THE EFFECT OF SUPPLY PARAMETERS ON THE VOLUME OF FUTURE AIRCRAFT MOVEMENTS

by
Eckhard Urbatzka
DFVLR - Transport Research Department
Linder Höhe
5ooo Köln 90
Germany

1. INTRODUCTION

For the planning of new or the extension of existing airports the volume of passenger traffic and aircraft movements must be forecast in order to get to know the dimensions of the airport facilities concerned.

Moreover for a country like the Federal Republic of Germany, it is significant to consider not only one airport for which a forecast must be done, but all the airports of this country in common in order to get a consistent forecast.

The method of estimating aircraft movements - described hereafter - allows to determine aircraft movements of one or several airports, but makes it also possible to estimate the number of passenger flights on single routes. For that it is necessary to forecast not only the total passenger demand of an airport but also the passenger flows between this airport and all the other destination airports. In the air transport forecast for which this method was developped, the destinations are airports for domestic flights and countries (or several countries) for the international flights.

This forecast of the commercial air transport of the FRG was published at the end of 1981. In most cases my statements refer to this study.

2. RELATION BETWEEN THE VARIABLES

In some air transport forecasts passenger travel is estimated in great detail whereas aircraft movements are estimated very roughly. The movements are deduced from the number of airport passengers, often only by taking into account an average passenger load factor and the present number of seats per flight increased by a varied margin.

The following example will show the great variablility of deriving aircraft movements from passenger flows. In general, there is the possibility to fly a route with different aircraft types and with different flight frequencies. In addition the passenger load factor can vary from route to route and from flight to flight. Regarding one connection between two airports in Europe with a given passenger flow, an airline can serve this route for instance either with a Boeing B-737 or an Airbus A 310. This means that in the case of the B-737 the flight frequency on this route must nearly be two times as high as with the A 310.

By doing so, a variation caused by different passenger load factors is still unconsidered. For instance, if the passenger load factor is varied only by ± 10 %, the difference of the number of flights (flying with B-737 or A 310) is growing to more than 2.5.

This shows that in theory different volumes of aircraft movements can be estimated for a given route. However it can be shown that the number of plausible solutions is rather limited.

The number of movements on a given route with a certain passenger demand is mainly dependent on the passenger load factor, the aircraft seats per flight - and thus, on the aircraft types and mixture - , and the flight frequency. The analysis has shown a high degree of inter-correlation of the variables. Besides the fact that in general the flight frequency on the one hand is decreasing with distance - middle and long range distance - and on the other hand is increasing with growing passenger volumes, the following empirical correlations are important for using this method. It can be shown that for both types of operation - scheduled and non-scheduled - there is a linear relationship between the flight frequency and the seats provided. The same relation exists between the passenger volume and the aircraft seats offered (fig. 1). It follows that in the first approximation aircraft movements can be estimated by means of an average number of seats per flight and an average load factor. A distinction between types of operation and of routes - short range (domestic and Europe)-, middle- and long range distance - must however be drawn.

With reference to the passenger load factor the analysis showed that over the period of the last ten years this factor varied only by a small margin if the type of route and of operation is reflected. Therefore the passenger load factors - once estimated for the forecast-year for the types mentioned - needs not to be changed in the estimation procedure. In the study mentioned above the passenger load factors were varied within defined, plausible margins after aircraft movements were determined. It was found that there was only a small change in the total of aircraft movements.

For the variables: mixture of aircraft types by size (and thus seats per flight) and flight frequency distinct values for each defined type of route and of operation are fixed. The information of the future aircraft fleet of the airlines and the knowledge of their payload-range capability allows to determine a specific aircraft mixture per route. A definite number of seats offered was assigned to each aircraft type, and aircraft types are classified according to eight type classes (fig. 2). With the given aircraft mixture on a route the average number of seats per flight for each type of route is thus determined. In a similar manner minimum and maximum values are estimated for the flight frequency. For instance, ten flights per week are considered as a minimum value for domestic scheduled flights, or about 105 flights per week as a maximum for short distance european destinations.

3. ESTIMATION OF AIRCRAFT MOVEMENTS

As a result of the analysis of the variables - taking values only within distinct margins - aircraft movements can be estimated. From the passenger flows per route and the load factors for every route the number of seats to be offered (SO) are derived. Based on the number of seats to be offered (SO) one has to find values for the flight frequency (F) and the average number of seats offered per flight (SF), in such way that the equation (1) holds:

$$SO = SF * F. \quad (1)$$

In the case of determining values of SF only those solutions are valid for which F remains within the predetermined range. The number of possible solutions is furthermore limited by the fact that SF itself is only valid within a fixed range. This range is given by assigning distinct aircraft type classes to certain types of route (fig. 3). In the case of determining F only solutions are valid for which values of SF and F remain in the ranges defined before.

Applying values of aircraft mixture and flight frequency within the possible range in an iterative way, a great number of possible solutions to the problem of estimating aircraft movements are produced. The number of solutions however can be limited by parameter estimates for extreme situations.

In the first parameter estimate (E I) the flight frequency per route for the forecast year is assumed to be the same one as in the base year. As a result of demand growth the seating capacity of the aircraft mixture will grow. Summarized over all routes one gets the average number of seats per flight (by unchanged flight frequency). This result is in general a maximum for the average number of seats per flight and a minimum for the flights under the condition that the present demand is not decreasing for the forecast-year. In the second parameter estimate (E II) the average number of seats offered per flight in the base year remains constant for the forecast year. The result is the maximum number of aircraft movements. Under the condition of growing passenger volumes and the supply of any route exceeding the demand one cannot expect routes to be operated by aircrafts of smaller capacity than in the case of the base year.

Starting from the hypothesis that aircrafts seating capacity will grow, two more parameter estimates for extreme situations can be created. The first one (E III) aims at the sortie of large aeroplanes within the defined aircraft mixture. The second one (E IV) presumes flight frequency and aircraft mixture of the base year to remain constant, the supplementary demand for seating capacity is assumed to be covered by the largest aircraft type within the defined mixture. The results of these parameter estimates limit the number of possible solutions furthermore.

Knowing a) the situation on each route, b) the results of the parameter estimates for extreme situations, and reflecting c) some basic criteria, like limits of changing flight frequency and aircraft mixture, one can find one solution that can be regarded as the most favourable one of all possible solutions, a so-called "plausible" one (PL). This solution however always must be seen within a certain degree of accuracy which can be derived from the estimation procedure. The following examples shall elucidate the method.

4. EXAMPLES ILLUSTRATING THE METHOD

Let us first regard the derivation of aircraft movements of the scheduled traffic on two single routes: Hamburg-Denmark and Stuttgart-Paris. The values of the passenger flows and the supply parameters are taken from the air transport forecast of the FRG for 1990 (fig. 4). On the route Hamburg-Denmark only one destination (Copenhagen) is to be served. As can be seen from the estimation results in figure 4 there was no reason to increase the flight frequency of five flights per day, however a need to change aircraft mixture. Taking into consideration the possible future aircraft fleet for short range distances of the two airlines LH and SAS 22 flights with aircrafts of the type class T3 and 13 flights with T5 can be regarded as a plausible solution.

On the other side the route Stuttgart-Paris was served only by the minimum frequency in the base year i.e. two flights per day. With the tripling of the demand there is the possibility to improve service quality by increasing the flight frequency. Considering the aircraft type classes most likely to be operated on short range distances the plausible result of the extremes is: 13 flights with the type class T3 and 12 flights with T4.

In adding up the estimation results of each route one gets the total volume of aircraft movements in a network and the average number of seats per flight.The relationship between aircraft movements and aircraft size as characterized by the number of seats is shown in figure 5. The values of this example are taken from the air transport forecast of the FRG 1990. With the future demand given and a constant load factor the hyperbola gives the mutually dependent variation of the volume of aircraft movements and the average aircraft size. The great difference between the extreme estimation results E I and E II are caused by the different concepts of satisfying demand (see chapter 3). The estimation results of E III and E IV already limit strongly the number of plausible solutions to the quested number of future volume of aircraft movements, however they can't be regarded as plausible results, since there are too many large aircrafts in E III, and on the other hand too many small aircrafts in E IV, like the BAC 111, which will be sorted out before 1990.

Therefore the most probable volume of future flights can be assumed to lie within the volume given by E III und E IV in a certain range around the volume of the estimation result PL as shown in figure 5. Within this range (shaded area in fig. 5), one must assume equally plausible estimation results. The limits of this range are found by examining a sample of routes on which changes in aircraft mixture and/or flight frequency seem possible.

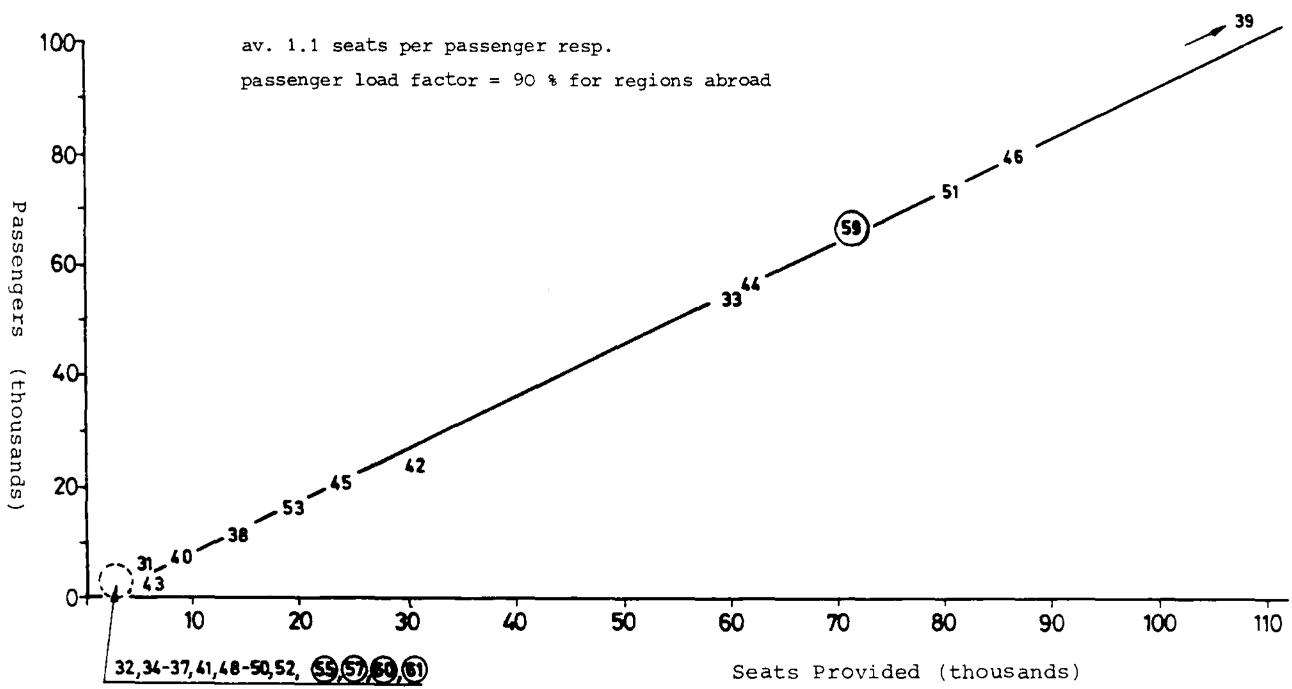
After having determined the volume of aircraft movements by taking into account the factors flight frequency and aircraft size one must examine to which degree the variation of the passenger load factor changes the result. With the load factor taken in the example above, probable changes of this factor are: + 5 % and + 10 % for scheduled services and - 5 % for non-scheduled services. The variation results are a reduction of flights of about 3.5 % respectively 6.5% in the case of scheduled flights and an increase of movements of about 5.5 % in the case of non-scheduled flights. These margins however are within the range given for the plausible estimation result PL.

5. SUMMARY

The method described for estimating future volumes of aircraft movements calls for a route specific analysis of the factors: passenger load factor, aircraft mixture (and thus seats per flight), and flight frequency. Since hardly any route resembles another one, the method described does not lend itself to computerization. For each route one must consider:

- the domestic and foreign politics in air transport
- the present and future demand
- the passed development and structure of supply
- the development of aircraft fleets of airlines involved and the aircraft market in the world.

The method described is used so far for forecasting commercial air transport in Germany. It is possible of course that other base situations in air transport yield other parameter estimates for extreme and plausible situations. The method is considered to be applicable in other countries, too, particularly in Europe, if the corresponding analysis are done.



No.= number of destination region
○ = intercontinental regions

DFVLR

Seats provided as a function of the passenger volume
- Non-scheduled traffic, July 1975

Figure 1

Type-Class	Classification of Aircraft	Aircraft Type (Examples)	Maximum Seating Capacity	Average Seating Capacity per Type-Class			
				1975 (July)		1990	
				Scheduled	Non-scheduled	Scheduled	Non-scheduled
T 1	Third Level	Twin Otter SD 3-30 F 27	50	31	20	35	35
T 2	Small Turbo-Jets	BAC 111 Caravelle F 28	90	79	78	80	80
T 3	Medium Turbo-Jets	B 737 B 727-100 DC 9	130	110	110	115	120
T 4	Large Turbo-Jets	B 707 DC 8 B 727-200	180	155	159	160	165
T 5	Large Stretched Turbo-Jets, Small Wide-Bodies	DC 8-63 A 310 B 767	250	220	213	220	230
T 6	Medium and Large Wide-Bodies	L 1011 DC 10 A 300	350	251	333	300	335
T 7		B 747	500	355	482	430	490
T 8		B 747-derivatives	800	-	-	600	650

DFVLR

Distribution of the aircraft types in type-classes, 1975, 1990

Figure 2

Range	Aircraft-Mixture			
	Scheduled Traffic		Non-Scheduled Traffic	
	Predominant	Additional	Predominant	Additional
Short Range	T3, T4, T5		T3, T4	
Inland		T1, T2 commuter traffic and extreme short routes (up to av. 300 km)		T1, T2 commuter traffic and to neighbour-states
Europe		T6 on routes with high passenger volume		T5, T6 on routes with high passenger volume
Medium Range Europe	T4, T5, T6	-	T4, T5, T6	T7 on routes with high passenger volume
Long Range Interkontinental	T4, T6, T7	T5 (to Middle East), T8	T4, T6, T7	T8

DFVLR

Assumed aircraft-mixture per type of range and of flight for the forecast year 1990

Figure 3

640

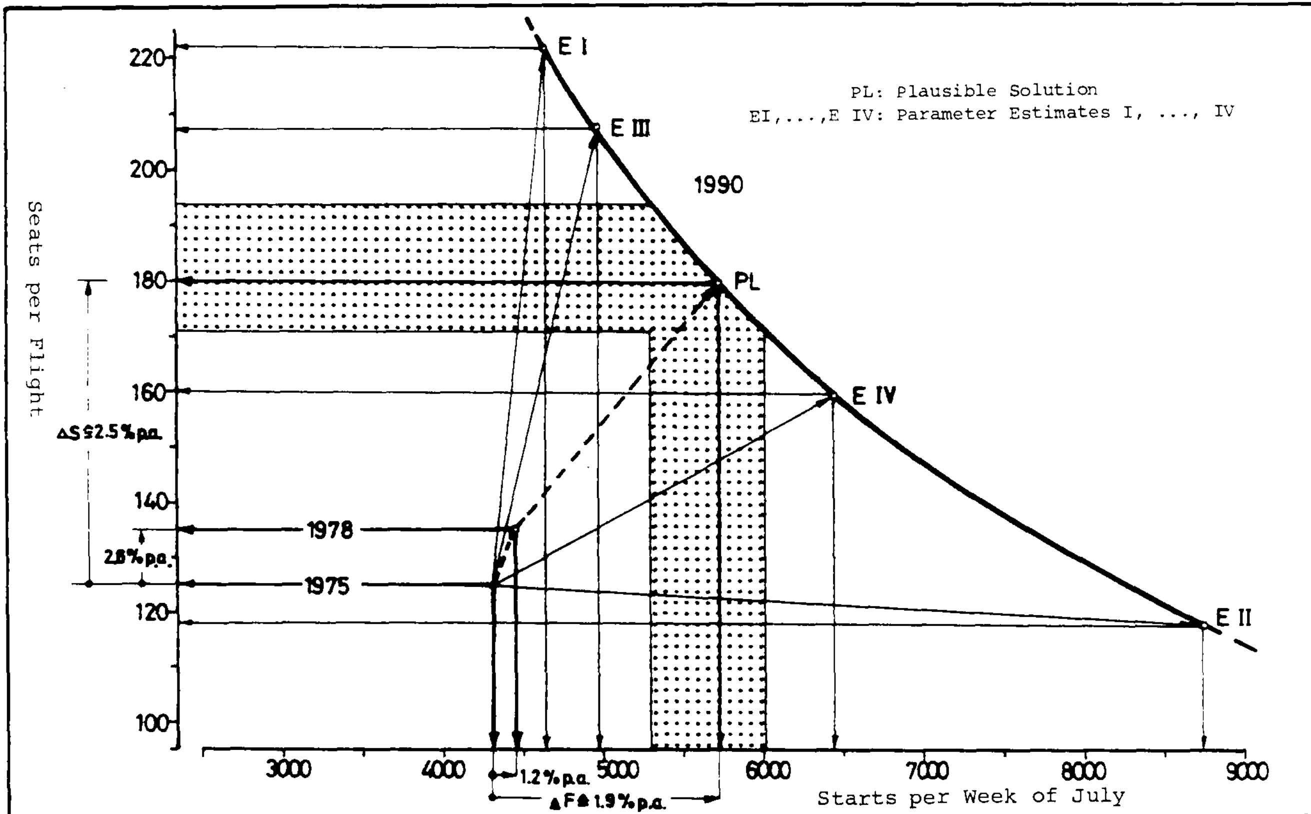
	Hamburg-Denmark		Stuttgart-France(Paris)	
	1 9 7 5	1 9 9 0	1 9 7 5	1 9 9 0
Passengers per Week of July	1 721	2 949	637	1 882
Passenger Load Factor	45%	55%	39%	55%
Seating-Capacity	3 824	5 362	1 633	3 422
Flights Provided: *				
Actual	35 T3	--	6T2, 6T4	--
E I	--	35x153 (T4)	--	12x285 (T6)
E II	--	50x107 (T3)	--	29x119 (T3)
E III	--	34x160 (T4)	--	16x220 (T5)
E IV	--	35T3,6T5	--	6T2,6T4,9T5
PL	--	22T3,13T5	--	13T3,12T4

* measured in frequency x type-class or frequency x seats per flight

DFVLR

Examples for the application of the method

Figure 4



DFVLR	Relation between the average seating capacity per flight and the number of flights by given passenger volume for the scheduled traffic 1990	Figure 5