International Air Rail Organisation

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Air-Rail Forecasting

IARO Report 18.13: **Forecasting Air-Rail**

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IARO's mission is to spread world class best practice and good practical ideas among airport rail links world wide.

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1. Introduction

IARO

IARO's vision is to be the trade organisation of choice for key stakeholders in the air/rail sector, which facilitates communication, shares best practice and promotes its members' interests. This report includes areas of best practice and some examples where a better solution might have been considered.

Many of IARO's members are, or have been, directly involved in the planning, design and operation of the air rail links discussed in this report. Details of their activity and the lessons to be learned can be obtained by becoming a member of IARO.

The need for forecasts

There are around 200 airports with rail links in the world (see IARO report 17.13) and many more are under construction or planned. Airports in most countries are growing and see a need for rail links to ensure that air passengers and employees can get to and from their destinations easily and without delay. Rail links are essential at most large and medium airports and may also have a role at smaller airports. Much rail infrastructure was originally built in the era before air travel and there is therefore often a need for new lines as well as services. This investment is expensive and investors, be they public or private sector, want to know if their investments will provide a return. City and airport authorities also want to know if a rail link will help to manage road congestion and serve their airport. Airports also want to be sure that a rail link will be a valuable asset in terms of providing choice to air passengers. There are therefore a number of stakeholders who would like an accurate prediction of the outcome.

The investment may be in the order of hundreds of millions of dollars, pounds or euros and the return is likely to be over many years, so forecasting is a real challenge. Although there is now significant experience worldwide, in many locations an air rail link may be the first of its type and it is therefore difficult to forecast on an incremental basis - for example, the effect of a small change on an existing service.

Often, the best place to start, although it is only a start, is to look at similar air rail links elsewhere. For a given size of airport with similar characteristics, for example distance to city, type of traffic etc, it may be possible to note the proportion of air passengers using a rail link. However, care should be taken as rail shares vary from a few percent to over 50 per cent. Examples of mode shares achieved by various airport rail links are shown in Figure 1. There are some surprises in these figures, for example small airports do not necessarily have small rail shares, airports with dedicated rail links do not necessarily have large rail shares and airports with a number of rail services do not necessarily have a higher rail share. However, it is clear that North American airports generally have lower rail shares than European or Asia airports. This may be in part because air rail links in North America tend to be metro or light rail types aimed at employees, whereas service quality may be a more important factor for air passengers. It is also important to note that public transport mode shares (which include bus and coach) will show a different pattern.

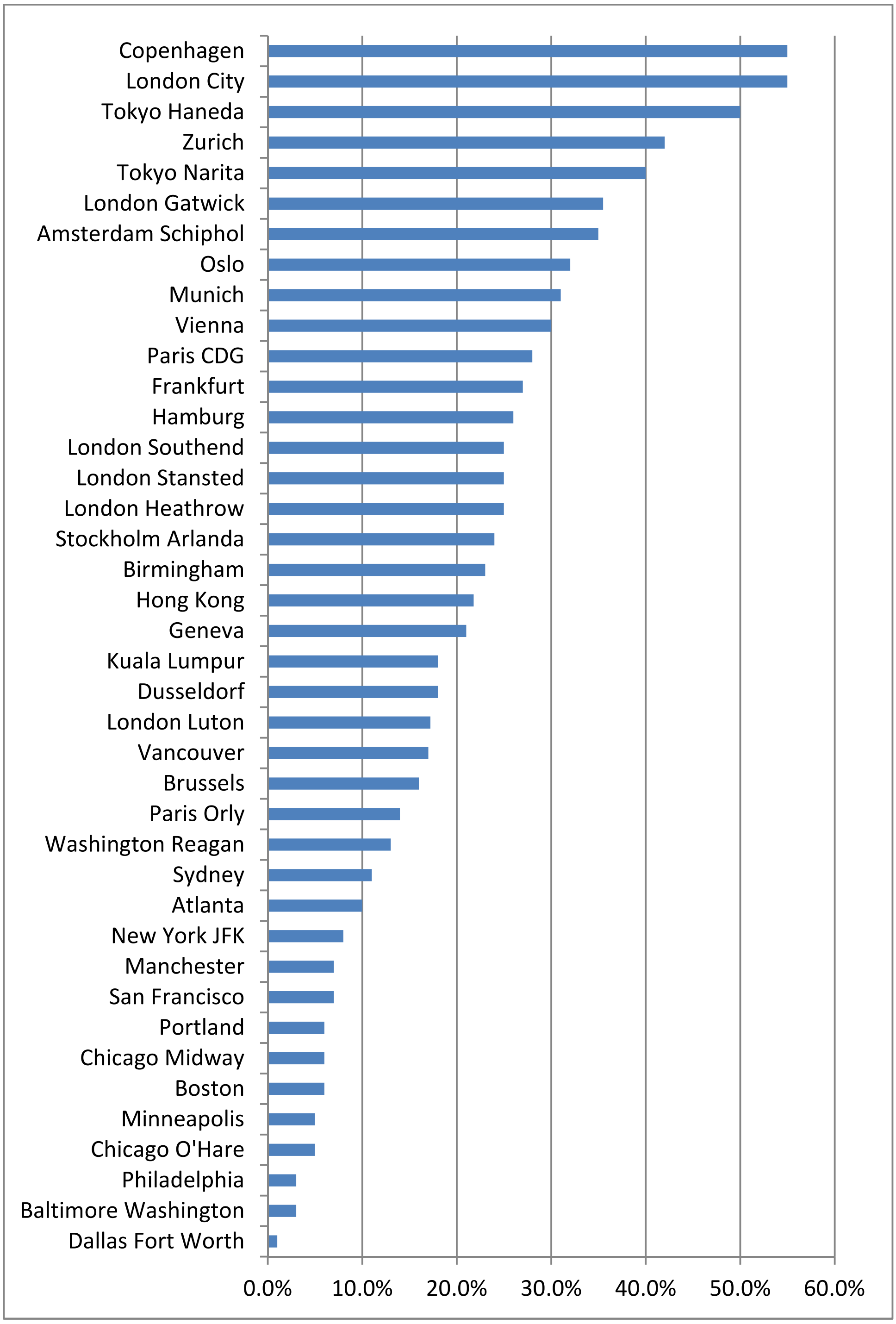

Figure 1 Airport rail shares

2. Forecasting air passenger usage of air rail links

Introduction

Rail is one of several modes which might be used by air passengers travelling to or from an airport. The most common method of preparing airport rail link forecasts is to take a forecast of air passengers and divide it into the various modes. The first step is to deduct transfer passengers (who by definition do not need a ground access mode) to give the number of terminating passengers. The next step is then to seek to divide the terminating passengers into modes based on a number of characteristics of the passengers and the modes, one of which will be rail.

A comprehensive review of airport ground access mode choice models can be found in ACRP Synthesis 5[1]. A brief summary of the methods of forecasting air passenger use of rail is set out in the paragraphs which follow.

Market Segmentation

The starting point is the number of terminating (ie. non transfer) air passengers at an airport, either existing (for a previous year) or a forecast for a future year. This number should then be split into geographic zones according to origin or destination. As a minimum, this should be those going to or from the city centre and all others, but a larger number of smaller zones may be appropriate. An example of the zones use in a model of ground access to a London Gatwick Airport is shown in Figure 2.

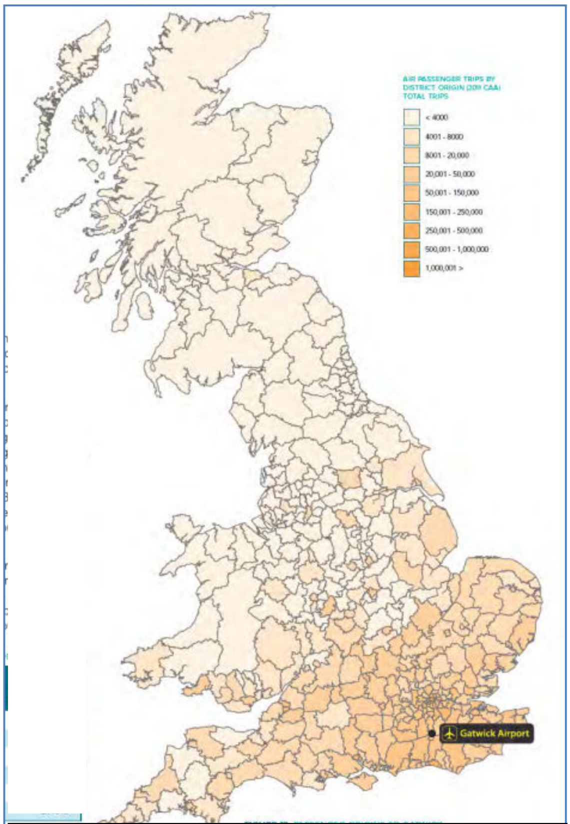

Figure 2 Gatwick Airport Surface Access Zones

The numbers of air passengers from each origin/destination should then be separated into different market segments, usually as follows:

- Resident international business
- Resident international leisure
- Non resident international business
- Non resident international leisure
- Domestic business
- Domestic leisure

The significance of residency is that resident passengers tend make journeys to and from their home, and have access to a private car, whereas non resident passengers tend to make journeys to or from a hotel or office and do not have access to a private car. This means that non residents are more likely to have journeys to the centre of the city and are more likely to use public transport.

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[1] Airport Ground Access Mode Choice Models, Geoffrey D Gosling, ACRP Synthesis 5, 2008 http://onlinepubs.trb.org/onlinepubs/acrp/acrp_syn_005.pdf

The significance of journey purpose is that business passengers have a higher value of time and are more likely to use modes which are quicker or more reliable, while leisure passengers are more likely to use cheaper modes. To an extent, business passengers are also more likely to be travelling to or from a city centre, while leisure passengers are more likely to be travelling in groups and have more luggage, making public transport more difficult or expensive.

The significance of international/domestic is that domestic passengers may be residents of the country but not residents of the city served by the airport. Thus a resident passenger on a domestic trip may be travelling to a city (rather than from it) and will have the characteristics of a non resident.

An illustration of this can be seen in the data from a small UK airport. A survey at this airport showed that, on a domestic route where over 50% of passengers were non residents, nearly 50% of them used public transport. On the other hand, on an international route where virtually all the passengers were outbound residents travelling for leisure purposes, none of them used public transport. This may be an extreme example but it illustrates the trend.

Of course, these segments are not the only ones, but they have been shown to be the most significant in terms of mode choice.

The probability of a passenger from a market segment and a geographic zone using a mode is sometimes known as the 'preference' and such preferences can be found by surveys where potential passengers are asked to choose a mode given a set of circumstances (eg. fare, journey time etc). This is known as a 'stated preference' survey. An alternative, which is more reliable but not possible where the mode is new, is 'revealed preference', where passengers' actual behaviour is monitored.

Modal Shares

The next step is then to look at each segment and determine the propensity to use each mode. Some models look at all modes together and are known as Multinomial Logit, but more recent versions are called Nested Logit which consider choices in a way similar to the passenger. An example of the Nested Logit model is shown in Figure 3.

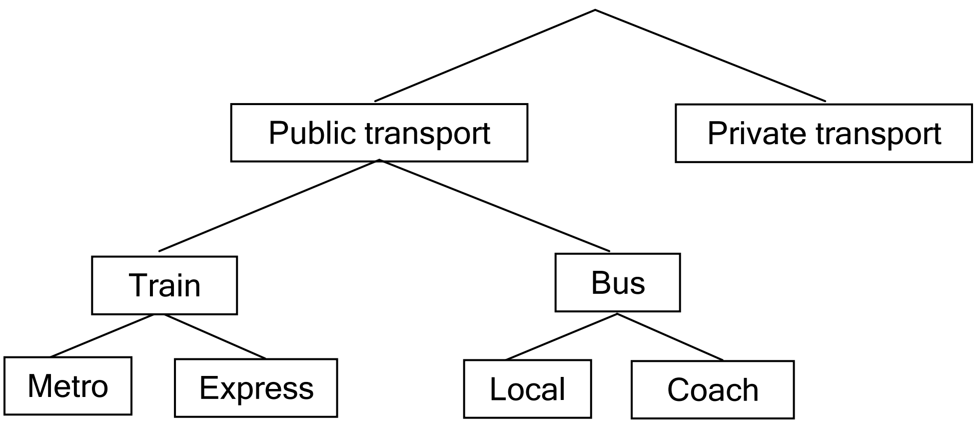

Figure 3 Nested Logit model structure

The Nested Logit model replicates the first choice made by passengers – can I use private transport? – which is primarily determined by the availability of a private car, and then looks at the public transport choices. The illustration in Figure 3 may not be the only way in which the modes are 'nested'. For example, there is an argument that some passengers might consider the first choice as between a dedicated express rail link and a taxi, so that if a particular mode of public transport is not available, they will effectively chose a private mode.

The choice between public transport modes is based on the various characteristics of the modes – their costs, journey times, frequencies, etc., which are usually represented by a generalised cost. This is where the value of time becomes important, as the value of time for a business traveller (eg. $50 per hour) may be significantly more than for a leisure traveller (eg. $10 per hour) so that a quicker, more expensive journey is more likely to be chosen by a business traveller than a leisure traveller. The journey times and costs are those to the centre of the origin or destination.

For each segment, there is a different equation which gives the probability that a passenger will choose a particular mode. For example, the probability that a resident international business passenger will use an express train is determined by the fare plus the journey time plus the waiting time costed at an appropriate value of time. As it is a probability (ie. a proportion), it is then applied to the relevant number of passengers to give a forecast of the number of passengers using the express train. An example of the equation for rail is as follows:

$$U_{rail} = \frac{T_{rail} + \alpha W_{rail} + (1/v)F_{rail}}{\sqrt{D}} + \tau_x X1 + \tau_1 I1 + \tau_2 I2 + \Theta$$

This complicated formula can be explained in logical terms as follows.

- U_{rail} is the Utility of rail or, in other words, the probability that a passenger in a particular segment will use rail.
- T_{rail} is the in-vehicle time plus an access time. So, for example, a 30 minute rail journey with a five minute walk at either end would give a value of T of 40 minutes. Of course, the function may be more complex if there are several modes, for example a taxi to the station.
- W_{rail} is the wait time, which is usually noted as half the frequency. Thus a train operating every 30 minutes has an average wait time of 15 minutes. This is acceptable for relatively high frequency services, but would not be appropriate for example for a service every 2 hours, because the passenger will seek to time the journey to meet the timetable. α is a weighting applied to the wait time, as some passengers perceive the wait time as longer than in-vehicle time, for example 1.5 times.
- F_{rail} is the fare and this is multiplied by 1/v to convert it to a time, where v is the value of time. So, for example, if the fare is $10 and the value of time is $50 per hour which is $0.83 per minute, this function would equal (1/0.83) x 10 = 12.05 minutes
- The total of these three elements is then divided by the square root of D, the distance from the origin or destination to the airport. If for example this distance is 20 kilometres, this would be (40 minutes in-vehicle + 22.5 minutes weighted wait time + 12.05 minutes fare) / 4.47 = 16.67.
- The parameters τ_x, τ_1 and τ_2 represent various interchange penalties, for cross-platform interchanges between two rail services and for various intermodal changes, for example between taxi and rail.
- Θ is a 'modal constant' which represents an additional likelihood of using a particular mode because of its particular quality aspects. This is usually applied to dedicated airport express services. For example, for the Heathrow Express service this can have a value of between 3 and 18 (depending on passenger type).
- The higher the total, the greater is the 'utility' of the mode for that particular geographic zone and that particular type of passenger and therefore the more likely that mode will be chosen.

The journey times, fares and distances are factual and the other values are estimated, either from actual passenger behaviour (known as revealed preference) or from surveys of what passengers might do (stated preference). The modal constant is sometimes controversial, as it represents a value which cannot be explained by the factual data of times and distances. However, it is clear that many passengers will choose a dedicated option even if it is significantly more expensive.

For each geographic zone, each passenger type and each mode there is an equation. Once these are all calculated, each result can be compared with the total to give a proportion of passengers using each mode. This proportion is then applied to the number of terminating passengers to give a forecast by mode.

Validation

It is normal practice in forecasting models to seek to validate the model by looking at historic results (backcasting). This then provides confidence that the forecasting reasonably predicts future trends.

Assumptions

In order to produce rail share forecasts, it is of course necessary to make assumptions about the future characteristics of passengers, particularly the six market segments referred to earlier. This in turn is a forecast, or at least an assumption, and may itself be subject to error.

Explanations of the various market segments and examples of how they are used, as well as a comprehensive review of airport public transport, can be found in a series of ACRP and TCRP reports authored by Matthew Coogan[2,3,4].

Using Airport Rail Forecasts

The most critical use of airport rail forecasts would be when a proposal for a new link is made and the decision to proceed and the financial terms may be entirely dependent upon the forecast. In these circumstances it is almost always better to be cautious and look for assumptions which have a large impact on the result and test these thoroughly. If the forecast is for an existing link for a short period when the service (or competing services) are not changing, then it is less critical and less subject to error.

The fare is an important element in the formula and it is possible to forecast the revenue and, if costs can be predicted, the profit. If all other things are equal, a higher fare will result in fewer passengers. However, the revenue will grow with fare until it reaches a maximum and then decline. Figure 4 shows a simple example with fares of between 5 and 15 (currency units) where

[2] Ground Access to Major Airports by Public Transportation, Matthew A Coogan and others, ACRP Report 4, 2008
http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_004.pdf

[3] Improving Public Transportation Access to Large Airports, Matthew A Coogan and others, TCRP Report 62, 2000
http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_62-a.pdf

[4] Strategies for Improving Public Transportation Access to Large Airports, Matthew A Coogan and others, TCRP Report 83, 2002
http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_83a.pdf

corresponding passenger numbers fall from 15 million to 5 million and where revenue (fare x passengers) maximisation occurs at a fare of 10. Of course, if the objective is passenger maximisation (for example to relieve road congestion), then revenue maximisation will be secondary.

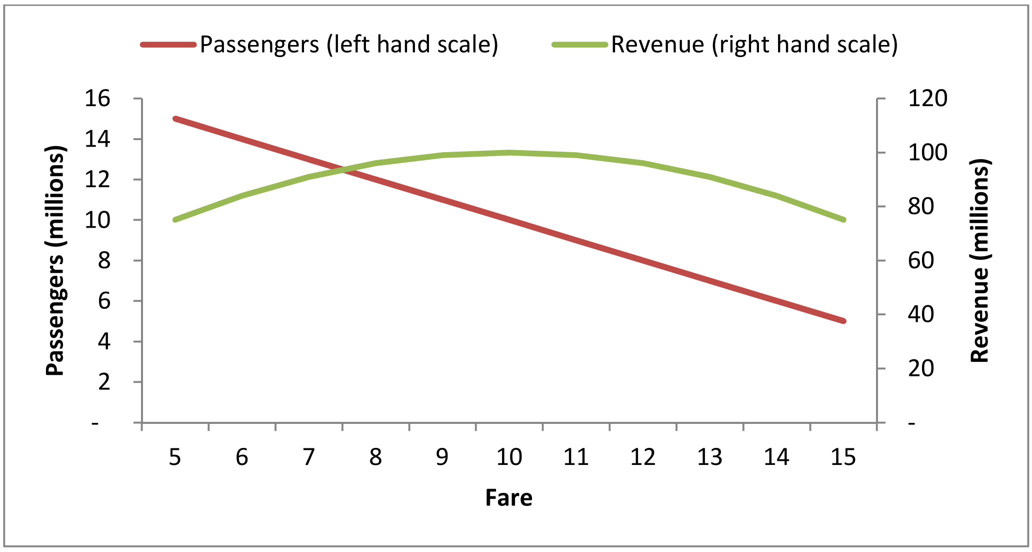

Figure 3: Simple example of revenue maximisation

Another use of airport rail link forecasts might be to determine resource allocation (eg. staffing, rolling stock requirements). For this, there needs to be an understanding of the airline arrival and departure pattern and the lead and lag times related to airline timetables. Airport rail link patronage is unlikely to follow the same pattern as commuters, for example with high flows in the tourist season (usually Summer) when commuter flows are lower. The daily and weekly pattern of movement will also be different from commuters.

<u>Conclusions on air passenger forecasting on airport rail links</u>

Forecasting air passenger usage of airport rail links requires an understanding of the geographic origins and destinations and the market segmentation of passengers. These characteristics give rise to different propensities to use various modes of transport which can be modelled against variables such as travel time, fare and other factors. Once these are determined for each zone and segment, they can be added to give a total forecast. As with any forecast, the assumptions are critical and should be tested, not least be checked against actual usage at similar situations. Passenger forecasts lead to revenue forecast which can then be used in looking at the financial situation of a proposal or to test various fare levels. Daily, weekly and seasonal flows on airport rail links will be different from other rail users.

3. Forecasting employee usage of air rail links

Employees can be a significant group of passengers on airport rail links, especially if the link is a metro or network type serving the local area where employees live as well as the city centre. It is possible to create a simpler version of the nested hierarchical logit model described above for air passengers. However, it is more usual to use the same modelling process that is used for forecasting city wide transport networks, with the airport as a major employment centre. This is often described as having four key steps, as follows:

- Trip generation: the number of trips at a particular location (eg. daily number of employees at the airport)
- Trip distribution: where the trips are going to
- Mode choice: what proportion will use each mode
- Assignment: allocating each trip to a particular route

Particular considerations that should be given to airport employees in such models include shift patterns. Some airports operate 24 hours but most have early starts and late finishes, in plenty of time before the first passenger arrives or after the least passenger leaves. Other servicing staff work during the quieter night period. The shift pattern often means that public transport, which tends to provide a service designed for normal Monday to Friday commuting, may not be suitable.

Data on rail mode shares for employees at airports is vey scarce, but some is shown in Figure 5.

Airport	**Employee rail mode share**	**Notes**
London Heathrow	5%	Piccadilly Line
London Gatwick	11.4%	
London Luton	6.2%	
London Stansted	5.7%	
London City Airport	22%	
Birmingham	5.3%	
Chicago O'Hare	20.7%	
Boston	11%	
Stockholm	7%	Arlanda Express. Estimate based on 435,000 annual journeys and 16,000 employees
Vienna	15%	City Air Train
Lyon	5%	Rhonexpress

Figure 5: Employee rail share

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