.

BASIC FORMS OF A DYNAMIC AIRPORT MODEL

In a dynamic model, output should be distinguished from demand. Demand is controlled not only by the internal variables of transport supply, but also by sociopolitical factors that act externally to the airport system. Output, however, can be considered to be determined internally at the interface between flight demand and flight provision. Forecasts of future de-