Airline Equipment Planning

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Planning in the airline industry now faces one of its severest challenges in terms of economic, technical, and financial considerations. This paper discusses the variety of planning problems now facing the airlines and deals with various new techniques and developments being designed to cope with them more effectively. The three basic types of aircraft selection problems faced by airline planners are defined and specific aircraft procurement studies within each category are described. In the course of this discussion the application of computer technology to schedule simulation, aircraft routing, and fleet planning is explored. Techniques employed in recent equipment planning analyses relative to the 747 and the SST are outlined. Attention is focused on the need for airlines to play a more significant role in aircraft development, particularly in terms of mission designation and sizing and the current sponsorship by American of air bus development is highlighted. The paper concludes with an item by item discussion of the nine basic equipment selection factors given most weight by airline planners. Each of these nine factors is discussed and attention is focused on areas of difference between manufacturers and airlines.

I. Introduction

EQUIPMENT planning and equipment selection are the most fundamental aspects of planning in the airline industry. Many examples exist of the disastrous results of incorrect equipment choices on the part of an airline.

One bad equipment choice can affect the financial results and financing capability of an airline for a period of five years or more and can cause losses in market share and market identity which are difficult to recoup at a later time.

At no time in airline history has the breadth and difficulty of equipment choice been greater than today. Conversely, at no time has the opportunity for major technological and economic strides been more striking. Since scheduled airline passenger service began, the airline industry has experienced a new technological cycle on the average of about every seven years. Although these short equipment cycles create tremendous financial and planning pressures on the airline industry, they are beneficial. They have guaranteed continued service improvements to the flying public, and they have provided the airlines with the ability to absorb ever-increasing wage and material costs while maintaining or reducing fares.

Today, we can look to the future and see at least four new aircraft types, constituting two separate development cycles, on the immediate horizon. The first of these cycles will result from the application of high by-pass engine technology to aircraft development in the form of the 747 and the air bus. Supersonic aircraft will constitute the second cycle. American's first supersonic Concorde will be delivered less than two years after we receive our first 747. The closeness of the two cycles, more than ever before, has created a recognition of the vital need for improved and broadened airline planning, planning which utilizes the most effective management and technical tools and which has full corporate support.

Selecting and planning the scheduling, maintenance, ground equipment, and facility improvements and modifications necessary to support and optimize use of these equipment types is a heavy planning burden. It is the recognition of this burden which has caused the increased emphasis now being placed by airlines on the need for improved planning.

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At American the role of the planning department is to focus corporate attention on basic policy questions and decision points and to provide the ground rules, the stimulation and the coordination for the various departmental planning efforts carried out in necessary support of the over-all corporate effort.

II. New Problems Facing Airline Planners

Many of today's planning problems are new, at least in terms of their dimensions. Forecasting traffic growth against a background of lengthening delivery lead times, providing timely, adequate and efficient ground facilities and equipment, and planning orderly expenditures of vast sums of capital investment are perhaps the most difficult aspects of today's planning function.

Growth forecasting may be the biggest problem now faced by airline planners. It has never been easy to forecast traffic growth with accuracy. Nonetheless, the penalties for being wrong in the days when we were working on a small base and debating growth rates in the 6–12% range were far less than today. This year the domestic trunklines will fly somewhat over 70 billion passenger miles. If we project traffic growth at 12% for the next five years, the domestic trunklines will be required to provide an additional 100 billion seat miles to accommodate 1972 volumes. If, on the other hand, growth occurs at a 16% rate during this five year period, the industry will need to add almost 150 billion seat miles by 1972.

Expressed in terms of units of aircraft and dollars of investment, these figures become even more significant. If a 12% growth rate proves right, the additional seat miles could be provided, for example, by purchase of 165-odd 747's at a cost of about three and a half billion dollars. If, on the other hand, the 16% figure, proves correct, it would require 250 747's and an investment of five and a quarter billion dollars to provide the increased capacity. A 4% higher growth rate during this period, therefore, would result in a requirement for 85 more units of the largest aircraft available and an additional investment of one and three quarter billion dollars.

Forecasting cargo growth is even more difficult. In recent years the large domestic airlines have experienced successive freight growth rates of 27, 25, and 18%. Continuation of these kinds of rates would result in about a nine-fold increase in airfreight in ten years. The small base from which we are starting and the previous erratic behavior of air cargo growth make such projections extremely hazardous, however.

The forecasting problem is further compounded by lengthening in delivery lead times. In the 1950's delivery lead times normally averaged a year or less and seldom exceeded a year and a half. Today, orders for off-the-shelf aircraft must be placed 18 months to two years prior to delivery. Because of the increasing technical and financial requirements inherent in developing new aircraft for service in the 1970's, the lead time for these new aircraft types is now approaching four to five years. The first order for the Boeing 747 was placed in the first half of 1966; first delivery will occur in late 1969. The earliest possible delivery of an air bus is now estimated to be 1971–1972. And the U. S. supersonic transport now under development will not be in operation until 1974 or 1975.

A second area where airline planning problems are new in terms of dimension is that of financing. It is only within the last five years that the airlines have emerged as one of the nation's major capital spending industries. As recently as 1963, airline expenditures for new plant and equipment totaled only $370 million, or less than 1% of all such spending by industry. In 1967 airline capital spending is now estimated to exceed $1.7 billion, or 2.7% of the national total. Table 1 summarizes capital spending by transportation industries since 1955 and highlights the emergence of the airlines as the dominant component during 1967.

As indicated previously, the airlines are now approaching the end of the first jet equipment cycle and are looking immediately ahead to two new equipment cycles that will follow each other in rapid succession. Spending for these new aircraft by the airlines will inevitably accelerate the kind of capital spending growth illustrated in Table 1. It is one of the planner's principal responsibilities to be constantly aware of equipment life cycles, technological developments that can affect such cycles, and financial requirements in relation to available financial resources.

The piston era was financed largely through internally generated funds and equity capital. The jet era has been financed in large part through borrowed capital. The financing of the jumbo jet and SST era will require the tapping as of yet unutilized financial sources. Our success in gaining access to such sources will depend upon the success of airlines and airline planners in optimizing near-term profits and long-term equipment selection.

A third area where planning problems and penalties also have increased in dimension is the provision and timing of the ground facilities and equipment necessary to support the operation of new equipment types. If we are to keep pace with the rapid growth in demand for air travel without overwhelming our airports, our terminals, and our available air space, we must look to the larger equipment types exemplified by the 747 and the air bus. Yet, the sheer size of this new generation of aircraft is itself a major ground handling problem. In our judgment the 747 will create such a peaking in passenger arrivals and departures that many of our present passenger terminals will be totally inadequate with respect to corridor widths, baggage handling areas, curb space, etc. 747 size aircraft will also force redesign of ground equipment and the development of new concepts in aircraft and passenger handling.

Table 1 Expenditures for new plant and equipment (billions of dollars)[a]

	Total all industry	Railroads	Airlines	Other[b] transportation	Total transport
1955	28.70	0.92	...	1.60	2.52
1956	35.08	1.23	...	1.71	2.94
1957	36.96	1.40	...	1.77	3.17
1958	30.53	0.75	...	1.50	2.25
1959	32.54	0.92	...	2.02	2.94
1960	35.68	1.03	...	1.94	2.97
1961	34.37	0.67	...	1.85	2.52
1962	37.31	0.85	...	2.07	2.92
1963	39.22	1.10	0.37	1.55	3.02
1964	44.90	1.41	0.91	1.47	3.79
1965	51.96	1.73	1.13	1.68	4.54
1966 P	60.63	1.98	1.63	1.80	5.41
1967 E[c]	64.04	1.60	1.74	N/A	N/A

[a] Source: SEC, Department of Commerce; and McGraw-Hill Inc., for airline data.
[b] Includes Airlines through 1962.
[c] McGraw-Hill estimate, April 1967.

New Planning Developments

Fortunately a number of new developments offer today's planner increased ability to cope with these complex problems. Probably the most important of these new techniques is the ability to apply computer technology to airline planning problems, particularly in the area of long range schedule planning and equipment selection. At American we have embarked upon a three-phase computer program that will better enable us to determine the number and type of aircraft we require in the future and to examine a wider range of growth assumptions and equipment alternatives. A number of manufacturers have been of assistance in this development. The three aspects of our program are 1) schedule simulation, 2) schedule optimization, and 3) dynamic fleet planning.

The schedule simulation program, our first major computer application, is now in day-to-day operation. This application provides us with greater planning capability in three areas; first, the program develops integrated traffic forecasts on a segment-by-segment basis; second, it flows the forecasted traffic over nonstop segments and allocates the traffic flows between available scheduled flights; and third, it identifies segments requiring additional schedules and will select equipment types and generate appropriate schedules to satisfy the needs.

A typical application of this program to a specific problem would be the forecasting of 1975 gate requirements by airports. Using this program we would approach such a problem as follows. We would input into the computer our 1975 traffic forecast for the domestic trunklines and forecasts of American's share of market by origin-destination city pairs. We would also input specific growth rates for segments important to American Airlines. The computer would utilize these inputs to generate 1975 American Airlines forecasts for all O & D city pairs served.

Our second step would be to input a base schedule into the computer. This base schedule would be today's schedule, or a schedule previously defined for some year in the future. The computer would flow the passenger volumes forecasted in step one over the nonstop segments and allocate them between available flights. Finally, the computer would recognize unaccommodated or poorly accommodated passenger flows and develop aircraft itineraries to service these flows in accordance with selected priorities. In this process the computer selects the most appropriate equipment types based on input economic and passenger preference criteria.

At each step the computer summarizes the total schedule pattern by fleet type, including plane miles, flight hours, ramp hours, load factors, and departures by station. Finally, the departures and arrivals at each station are arrayed by time of day and peak gate activity levels identified for all airports served by American.

The biggest job of an airline planner is the anticipation of future scheduling needs in order to plan aircraft procurement and provide the basis for facility planning. At American we do this job on an extremely detailed basis for the immediate five-year period and on a progressively less detailed basis extending 10, 15, and even 20 years into the future. This schedule simulation program, for the first time, permits us to do this without expending several man years of work. The program runs in about six minutes. Despite its tremendous usefulness this program has two inadequacies however; it does not actually optimize schedules from a profit point of view, nor does it do fleet planning on a dynamic basis.

Our second computer application, now in the process of development, is a schedule optimization model. Such a model will give us the ability to convert a given set of frequency assumptions into actual aircraft use in a matter of minutes to achieve maximum utilization, greater responsiveness to competitive changes, fuller utilization of ground facilities, and maximum profit. Although many competent technicians have tried without successs to develop such a model, we believe that the opportunity to build upon the existing schedule simulation program, plus new developments in computer storage capacity and programming knowledge, have improved the chances of success.

Phase three of our proposed computer application is the development of a fleet planning program capable of optimizing fleet mix over a period of years. Such a model can help the planner avoid the trap of purchasing aircraft to meet short-term needs, when such aircraft have limited economic lives. It can optimize fleet mix over a selected period of years to maximize long-term profits.

Because of the greater risks to which both the airlines and manufacturers are now subject and the enhanced ability of airlines through planning to clearly identify their needs, we strongly believe that the airlines must play a more dominant role in the development of future aircraft. The risks to manufacturers and airlines alike have now become so great that neither can afford mistakes. Therefore, the development of aircraft carefully tailored to airline mission requirements becomes critical. Only in this way can the airlines be fully protected against the competitively forced purchase of aircraft whose noise, configuration, or cost characteristics are less than desirable. Only in this way can manufacturers be protected from the sinking of large investments into the production of aircraft with limited sales due to inappropriate sizing, timing, or cost characteristics. American's current effort to foster the development of an air bus optimized around high by-pass engine technology is, we believe, illustrative of the most constructive process for the development of future aircraft and demonstrates the potential benefit to aircraft development from airline participation in the initial design stages.

About a year ago, American began to focus on three basic problems faced by the airlines: 1) increasingly limited terminal and gate facilities, 2) increasingly inadequate airport capacity, and 3) increasing air traffic congestion and delays.

Based on any reasonable traffic forecast, the frequencies necessary to serve the demand of the 1970's with today's aircraft would produce an intolerable intensification of these already serious problems. The 747 can alleviate only a part of these problems, since its added capacity will be economically adaptable only to longer haul, high-density routes. Such routes account for only a small fraction of total daily departures. The only possible solution therefore is the development of large capacity aircraft with good airport performance, capable of serving high-density medium and short-haul routes and lower-density, long-haul routes on an economic basis. Fortunately, new engine technology mates perfectly with this mission requirement.

Based on this thinking, American determined to promote the development of such an aircraft. Our Development Engineering Department, in conjunction with our Planning Department, drew up a set of mission and performance specifications which were distributed to all interested airframe and engine manufacturers. One of the most critical decisions faced in issuing these specifications was the question of sizing. The air bus was sized based on two considerations, 1) forecasted traffic volume in the peak period of 1975 and 2) over-all dimensional compatibility with available airport land and passenger facilities. Although demand projections have always been given heavy weight in aircraft sizing, facility considerations have frequently been overlooked. The proposed air bus size of about 225 mixed class passengers with a wing span of about 155 ft and an over-all length of about 170 ft not only fits well with projected 1975 traffic, but permits the handling of the maximum number of passengers per hour through airports and passenger terminals.

The interest generated in these specifications has been intense. Several manufacturers are now actively exploring design of aircraft and engines basically tailored to the original specification. We believe that airline-sponsored equipment development must become the dominant form in the future. The risks to manufacturers and airlines alike have now become so great that neither can afford mistakes. Additionally, it now appears that financial constraints on manufacturers will not permit the production of more than one, or at most two, aircraft for any given mission. Therefore, the development of aircraft carefully tailored to airline needs becomes critical. Only in this way can both the manufacturers and airlines be fully protected.

Aircraft Selection Factors

Airline planners base their aircraft selection analysis on nine principal factors. In recent discussions with both airframe and engine manufacturers it has become evident that the airlines evaluate a number of these factors differently than do the manufacturers.

The first of these factors is mission. Recognition of a specific mission requirement must be the starting point of aircraft design. Design of aircraft capable of performing more than one mission is, of course, frequently desirable. Nonetheless, any changes made to aircraft designs in order to broaden mission capability must be identified as such and the penalty to performance of the original mission be measured in terms of dollars and cents. In such measurement the manufacturer can incorporate any price effect he anticipates from greater sales due to broadened mission capability. Only then are the airlines able to determine whether the mission broadening is worthwhile. Too frequently in the past, aircraft have been overcompromised by the manufacturer in an attempt to expand sales by stretching range or capacity or achieving cargo capability. In many such instances the cost of the compromises was not identified, nor were the airlines consulted. Such aircraft may perform no mission adequately, leaving both the manufacturer and the purchasing airlines vulnerable to competition from less greedily designed aircraft.

The second selection factor is size. Aircraft must be sized in accordance with the principal design mission and the appropriate traffic forecasts for that mission. In the past, manufacturers have occasionally failed to consult airlines regarding these forecasts. Too often manufacturers have oversized in an attempt to minimize available seat mile costs as a sales tool. Airlines evaluate aircraft based on revenue passenger miles or revenue ton mile costs, not on available seat miles or available ton mile costs. Added capacity is valueless if it cannot be sold a reasonable percentage of the time and may be detrimental if it compromises performance excessively.

The third selection factor is passenger preference. In the past, passenger preference has been judged essentially on the basis of speed. We are now entering an era when new subsonic aircraft will be forced to compete with alternative subsonic equipment on the basis of passenger comfort. Varying comfort levels between supersonic and subsonic types will also be important in determining the surcharge that passengers may be willing to pay for supersonic speed. Too often in the past, manufacturers, in their attempt to optimize available seat mile costs, have designed aircraft around triple coach seating. There is little our customers dislike more than triple seats. We believe that manufacturers now possess the technology to size subsonic aircraft fuselage dimensions in order to avoid triple coach seating, The fourth selection factor is noise. Most manufacturers now recognize the importance of noise as a basic airport acceptance characteristic. Nonetheless, there still appears to be a willingness on the part of manufacturers to sacrifice noise considerations excessively in an effort to gain added payload or range. We believe that noise acceptance must now be one of the critical design points of any new aircraft built for service in the 1970's. For that reason, noise performance was one of the major design criteria contained in the air bus specifications issued by American Airlines last year.

A fifth aircraft selection factor is facility impact. Aircraft manufacturers tend naturally to focus their costing efforts on direct operating costs. Typically, they spend pages in their brochures detailing such costs and their potential impact on discounted cash flows and other rate of return measures. Almost inevitably the impact of such aircraft on facility requirements is ignored or underplayed. Nothing is in scarcer supply today than airport space. Airport land and facility costs now represent a substantial and ever-increasing percentage of an airline's capital outlays. Future aircraft must be designed, in so far as possible, in terms of length, height, wing span, and loadability to utilize facilities and ground handling equipment common to other aircraft types. Airlines cannot afford to redesign facilities each time a new aircraft type is introduced; nor can they afford to have gates that can only serve 747's or supersonic transports or air buses. Optimum utilization of our facilities requires interchangeable gate positions in which a range of equipment types may park without excessive ground maneuvering time and lost aircraft servicing efficiencies.

A sixth aircraft selection factor is ground time or turnaround time. Just as similar aircraft may vary in their facility impact, they may also vary widely in our ability to utilize them efficiently. When we spend 20–40 million dollars for an aircraft, it is essential that a high percentage of that aircraft's daily time be spent in productive flight, rather than at the gate being loaded, fueled, cleaned, or provided food and lavatory service. Much more attention needs to be focused by both the manufacturers and the airlines on aircraft servicing techniques. Little technology has thus far been applied, for example, to the process of galley provisioning. The problems of aircraft access and rapid aircraft servicing will be further compounded by the need to provide multiple exit and entrance ramps to speed 747 and SST passenger handling.

Another aircraft selection factor is maintainability and reliability. Although the jet engine has brought a quantum improvement in both maintainability and reliability, there is need for much additional work in the area. Engine manufacturers still tend to optimize such easily measurable engine characteristics as specific fuel consumption, thrust to weight ratio, etc. What is needed is a thorough study of total engine operating costs identifying trade-offs between durability on the one hand, and good engine specifics on the other. Engines and aircraft systems must be designed from birth to incorporate maximum ease of access to components and maximum maintainability. One example will serve to illustrate the importance of improved maintainability to the airlines.

A recent check of our results on Electra component maintenance showed that depending upon the component studied between 20% and 70% of our unscheduled component removals involved improper identification of malfunctions. In these instances the components removed were functionally checked by our shops and were returned to service without repair. To be more specific, 66% of the cabin temperature control removals and 46% of the engine driven compressor removals were unconfirmed. The American Airlines inventory investment in these two units alone totals 562,000 dollars. Other systems show varying but similar indications of our inability to isolate trouble in the time available to our line maintenance people during the daily operations.

Solution to this problem involves either lengthened ground times or improved systems for identifying malfunctioning components. The latter is a far more palatable solution. Although the earnings loss per flight hour on a 707 is $655, the earnings loss per flight hour on a 747 will be approximately $2500. Obviously over the life of a 747 aircraft the cumulative earnings loss from down-time justifies a major effort to improve maintainability of aircraft of this type.

Another aircraft selection factor is safety. Safety has been mentioned so late in this listing only because airlines and manufacturers are in such wholehearted agreement regarding its importance. There is, however, further need for ever-improving safety standards primarily in conjunction with the larger capacity aircraft of the 1970's.

The final selection factor is cost. Cost has been listed last, not because it is least important to the airlines, but rather to divert attention away from direct aircraft operating costs and focus attention upon the aircraft characteristics that vitally affect total system costs. As indicated, new aircraft types may exert a profound impact on our costs in many areas. Possible impacts of aircraft characteristics on facility costs and utilization have already been discussed. New aircraft may have similar effects upon training costs, maintenance costs, passenger service costs, etc. They may also vary widely in their useful economic life. Manufacturers and airlines alike must learn greater sophistication in evaluating such costs. It is minimum system cost, including such considerations as reliability, scheduling flexibility and facility compatability, that must be the ultimate concern of air transportation.

Summary

1) A number of factors have combined to make airline equipment decisions both more difficult and more important than previously.

2) Computer technology and increasing technical support from manufacturers and government are assisting airline planners in meeting this challenge.

3) There are three types of equipment planning problems faced by airline planners: a) recommendations regarding amount and types of additional orders for available aircraft, b) analysis of new aircraft types developed by manufacturers or by government, and c) airline sponsored aircraft development.

4) It is important that airlines play an increasingly major role in aircraft design and development.

5) Airline planners place fundamental emphasis on nine basic selection factors in fleet planning. These are a) mission, b) sizing, c) passenger preference, d) noise, e) facility impact, f) turnaround times, g) maintainability and reliability, h) safety, and i) cost.

6) The difference between airlines and manufacturers in their evaluation of these nine factors is sizeable.