AIRLINE ECONOMICS IN THE TURBINE ERA

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INTRODUCTION

In the past five years, the airlines of the world have gone through a period of transition in which the gas turbine type of powerplant has replaced the piston engine as a primary propulsion unit. The characteristics of such powerplants are different from those previously used and these differences tend to be reflected in the personality of the vehicles produced. At the same time, the state of the aeronautical art has advanced to a very considerable degree and many improvements which had been developed over the years, were incorporated into these vehicles, thus further changing their characteristics. A third major factor which has been a source of profound change in this period, has been the extremely rapid growth of aircraft as a basic means of passenger transport. This growth has served to alter the environment in which airlines operate and has had an extremely important effect upon operating results and efficiencies. Thus, when we examine the economics of air transportation, we have truly been in a period of transition. It is appropriate that our economic experiences be reviewed and, if possible, the important conclusions drawn, if we are to plan prudently for further development in the future. My presentation is based upon the experiences of an American domestic operator and may not be directly applicable to the present day situation of many of the International carriers; but I believe that our story is of major significance because many of the factors which have given us the most difficulty will be found to an increasing extent in all operations in the future.

The term "economics" broadly deals with the science of production and distribution of wealth or the study of the way in which resources are used to satisfy the wants of people. Under a system of free enterprise, this generally connotes the existence of a satisfactory profit, to support the economic fabric and to make it practical to attract the required risk capital to be invested for the maintenance and expansion of the business. We use the existence of profit as a measure of the satisfaction with which the general public regards an enterprise and, at the same time, as a measure of the excellence of its management. It is apparent that an enterprise not producing profit is economically unsound—either by being inefficiently managed in its production of wealth or by virtue of having produced wealth for which no demand exists. In the field of transportation, the unused supply of the product is quite wasted and cannot ever be stored. Hence, it is necessary to create supplies only to meet demands.

When a transportation system becomes so large as to exclude other transportation systems from direct competition, it becomes a public utility and as such is capable of social abuse. Hence, governments have instituted systems of regulation on the one hand, aimed at promoting the existence of transportation not otherwise available without external encouragement and on the other hand to insure adequate regular and economic supply of transportation to the citizens who have become dependent upon it. Any successful transportation system rapidly approaches the status of a public utility and it must be so operated as to accept its social obligations as such. The extent to which the management function is usurped by regulatory agencies is a reflection of the general public's attitude towards the management of the utilities and their satisfaction with the results obtained.

There have been few utilities that have attracted the attention of politicians and the public-at-large to the extent that the airlines have, in recent years. As we have grown in size, the general public has become increasingly aware of our services, their advantages and their shortcomings. This very familiarity has created a sense of intimacy between us and the average man on the street and he has greatly increased his knowledge and awareness of our potentialities. Individually, we have received a great deal of criticism and there has been a vast amount of what we call, in our country, "Monday morning quarter-backing", as to how we should have conducted our business. This is, to a great measure, a product of the desire of the common man to "grouse". Yet, the very growth of the air transport industry, both at home and abroad, has indicated the fundamental soundness of the solutions achieved and their acceptance by the general public. The growth of the airlines in the past decade has been absolutely astounding.

The problem in managing an airline can be stated simply. It is to carry the greatest number of people possible, at a fare that will cover the cost of the operation plus a reasonable profit. The achievement of this aim is far from simple. There is a relative economic value to each of three attributes of a service. The first is the cost of the journey; the second is the time required to make the journey; and the third is the degree of comfort encountered by the passengers during the journey. None of these factors are mutually exclusive. Take an absurd case of a transportation system requiring a year to cross the American Continent, at a price which is zero. This service obviously would not develop high demand because very few persons can arrange their affairs to conveniently spend a year enroute to achieve transcontinental passage, regardless of the cost involved. An equally absurd example can be taken the other way. We could visualize a matter transmitter which produces an instantaneous transit of the country, but which requires the spending of several hundred thousands of dollars. Again, the market would be negligible because of the lack of persons who could afford such travel arrangements. As far as the individual's creature comfort en route, there is a certain minimum range of standards of arrangements beyond which the service will be unacceptable unless no competing means of transport is offered. We must conclude—both from an examination of the aforementioned absurdities plus our experience in developing and selling air transportation—that block time and market price are extremely important factors in defining the suitability of a transport service to a wide cross-section of our population. We cannot offer economical transportation without fast transportation nor can we offer fast transportation without economical transportation.

There has been much written on the desirability and traffic appeal of jet airplanes by virtue of their pleasant passenger environment. That is to say, the relatively low noise level, the lack of engine vibration and the ability to operate at altitudes where rough air is rather rare, has created a concept of comfort which is an order of magnitude improved in relation to previous vehicles. With these factors at work, and in addition, with some considerable novelty value being present, the jet transport was accepted eagerly when it was first introduced to commercial service. Yet, the very markets serviced by the jets have continued to show a rapid increase in growth after this novelty had worn off. We must assume that at least some of the increase in travel must be attributed to the reduced travel time for the trip. We have certainly had this experience on previous occasions, in the same market, when services were introduced which decreased the total travel time. The importance of the passenger comfort items lies in the competition between several carriers in a price regulated economy wherein the important factors of speed and fare levels are equalized by economic regulation.

The tendency over the years has been to improve the standard of service of a given class of travel. Thus, we find that the first class passenger has several times the space available to him as he has had in previous services. He has more frequent attention from the cabin crew, he has a higher standard of meal and beverage service and various other niceties are provided which were previously unobtainable. This is the natural result of the striving for business within a given class of accommodations. A similar situation has been true in tourist travel, wherein over the years the comfort provisions have steadily increased. It appears unfeasible, from a competitive standpoint, to degrade a given class of service. Yet, in response to the demands for a still more economical service, we have seen the introduction of economy class and the resulting virtual elimination of tourist class accommodations in the North Atlantic market. The evolution of this pattern indicates very clearly that the general public wishes faster and less expensive transportation. Our progress towards this goal has, as an industry, been somewhat jerky and discontinuous, but we have made great strides towards the realization of these desires.

In addressing this audience, I believe that we can assume that there will be no question about the conclusion that other things being equal, a fast airplane will outsell a slow airplane and that other things being equal, a comfortable airplane will outsell an uncomfortable airplane. Both the speed and the comfort are inherent features of the jet airplane and this superiority has demonstrated itself to such a marked extent as to cause a revolution in air transportation. It must be equally obvious that we must continue to improve the economy of the operation as measured by profitability. That is to say, we must continue the evolutionary trend of producing transportation, the price of which, relative to general cost of living indices, continues to decrease so as to broaden further our market.

Herein lies the controversy that has surrounded the jet aircraft since the very beginning. The burning issue has been whether we could afford the introduction of the jet airplane and whether or not it is sufficiently attractive on an economic basis to support its advantages of speed and travel comfort.

ECONOMIC RESULTS OF THE INTRODUCTION OF 707 AIRCRAFT

The accompanying figure (Fig. 1) shows the comparison in our system of DC–7 and the 707 when these aircraft are considered to operate in comparable service. That is to say, an adjustment has been made in the equivalent number of seats in each case to produce a comparison consistent with the cost of equivalent first class seating on a revenue basis. It is important to note therein that the achieved level of economy is not at all unfavorable to the jet airplane; in fact, it would appear that from a direct operating cost viewpoint, the jet airplane did exactly what we expected it to do. I believe the comparison presented is a fair one inasmuch as the operation of each of the fleets concerned was reasonably stabilized and over the same general routes. This market, on the other

Aircraft	DC–7	B–707
Flying operations	\$187·13/hr	\$379·05
Direct maintenance	76·27	189·31
Depreciation	67·23	185·90
Total	\$330·63	\$754·26
Ramp speed	279 m.p.h.	443
Cost per aircraft mile	\$1·18	\$1·70
Cost per equivalent first class seat mile	¢1·97	¢1·72
Seats	60	99

FIG. 1. Direct flight costs B–707 and DC–7.

hand, represents the most favorable market possible for the carriage of passengers. It has a relatively long average trip distance so that terminal costs are reasonably low; it has an extremely high density of travel so that large units can be filled with adequate schedule frequency and the route pattern is clearly within the range capability of the two aircraft involved so that no direct penalty is paid for any inherent range limitations. It represents the cream of the passenger business. This table represents graphically the extent of the technological improvement made by the aircraft industry in a seven year period, when all of its accumulated resources of knowledge, technique and investment were marshalled together in a revolutionary step forward.

The next point that I should like to examine is the adequacy of our planning to prepare for such a step (see Fig. 2). This figure shows a comparison of the cost estimates prepared at the time the 707 was contracted for—both by the airplane manufacturer and our own airline, alongside

	Boeing est. 1/7/56	AAL est. 1956	Actual 1960
Flying operations	\$438·66/hr	\$348·03	\$379·05
Direct maintenance	208·06	200·28	189·31
Depreciation	234·18	202·27	185·90
Total direct operating cost	\$880·90	\$750·58	\$754·26
Ramp hour utilization	8·2	8·0	8·1
Average stage–st. miles	1751	1751	1789
Average ramp speed	491	491	443
Cost per mile	\$1·79	\$1·53	\$1·70

FIG. 2. Boeing 707 estimated vs. actual operating costs.

the actual achieved costs. Here again, it can be seen that the agreement was reasonably good and that in general, the aircraft did what it was supposed to do. There are however, several difficulties apparent. It should be noted that America did a somewhat better job of estimating the hourly operating costs of the aircraft than did the manufacturer of the machine, using standard ATA procedures. At the same time, it is to be noted that the average ramp speed achieved was somewhat lower than that originally estimated for the machine. This reduction in productivity directly affected the cost of the operation so that the error in per aircraft mile operating costs originally estimated by the manufacturer, using pessimistic, excessive hourly charges, was cancelled out by the error in the block speed and quite fortuitously, these data were much more nearly those actually achieved than those predicted within our organization.

The fundamental concept used in all of the cost estimation procedures currently available to us involves the estimation of the individual elements comprising expenses on the basis of a cost per hour of operation. In the case of the directly incurred costs, this approach is reasonable from several points of view. Many of the items composing the expenses can be dealt with to a fair degree of accuracy on an hourly basis; salaries, maintenance requirements and fuel costs compose the majority of the items in this category, except for the productivity of the aircraft itself. These items represent the expenditure of the resources of an airline to produce transportation and circumstances which cause errors in their estimation are extremely unlikely. The purchase price of the aircraft and the required stock of spares is also subject to accurate determination and therefore can be considered to be of a higher order accuracy. The productivity however and therefore the depreciation write-off is the function of the utilization of the aircraft and inasmuch as we have embarked on an era of expensive, highly productive machines, the correct estimate of utilization becomes a major factor in an accurate prognostication of the airline cost. In addition, a second measure of productivity, i.e. the block speed is used a multiplying factor to the sum of the hourly costs in order to convert these costs to airplane mile costs. Hence, small errors in either the utilization or the block speed can very greatly affect any conclusions drawn as to operating economy of future vehicles. I have noted the problem with block speed which has already become apparent in our operating results. The problem of utilization will show itself up in the future as a more and more important factor as fast airplanes are applied to shorter and shorter routes.

There are two purposes in making an economic analysis of aircraft operations. The first purpose is to insure adequate planning for the introduction of new equipment so as to use it most effectively. The second purpose is as a tool for judging the optimization of an aircraft design. Each of these purposes are closely related and we must always bear in mind that this relation can cause trouble for an airline unless the analyses produced adequately fulfil the requirements for each purpose; to wit, management needs accurate forecasts as to the expense of operation to plan the general financial structure which must be provided for the purchase and operation of aircraft. In this connection, it is necessary that any operating expense and productivity estimates be accurate on an absolute basis, even though they do not necessarily provide for good selectivity in comparing one aircraft design against another. The design engineer, on the other hand, needs a tool by which he can critically select optimum designs for differing purposes, although he may not be directly concerned with the absolute accuracy of the figures produced. Experience shows that analyses turned out for one purpose are invariably quoted out of context for another purpose and much confusion has resulted on these occasions, unless great care is made to control properly consistencies in analyses. To quote this problem very simply, the engineer is interested in insuring the best possible combination of parts to make up a complete airframe, whereas the management is interested in the overall economic productivity of a new airplane relative to its predecessor in service. In the past, this type of analyses has been made by use of an extrapolating formula which takes the known expenses incurred by the operation of current airplanes and translates this experience into aircraft of improved design. This approach is not new. Many years ago, I came across a file which contained someone's penciled notes on a cost estimate for the operation of one of the early Stinson aircraft. While these notes were undated, it was apparent from their context that the work had been performed sometime in the early 1930's. The first publication of a more or less complete system for cost analysis was made by Mentzer & Nourse of United Airlines and published in 1940. This system of analysis was widely accepted and provided the base for most succeeding work of this nature. The Mentzer–Nourse formula was developed from United's operating results with the DC–3 airplane. While it was in fact, very widely used and accepted, various American airlines developed their own constants or coefficients in this formula, based upon their own individual operating data and it was felt far more democratic to produce a unified set of equations which averaged the experience of the industry instead of one individual carrier. This effort produced the first ATA standard formula for the assessment of operating costs of aircraft which was published in 1945. Since that time, there have been periodic revisions to the ATA formula over periods of from three to five years and it has served as a major tool for the development of modern American aircraft. Inasmuch as economic conditions in Europe were so different from those facing the American domestic carriers, a similar formula was developed by the SBAC and this formula has been used in economic areas where it is more nearly applicable. Like the various versions of the ATA formula, it is based upon the principles originally proposed by Mentzer & Nourse for scaling up operating results from an existing aircraft to those of a new and untried model. The most recent revision of the ATA formula is that of 1960, a document very recently published and now procurable from the ATA. This formula is an attempt to up-date thoroughly the method and to provide a firm base for sound extrapolation, from present results. The basic airplane upon which the formulae were based became first the DC–3, then a resolution of the DC–6 and Constellation characteristics and more latterly, the jet transport of the 707 and DC–8 types.

One of the characteristics of the successive revisions to the formula has been the constant chasing after proper values of the cost coefficients. That is to say, the formula was used to estimate the DC–6 characteristics from DC–3 experience. We then climbed the next rung of the ladder and used the formula to project the DC–6 into the DC–7. The next step was to project the DC–7 into the B–707 sort of airplane. (Competition will forgive me mentioning the specific rungs of our ladder. There were other good aircraft in this period as well.) In each case, the revisions were made so that the formula accurately expressed the characteristics of the reference airplane to minimize the degree of extrapolation necessary into the new model. The extent to which this process is successful is the extent to which the new airplane and its operation resembles the older base line. If there is, in fact, very little change taking place, the formula is quite accurate. Conversely, if there is a big jump in characteristics, such as block speed or a radically different type of fuel, the formula can become increasingly inaccurate in its prediction.

There were good reasons why the 1955 ATA formula was set up the way it was. There were equally valid reasons for us, in American Airlines, to make certain changes in the formula in light of facts known to us. The factors that caused deviations from these estimates were not taken into account by anyone in 1955 and it is important that we fully appreciate the reasons for these factors because such effects will be more and more important in the future.

The most significant single item of difference between the prognosticated and actual operating results with the 707 was in the achieved block speed. This error in block speed was primarily the result of a lack of understanding as to how an airplane of this nature could be operated in a congested situation and a lack of isolation of the effects of these factors of congestion of overall aircraft productivity. Hence, in the 1956–60 issue, it is assumed that the aircraft operates at an arbitrary non-optimum condition, i.e. several thousand feet away from its optimum altitude and it is further assumed that a 6 percentage increase in the Great Circle route miles is used to compute block time. These two effects are the prime loss of producitivity encountered in the domestic operation of jet airplanes. Because of congestion, we cannot operate at optimum altitudes but must operate at arbitrarily assigned altitudes and our routes which are fixed by available navigation facilities and are not Great Circle routes. Also, we have run into increasing time spent on the ground awaiting takeoff. This has resulted from Airway Traffic Control delays, Departure Control delays, delays caused by awaiting the availability of the runway and, strangely enough, straight traffic jams on the ground due to poor airport layout and ground traffic control. A by no means typical example is Idlewild, where the average time from ramp departure to takeoff clearance is of the order of 27 min, despite all of the best intentions of the responsible officials. One might take the view that domestic American experience in this regard is unique but I would like to point out that it is unique only because we have more aircraft in the air and on the ground than anywhere else in the world and our procedures are designed to prevent recurrences of disastrous collisions in flight. Further development of air transportation in other areas of the world will rapidly produce the same sort of congestion with the same result; i.e. forced imposition of assigned altitudes and routes for traffic control purposes to avoid collisions. The loss of range and block speed which results from this is fundamental to the conduct of business in the future and the conditions will get worse instead of better. My own concern with the new ATA formula revision is that it has not, perhaps, gone far enough in this respect.

Utilization has, in the past, been treated as an empirically derived constant based upon past experience. A little reflection however, will serve to indicate that utilization doesn't happen, but is achieved by hard work. The character of the aircraft may, in fact, limit the achievable utilization. It further appears that it is possible to calculate the effects of various design variables and parameters on utilization and we, in American Airlines, have done some work in attempting to come to grips with this problem.

DERIVATION OF UTILIZATION RELATIONSHIP

1. We can divide time into various categories so that:
   B denotes block time or ramp-ramp time
   M denotes time required for maintenance
   G denotes time required at gate

S denotes time required in scheduled protection services

W denotes time not utilized, or waste time

Utilizing T to denote time per day spent in various services or activities:

$$T_B + T_M + T_G + T_S + T_W = 24$$

2. Then, if N is number of flights per day per aircraft and t denotes the time spent in each category of activity per flight leg, it follows that

$$T_B + T_M + T_G + T_W = N(t_b + t_m + t_g + t_s)$$

and

$$N(t_b + t_m + t_g + t_s) = 24 - T_W$$

3. Or

$$N = \frac{24 - T_W}{t_b + t_m + t_g + t_s}$$

$$Nt_b = \frac{24 - T_W}{1 + \frac{t_m}{t_b} + \frac{t_g}{t_b} + \frac{t_s}{t_b}} = \text{utilization}$$

The utilization formula developed above indicates that certain natural ratios exist which control the available utilization. The factor T_W arises naturally from the fact that it is impossible to schedule a fleet of airplanes around the clock. There are certain hours of the day during which the demand for transportation is so lacking as to make the operation of the aircraft virtually useless. A good example of this is overnight service with arrival times of say 3:00 a.m., which are very difficult to sell in competitive economies. The nature of this factor suggests that the value of T_W will increase as the average block time of the service decreases so that it is logical to expect the fast airplane to have a higher T_W than a slow airplane. The ratio t_M is again a natural constant and it depends largely on the maintainability of the flying machine. That is to say, a very efficiently designed airplane which has easy maintenance may have a low value of this parameter, whereas an airplane with high maintenance cost or difficult maintenance operation will have a high value of this parameter. The value $\frac{t_S}{t_B}$ is the extent to which individual schedules are protected by spare airplanes at time of departure and this factor is, in turn, controlled by both the standard of service and the mechanical reliability of the aircraft. The factor $\frac{t_G}{t_B}$ is the ratio of time of gate occupancy over productive flight time and this ratio is a function of the block distance, the block speed and the achievable gate occupancy times, depending upon the design of the airplane for fast through and turn-around service. It is apparent that the value of T_W in the formula above represents a catchall of several variables, some of which are functions of the aircraft design and some of which are merely nature of the business and so represent natural limitations. We can infer that as the block time decreases, the value of T_W must increase. This results from inability to schedule such block times around the clock. We can also infer that as the maintenance time requirements increase, so will the value T_W decrease because some maintenance can be performed during otherwise useless periods of time, such as the middle of the night.

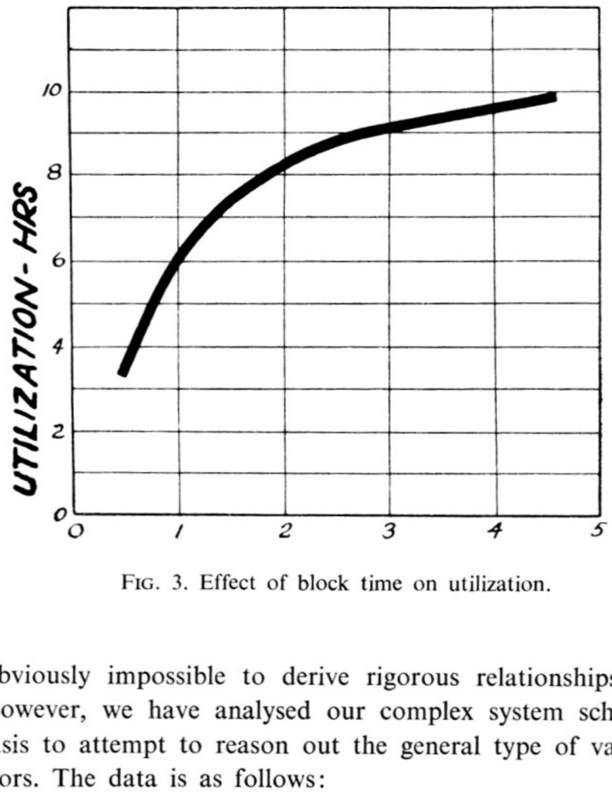

FIG. 3. Effect of block time on utilization.

It is obviously impossible to derive rigorous relationships for these values. However, we have analysed our complex system scheduling on a fleet basis to attempt to reason out the general type of variability of these factors. The data is as follows:

Aircraf	No. in service	U	T_w Actual	t_g	$\frac{t_m}{t_b}$	$\frac{t_s}{t_b}$	T_w Formula
CV-240	39	7:20	7·15	0·42	0·67	0·17	7·25
DC-6	67	8:39	6·06	0·54	0·55	0·21	5·95
L-188A	34	7:28	4·31	1·12	0·85	0·19	4·36
B-707	24	9:10	4·70	1·56	0·57	0·11	4·64
Freighter	13	7:02	6·76	2·21	0·56	0·26	

In light of the intuitively derived variation of the factor T_W proposed, it was assumed that this parameter would increase with the reciprocal of the block speed and reduce as a function of the maintenance time ratio. Solving this equation for the desired constant produces:

$$T_W = 6 \cdot 24 + \frac{3{\cdot}85}{t_b} - 3 \cdot 78 \frac{(t_m + t_s)}{t_b}$$

which fits the available data with extremely small scatter. I do not propose that this relationship is rigorous, but it is logical and it allows us to examine what happens when certain changes in the airlines operation is assumed. Take for instance, the problem of the effect of block time on utilization, all other values being held constant and appropriate to a current medium sized jet transport (see Fig. 3).

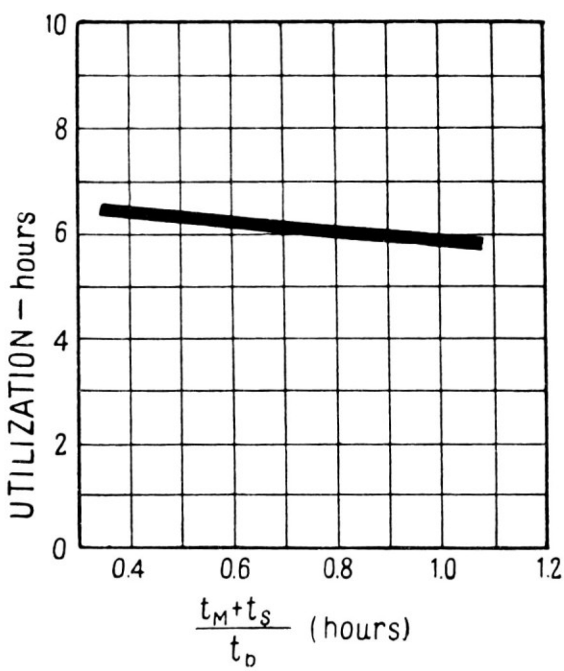

FIG. 4. Effect of maintenance and schedule protection time on utilization.

It can be seen that the available utilization falls considerably below the time honored light hours per day as the block time is reduced into the interesting range for this type of aircraft. This suggests that if we are to operate this sort of machine at average stage lengths which will produce such short block times, we must control both t_g and $\frac{t_m + t_s}{t_b}$. Calculations showing the effect of t_g and $\frac{t_m + t_s}{t_b}$ are offered on the next figures (see Figs. 4 and 5).

Clearly, if we are to make our economic mark in the short haul jet field, we must reduce our ground time and better our maintainability and regularity.

When consideration is given to cargo airplanes, it is quite obvious that the loading and unloading time will limit to a very fundamental degree the achievable productivity. This, in turn, points to consideration of

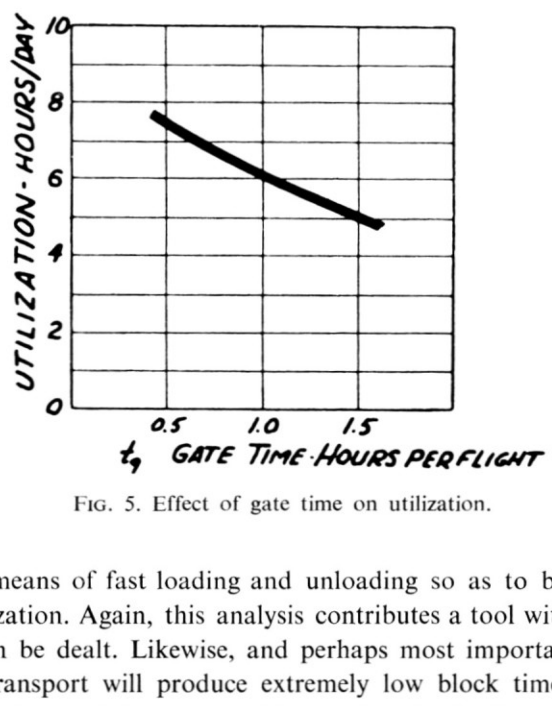

FIG. 5. Effect of gate time on utilization.

mechanical means of fast loading and unloading so as to bolster up the average utilization. Again, this analysis contributes a tool with which such problems can be dealt. Likewise, and perhaps most important of all, the supersonic transport will produce extremely low block times and therefore must be designed for very rapid operation for loading and servicing. Very careful consideration must be given to these factors before heavy investment is warranted in such vehicles.

The new ATA formula reflects, to a very great extent, much of the data herein presented. While this basic utilization formula was not incorporated in the ATA approach, a semi-empirical relationship was developed which does, in fact, reflect the average results of these processes on utilization. The curves of utilization vs. block time shown in this formula match the experience of several operators of large fleets in achieving reasonable utilization results. Organizations concerned with the analysis of the economics of fast airplanes on short haul flight legs must give due consideration to this new formula, if accurate results are to be achieved.

THE FUTURE

The foregoing portion of this paper has dealt with history. This history is only valuable as a means of extrapolating into the future. Quite obviously, the airline industry faces the possibility of extrapolation which is at least as great as that taken in the five years. Already we can see very difficult problems. The concept of the transport aircraft as a vehicle has changed and will change very radically. Further development will most likely take place in three areas; first the extension of jet service into short to medium stage markets; second the development of efficient large scale air cargo service; third, the development of the long haul supersonic transport.

From a management point of view it would be most convenient if the aforementioned three developments did not occur. In fact, there is a great danger that we, in the airline business, might attempt to prevent their occurrence. This negative approach is not realistically possible and we would be shirking our social responsibilities if we did not do everything within our power to improve further our industry. Hence, we must be most positive in attempting to develop further and exploit air transportation and to do so in a manner most benefiting the transportation needs of our expanding society. To do this, we must offer superior service at a lower cost than we have ever been able to do before. To fulfil this aim, we must have accurate economic studies to support the research and development effort into new types of vehicles. Hence, we will continue to use such studies and we will continue to change the methods used in such analyses as we learn more about these problems.

Perhaps at this point, we should regard the airline in a little different functional light than has been done before. An airline is an organization which makes use of resources in the form of flight equipment and supporting ground equipment and installations to produce economic transportation. In order to this, there must not only be equipment but it is necessary to employ the services of many highly skilled men. This manpower also represents a resource which must be used most efficiently. About two-thirds of an airline's expenditure is represented by labour costs and depreciation of equipment. Of the remainder, the single biggest item of consumption is fuel but even the fuel becomes a fairly small portion of the whole. It is the object of airline management to get the most benefit—that is, the most transportation out of its available resources in men and equipment and it should be the object of Equipment Planning to produce as much transportation as is possible from a minimum investment. Note very carefully that I have used the word "transportation" as opposed to "available transportation" in the foregoing. Our production costs must be taken in light of the passengers we carry and we must not credit ourselves for the empty seats or the unused cargo space that we happen to fly around, unable to sell. It is necessary that any transportation we offer be sufficiently attractive relative to other alternative forms of transport so as to be appealing in the market place. We can't offer shoddy merchandise. Thus, it follows that we must offer something a little better than the most economic aircraft—either in the form of speed or en route creature comfort.

It is obvious that in the next five years a continuous expansion will be made in the short to medium haul field and jet aircraft will invade this domain which has hitherto been reserved primarily for propeller types. At the same time, the aircraft manufacturers of the world are suffering from a heavy dose of technological unemployment. Government supported aircraft programs are tending to be fewer and farther between and excess capacity for design and production exists throughout the world. The resulting high pressure sales effort will tend to produce aircraft tailored to fit everyone's needs and economic data will be used to justify each of those designs. It is very easy to visualize the situation wherein optimum airplanes for many dozens of airlines might be designed and some of the larger airlines may be faced with the possibility of having several optimum airplanes to do various portions of their tasks in an optimum manner. This may be a very optimum situation for the preservation of the manufacturing industry but it is strictly counter to the best interests of the operating brotherhood and probably the traveling public. There appears to be an excellent case for rigid standarization of aircraft. Many papers have been presented showing the fact that large scale production runs are the only economic way of producing aircraft. Thus, it is necessary that the few manufacturers who will survive the next decade be encouraged to standarize their outfit sufficiently so as to pass on the economic benefits to the operators and the traveling public. This will require some considerable soul-searching on the part of the operators themselves. There appears to be no fundamental reason why, for instance, a perfectly standard cockpit cannot be accepted by all operators. The aims of all operators are certainly identical and broadly speaking, their capabilities must be quite identical and the conditions under which they operate are becoming increasingly identical. There is no supportable, logical reason why cockpits cannot be rigidly standardized in a given aircraft model.

In a similar manner, there is no fundamental reason why all airplanes in a production run cannot be equipped with the same type of air conditioning equipment which functions from standardized ground support equipment for supply of auxiliary power, starting, cooling and the like. There are vast differences between operating philosophies of competing carriers, which are acting to everyone's economic detriment and there is no reason why this situation cannot be changed, providing that the people involved take logical and prudent viewpoints in the solution to their difficulties.

Equally, there is no reason why the hardware portions of interiors of aircraft need differ from airline to airline, although I would confess that items such as upholstery material and a choice of colors will always be left to the taste of the individual who is decorating his house. It stands to reason however, that the less individual preference represented in design, manufacture and stock, the less expensive the cost of the transportation will be.

If the operating industry can achieve a rigid standardization of hardware between similar airplane models operated by the several transport companies, it naturally follows that inter-airline arrangements involving pools of stock and manpower can serve to greatly increase the operating efficiencies, particularly on thin routes and at low traffic density stations. Airlines do not need to lose their identity to partake of these advantages and it is probably to the ultimate benefit of the traveling public that they not lose their identity. On the other hand, we should satisfy ourselves that we have done all reasonably possible to keep our operating costs to a minimum.

Another important point in this regard is the number of aircraft types which seem to be in production today. We have found that there is a great saving to be had in operating large fleets. This saving today is very difficult to analyze. We, in American Airlines, have spent the better part of the past summer attempting to devise ways by means of which we can calculate these savings. No rational assumptions that we have ever produced appear to express adequately the real potentialities of the big fleet savings. Yet, aircraft fleet utilization is continuously increased, spare coverage becomes better and specific costs reduced, as the fleet size increases. There is probably a case for the operation of a single, rigidly standardized fleet in an airline providing that it has reasonably homogeneous character of service. Yet, this can only be so if we are able to benefit in the price of the airplane by buying them in very large quantities.

It is probably a practical impossibility to eliminate all but one type of airplane in operation. We should then strive to standardize as much as possible on components. The principal component involved in airline logistics is the engine. If an airline can organize its entire mechanical operation around the use of a neutral engine which can be installed in each of its airplane types, it can again save a vast amount of money in operating costs. This standardization may very well outweigh the advantages of using optimized engine-airplane combinations to specific purposes. Quite often, the performance requirements of different individual airplanes are dictated by the conditions such as runway length at certain individual key airports. It is necessary, when making long term plans, to include the possibility of designing the airport for the aircraft as opposed to the possibility of designing the aircraft to the airport. If one had a system composed of many 7000 ft airports, with one 5000 ft airport it would be most productive to attempt to elongate the 5000 ft airport and use a more efficient aircraft; whereas if the majority of the airports served were in the 5000 ft category, the aircraft must conform to the majority of the available facilities, even though its operating cost may suffer somewhat. Operating cost estimates should be based upon the total costs of the operation rather than on the so-called "aircraft directs".

From the examples that I have cited above, it is obvious that equipment planning in the future must be based upon a broader concept of operating costs than we have used in the past. Many legitimate costs, chargeable to the airplane design, fall logically within what is now known as "indirect expenses" and if we are to properly utilize economic analyses to design or optimize the design of aircraft, trade-offs in these areas must be considered. We are hampered in this endeavor by the rigid requirements of our bookkeeping systems which make a proper interpretation of many of the indirect expenses extremely difficult. The airlines must isolate, tabulate and publish much of this material covering these points if they expect the aircraft manufacturers to present them with sophisticated material in support of advanced aircraft designs. The extent to which such background information becomes available may indicate our future airplane design capabilities. A good example of this is in consideration of ground handling facilities. If an aircraft were built with a very high landing weight, the conventional direct operating cost penalizes it because it weighs more, costs more and is more expensive to maintain. Yet, such an aircraft need not be refuelled at intermediate stops. Therefore, ground time can be reduced and less station personnel employed. We will need to use methods which give us the overall operating costs of such concepts, rather than the simple direct costs.

The supersonic transport represents perhaps the ultimate challenge to our industry. In order to make this machine function, we must push the state of the art in every detail far beyond that presently achieved today. There have been many contributions dealing primarily with the physics of supersonic transports. We have apparently, insuperable problems in noise, sonic boom, cabin comfort and emergency survival conditions and landing and takeoff flight characteristics. We will require a radically new and different approach to flight instrumentation and en route traffic control. Each of these problems has been dealt with at some length in the recent literature. But the economic planning for such a project is in a pitiful state. People have been attempting to optimize aircraft of this category, using the 1955 ATA formula; a six times speed extrapolation. This sort of thing just won't work in the future and we must have adequate measures of the productivity of the aircraft and the total cost of operation if we are to have even a reasonably successful supersonic machine. One of the biggest debates today, i.e. of the size of the airplane to be built, can never be settled using methods known and accepted by today's aircraft designers. The operating industry contribution to the supersonic transport must be the creation of a rational means of evaluating its economic utility.

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