Introduction

Australia's experience with airport rail links in Sydney and Brisbane have reportedly proved to be somewhat unsuccessful in terms of patronage, or lack of it. Furthermore, as a possible consequence, the Victorian Government earlier this year decided to put on hold the concept of the Melbourne airport rail link.

The Australian experience has prompted this investigation into the drivers behind airport rail link patronage along with other issues that should be considered when providing an assessment of the ridership forecast.

This paper compares airport rail links in the USA and Europe in addition to the two Australian cases. The key comparative measure in each case is the rail mode share, and factors considered as being important in having an impact on this mode share are discussed. Other factors, evident in the case of Australia, are also covered in a qualitative manner rather than quantitative, which are considered to have a bearing on the mode share **and** also on the reasoning as to why ridership has not achieved levels that were forecast.

Methodology

Data was obtained for 7 airports in the USA, 4 in the UK, 12 in Continental Europe and 2 in Australia. Only those with 10 million or more passengers per annum were included in the study. Data for these 25 airports, all with rail links, were analysed to identify trends which could explain the relative success of each rail link in attracting a greater or lesser proportion of passengers travelling to the airport.

Four main areas of investigation have been explored, namely:

- Global metropolitan characteristics – most importantly indications of the urban form, the level of car dependency versus public transport usage;
- Geographic position of the airport in relation to the metropolitan area;
- Supply side characteristics of the rail link itself;
- Demand side characteristics – the profile of the passenger market; and
- In the case of Australia, other pertinent but non-quantifiable factors.

Statistical regression techniques have been utilized, where possible, to assess the relationships and the significance of the dependency, if any, between rail market share and the underlying dependent variable.

Overview of Existing Rail Mode Shares to Airports with Direct Rail links

The percentage of passengers using rail as their main access mode, for airports direct rail links, is shown in Table 1 below. The table also shows the total number of passengers enplaning and deplaning annually at each of those airports.

Transferring passengers are explicitly excluded from the calculation of mode share. These transferring passengers in general never leave the airport, with the exception of those long stop-over passengers, and as such should be excluded from the calculation of land-side airport surface access.

Table 1 Rail mode shares for airports with direct rail links (data is for the year 2000 where available)

Continent	Airport	Total Annual Passengers in Millions (including transfers)	Rail Share (%) of Air Passengers (excluding transfers)
Europe	Oslo	14	43
	Zurich	23	35
	London Stansted	12	28
	Munich	23	28
	Rome	26	28
	Amsterdam	40	25
	London Heathrow	60	25
	Paris CDG	48	24
	Frankfurt	49	22
	London Gatwick	29	22
	Brussels	22	18
	Dusseldorf	16	16
	Paris Orly	25	8
	Barcelona	20	7
	Vienna	12	7
	Manchester	17	6
Australasia	Sydney	23	6[1]
	Brisbane	11	3-5[2]
N. America	Washington National	15	14
	Atlanta	77	8
	Chicago-Midway	13	8
	Chicago-O'Hare	72	4
	St. Louis	30	3
	Cleveland	13	3
	Philadelphia	23	2

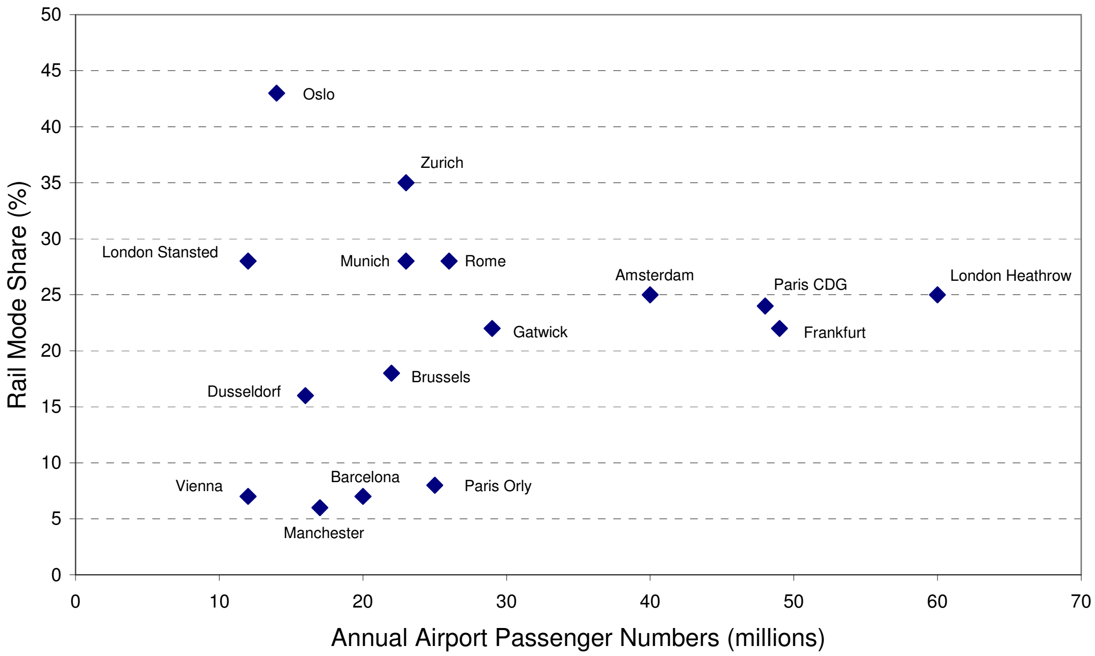
[1] Estimate based on a newspaper article by Darren Goodsir.
[2] Estimate based on a newspaper article by Matt Robbins estimating that the rail link was carrying 6,000 passengers a week in August 2001.

It is important also to note that in all of the USA cases studied (presented above), the rail links form part of the respective cities' public transport network. Some of the European examples are special dedicated links, e.g. Oslo, or possess both, e.g. London with the Heathrow Express and the Piccadilly Tube Line. This opens the door to the consideration that the type of service offered will generally influence the type of market that it will attract - A dedicated rail link with 'branded' rolling stock will target the business (premium) passengers for which premium fares can be charged, whilst a standard commuter train forming part of the public transport network is more likely to attract the leisure and fare-sensitive market.

There are two immediate conclusions to draw form the table above:

- The rail mode share is much higher for European airports than for American and Australian airports; and
- The total number of passengers at each airport has no bearing on the rail mode share, as shown graphically in Figure 1 below, presenting share and total passenger market for the European examples.

Figure 1 Mode Share for European Airports and their Respective Annual Number of Enplaning and Deplaning Passengers



On a comparison across continents, rail links at European airports are found to have a significantly larger rail mode share than the USA – 20% on average for Europe compared to 6% for the USA. Australia is found to be closer in comparison to the US examples rather than Europe at 7%. Looking at the range of results, in Europe, the largest rail mode share is found at Oslo Airport (43%), and the lowest at Manchester (6%). Similarly, for American airports, the largest rail mode share is found at Washington National Airport (14%), and the lowest at Philadelphia Airport (2%).

Metropolitan Characteristics

The first consideration as to the need, and success, of an airport rail link would have to be the characteristics of the city and its metropolitan area. Firstly, it has to have a sufficiently large population base. A high density of this population is also considered to be important, particularly within the rail corridor. Public transport usage and hence awareness may also be a feature indicative to usage of an airport rail link service, whilst high car ownership is considered as being detrimental to increased rail link usage.

For this analysis of Metropolitan characteristics on airport rail link usage, extensive use was made of the "Millennium Cities – Database for Sustainable Transport", produced by the UITP and ISTP, which compare 100 cities world-wide with respect to socio-economic indicators, public transport supply and demand, along with private transport supply and demand. The database contains three of the U.S. cities with direct airport rail links, twelve of the European cities and Sydney, Brisbane and Melbourne. Selected key indicators are shown in the Table 2 for a base year of 1996.

Table 2 Key background indicators (1996)

City	Population (millions)	Urban Density (Population / Hectare)	% Passenger km by Public Transport	Cars per 1,000 Population
Oslo	0.9	24	16	383
Zurich	0.8	44	24	462
London	7.0	59	27	332
Munich	1.3	56	30	469
Rome	2.7	56	34	655
Amsterdam	0.8	57	17	322
Frankfurt	0.6	48	14	451
Paris	11.0	47	24	418
Brussels	0.9	72	22	454
Barcelona	2.8	197	35	370
Vienna	1.6	69	25	373
Manchester	2.6	51	13	372
European Average		**56**	**24**	**401**
Sydney	3.7	19	12	516
Brisbane	1.5	10	5	596
Melbourne	3.1	14	8	594
Australia Average		**14**	**8**	**569**
Washington	3.7	14	4	572
Atlanta	2.9	6	1	746
Chicago	7.5	17	4	573
US Average		**14**	**4**	**573**

Each of these, where data exists, is plotted separately against airport surface access rail mode share, presented in figures 2 to 5 below. These individually show that there is no apparent, clear (and significant) relationships between any of the afore-mentioned characteristics and rail mode share. Nonetheless, they do highlight an apparent continental, or perhaps 'cultural' impact, with a clustering of European and American / Australian data (NB: taking into account the limited data).

Figure 2 Population versus Rail Mode Share (%)

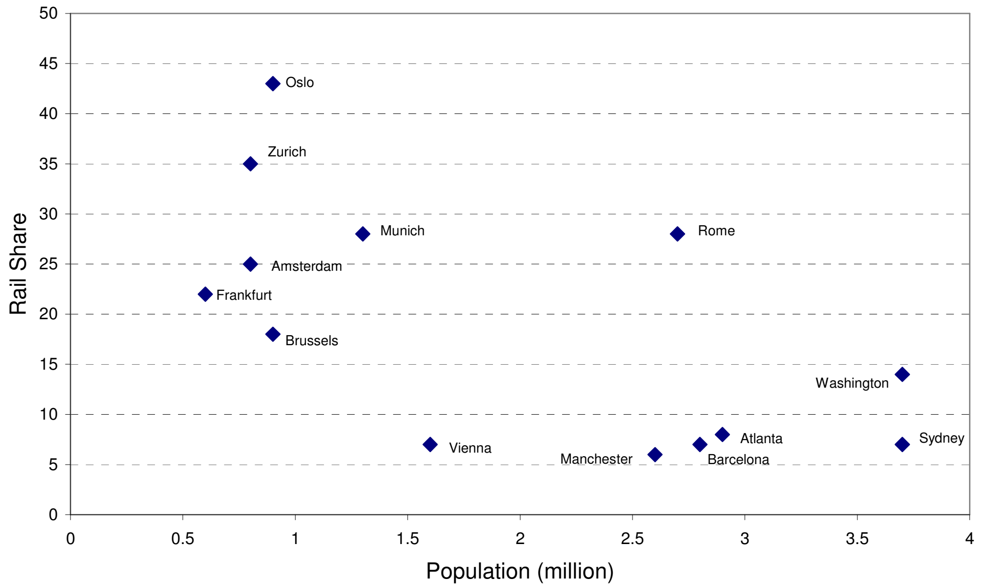


Figure 3 Urban Density versus Rail Mode Share (%)

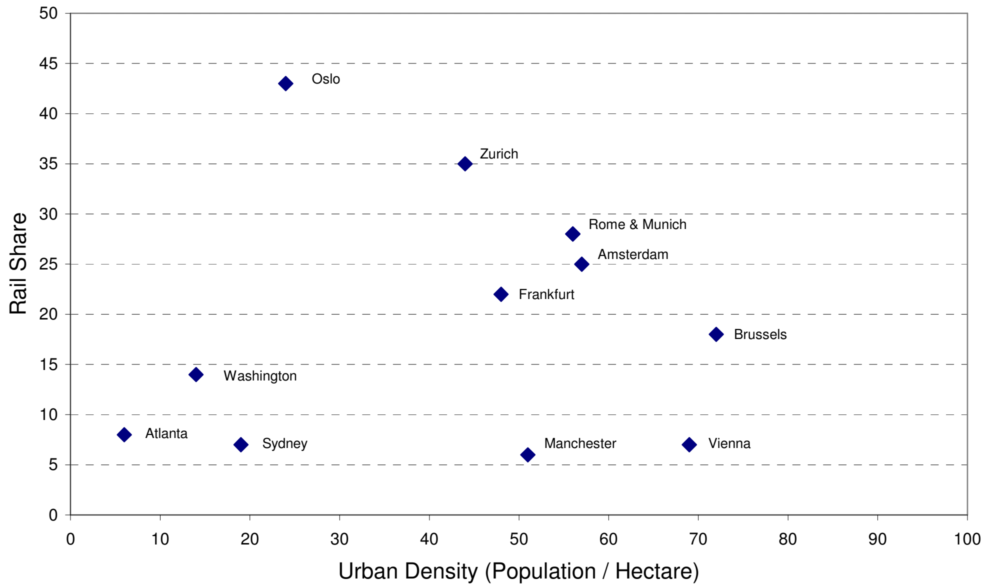


Figure 4 % Passenger km by PT versus Rail Mode Share (%)

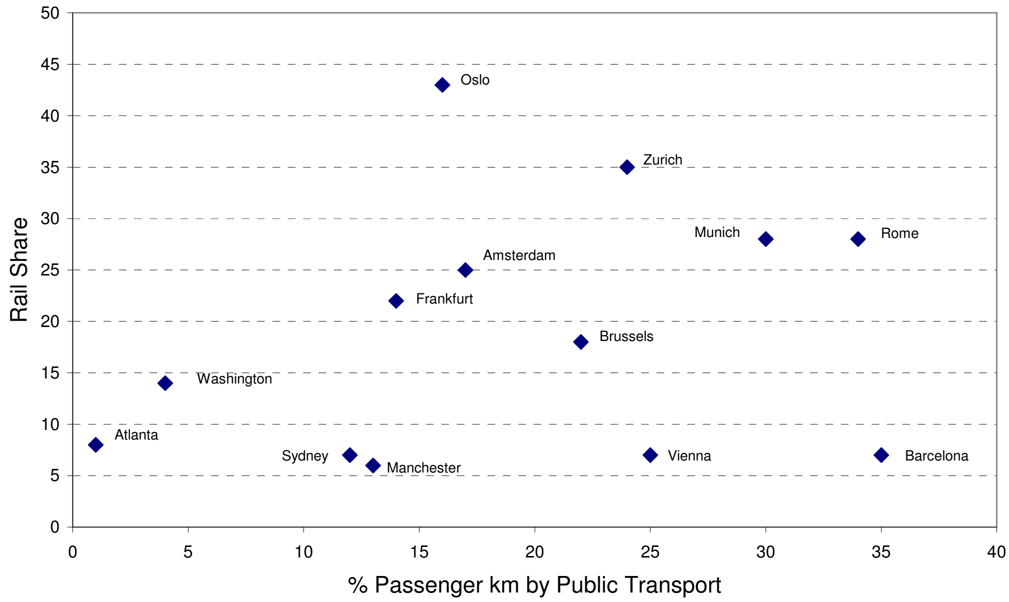
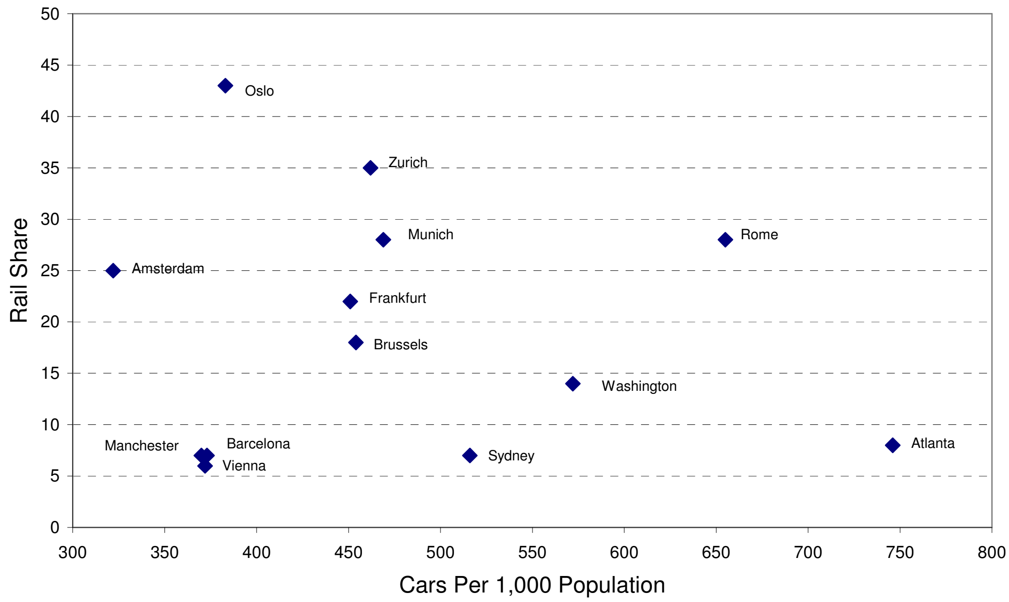
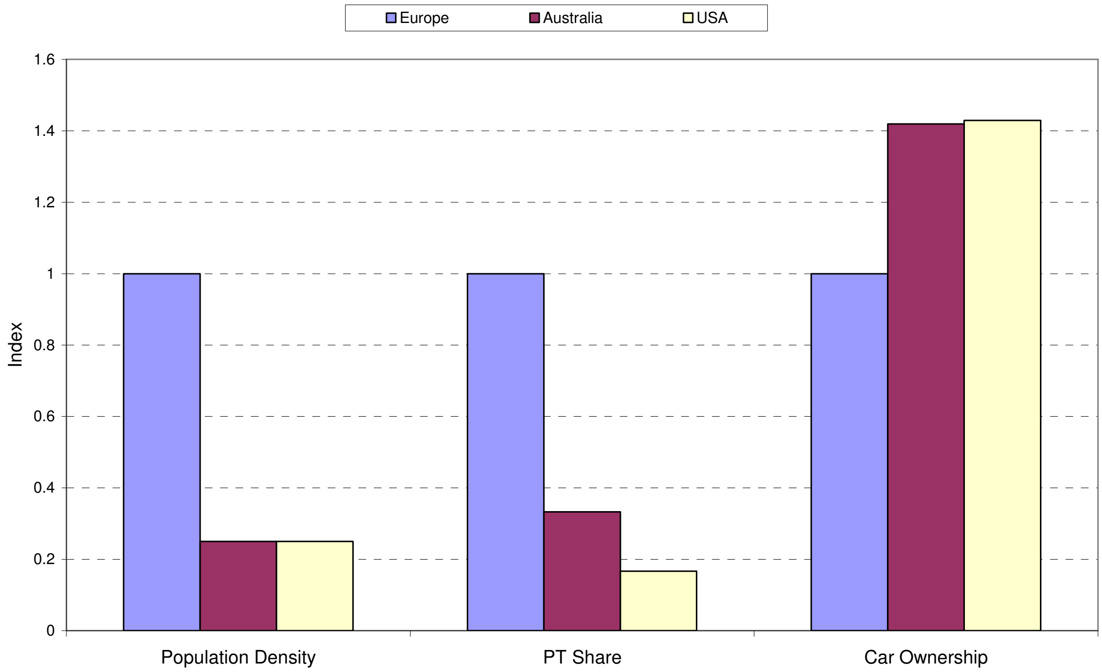


Figure 5 Cars per 1,000 Population versus Rail Mode Share (%)



Comparing the metropolitan characteristics with each other rather than with airport rail patronage, figure 6 below clearly shows Australia to be more comparable to the USA when looking at the continental averages. Consequently, in terms of the average rail link rail mode share on a 'continental' level, this indicates that low population density; low usage of public transport in the city (as a whole); and high car ownership (though to a lesser extent) are indicative of low airport rail link mode share, and vice versa.

Figure 6 Comparison of Key Indicators



Geographic Position of the Airport

The geographic position of the airport in relation to the metropolitan urban area is identified as a key factor that affects rail mode share at the airport. The more remote an airport is from the edge of the metropolitan (urban) area, the greater the potential for rail use since more of the urban area falls within the rail corridor – both in practical and "psychological" terms.

For this reason, the distance of the benchmark airports from their metropolitan city centres was compared to the distance from the city centre to the edge of the metropolitan built-up area. An "isolation index" was calculated as the distance from the CBD to the airport divided by the distance from the CBD to the edge of the metropolitan built-up area[3]. The resulting indices are compared with the current rail mode share in Table 3 and Figure 7.

[3] In many cases a convenient boundary is provided by an outer ring road (e.g. London's M25). In other cases the edge of the urban area has been estimated from maps.

Table 3 Airport isolation indices versus Rail mode share (%)

Airport	Isolation Index	Rail Share
Oslo	3.00	43
Zurich	2.00	35
London Stansted	1.80	28
Munich	2.60	28
Rome	1.90	28
Amsterdam	2.50	25
London Heathrow	0.95	25
Frankfurt	1.50	22
Paris CDG	1.30	24
London Gatwick	1.50	22
Brussels	1.60	18
Dusseldorf	1.10	16
Paris Orly	0.60	8
Barcelona	1.60	7
Vienna	2.00	7
Manchester	1.20	6
Sydney	0.50	6
Brisbane	0.80	3-5
Melbourne	0.90	N/A
Washington Nat.	0.50	14
Atlanta	1.00	8
Chicago-Midway	0.90	8
Chicago-O'Hare	1.00	4
St. Louis	0.90	3
Cleveland	1.00	3
Philadelphia	0.80	2

The figure shows that there is clearly some relationship between the “isolation index” and the percentage of passengers using rail, and this is especially true of the European airports. Although the R^2 goodness of fit statistic is relatively low 0.56), the t statistic for the linear regression on the isolation index is highly significant at 5.2.

The US airports have a much lower isolation index, as does Sydney airport in Australia. This is probably due to the rapid expansion of the metropolitan suburbs that have “engulfed” existing airports. In Europe, stricter planning controls are generally in place (such as the green-belt policy in the UK) that have limited urban sprawl, or the airports are newer and have been deliberately located further from the city.

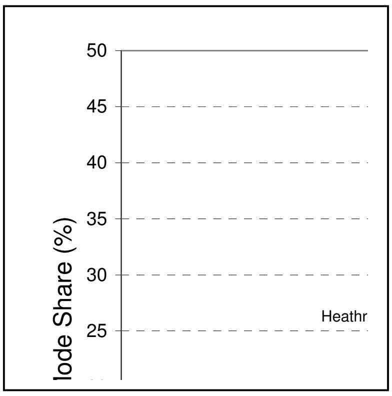


Figure 7 Airport Isolation Indices versus Rail Mode Share

Supply-Side Considerations

Clearly supply-side characteristics can be viewed as hurdles to capturing a ‘reasonable’ percentage of the passenger market. These characteristics include:

- Ease of access between the airport railway station and the departure / arrival concourse;
- Service headway or frequency;
- Vehicle comfort / baggage facilities;
- Competitive journey times; and
- Fares lower than the equivalent taxi fare.

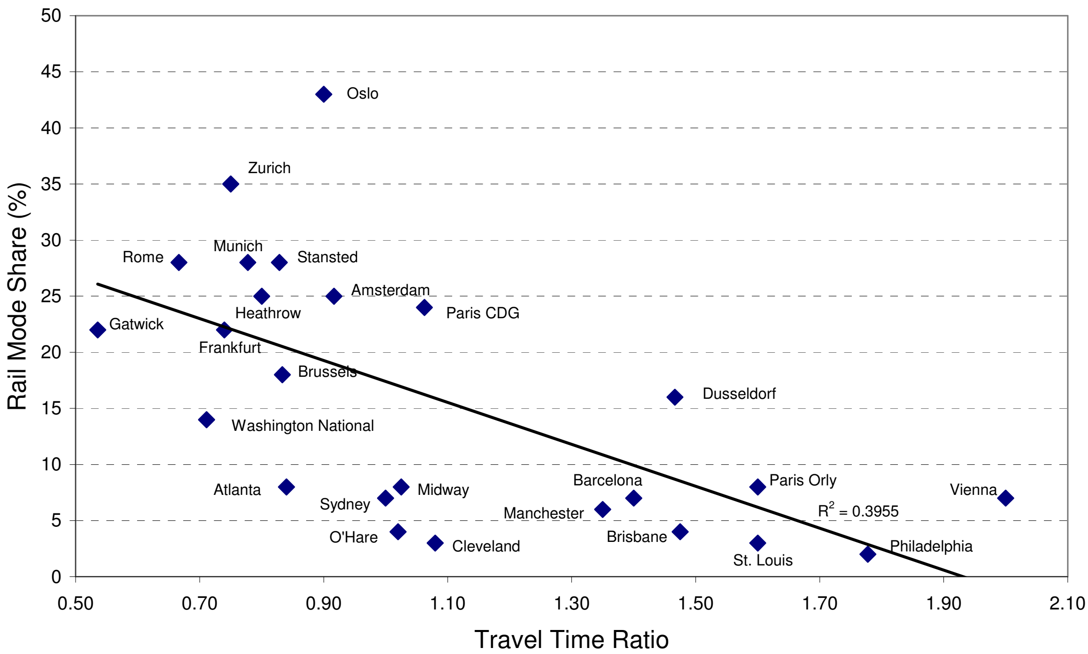
In the case of fares, there appears to be no relationship between fares charged for the rail service and the size of the market captured by rail for existing airports. This is probably because, air passengers generally have a very high value of time, and even the highest rail fares are considerably lower than the equivalent taxi fares.

Table 4 compares journey times by rail and taxi from the airport to the city centre at the airports. (Total rail journey time is taken as in-vehicle time plus half the headway.) The ratio of rail to taxi travel times is plotted against rail mode share in Figure 8.

Table 4 Comparative average travel times in minutes

Airport	Rail Time	Rail Frequency	Total Rail Time	Taxi Time	Ratio	Rail Share (%)
Oslo	33	15	41	45	0.90	43
Zurich	10	10	15	20	0.75	35
London Stansted	43	30	58	70	0.83	28
Munich	30	10	35	45	0.78	28
Rome	20	20	30	45	0.67	28
Amsterdam	20	15	28	30	0.92	25
London Heathrow	35	10	40	50	0.80	25
Frankfurt	11	15	19	25	0.74	22
Paris CDG	35	15	43	40	1.06	24
London Gatwick	30	15	38	70	0.54	22
Brussels	15	20	25	30	0.83	18
Dusseldorf	12	20	22	15	1.47	16
Paris Orly	30	20	40	25	1.60	8
Barcelona	20	30	35	25	1.40	7
Vienna	27	30	42	21	2.00	7
Manchester	22	10	27	20	1.35	6
Sydney	15	10	20	20	1.00	6
Brisbane	22	15	30	20	1.48	3-5
Washington Nat.	12	8	16	23	0.71	14
Atlanta	17	8	21	25	0.84	8
Chicago-Midway	35	12	41	40	1.03	8
Chicago-O'Hare	45	12	51	50	1.02	4
St. Louis	23	10	28	18	1.60	3
Cleveland	22	10	27	25	1.08	3
Philadelphia	25	30	40	23	1.78	2

Figure 8 Rail Share (%) versus Travel Time Ratio



The graph shows that there is a significant relationship between the travel time ratio and the mode share by rail, with the t statistic for the linear regression on the travel time ratio calculated as 3.8.

Demand-Side Considerations

Demand-side issues are those factors reflecting passenger characteristics which, unfortunately, are more problematic in terms of comparisons across airports, largely because:

- Some airports do not undertake regular passenger surveys;
- There is no common format for data collection; and
- Some airports are reluctant to release survey results to third parties.

Nevertheless, it was possible to obtain and analyze the following passenger characteristics, mainly for US and UK airports:

- Percentage of trips to or from the CBD;
- Percentage of trips with a business / non-business purpose; and.
- Percentage of trips with the passenger being resident / non-resident in the city.

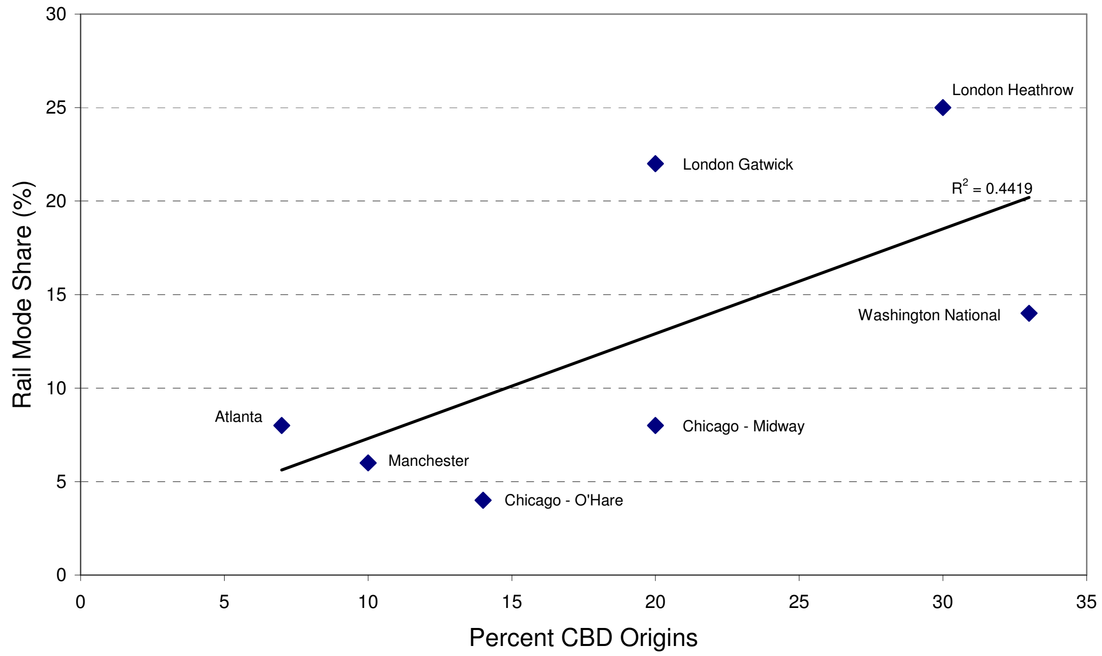
Table 5 compares the percentage of passengers whose origin or destination is the CBD, with the rail mode share of those airports for which data were available.

Table 5 Rail share (%) for CBD air passengers

Airport	CBD Passengers (%)	Rail Share (%)
London Heathrow	30	25
London Gatwick	20	22
Manchester	10	6
Washington National	33	14
Atlanta	7	8
Chicago-Midway	20	8
Chicago-O'Hare	14	4
Philadelphia	14	2

Logically, there should be a strong positive correlation between these two variables. This is supported by Figure 9 below, which shows signs of a relationship, albeit one which would be improved with a larger data set. However, although the data for the UK airports follow a logical pattern, the US data appears somewhat skewed by the rail mode share for Atlanta which appears high (by American standards) compared to the very low percentage of passengers with CBD origins / destinations.

Figure 9 Rail Share (%) versus CBD Origins



With regard to business and non-business travel, Table 6 compares the proportion of business passengers as a percentage of the total with the rail mode share of those airports for which data were available.

Table 4 Comparison of business travel and rail mode share

Airport	Business Passengers (%)	Rail Share (%)
Munich	45	28
London Heathrow	41	25
London Gatwick	18	22
Manchester	20	6
Washington National	64	14
Atlanta	66	8
Chicago-Midway	37	8
Chicago-O'Hare	50	4

In this case, with an R^2 value of 0.024, there is no evidence of a relationship between the percentage of passengers defined as business travellers and the rail mode share. However, It does appear that Washington National is a special case. The passenger profile at this airport is heavily skewed towards non-residents (see next section), on business, travelling to the CBD, presumably visiting federal government offices and a wide range of institutions, non-governmental organizations, and International Embassies

Table 5 compares the proportion of passengers that are non-resident (i.e. visitors rather than people for whom this is the home airport) with the rail mode share of those airports for which data was available.

Table 5 Comparison of residential status and rail mode share

Airport	Non-Residents (%)	Rail Share (%)
London Heathrow	45	25
London Gatwick	26	22
Manchester	14	6
Washington National	71	14
Atlanta	50	8
Chicago-O'Hare	46	4

Airports with a large percentage of non-residents should attract a higher public transport and taxi mode share since non-residents do not have access to their own cars. The data bears this out, although the results for the UK and US airports are so disparate it is not possible to perform any further regression analysis.

Based on the US data alone, as noted previously, Washington National appears to be a special case.

Australian Experience and Forecasts

The two airport rail links in Australia, Airtrain in Brisbane and Sydney's Airport Link, are both private sector projects and both, according to the press, are under-achieving in terms of ridership. Sydney was forecast to carry 48,000 passengers a week (Matt Robbins), equating to approximately 2.5 million passengers per year. Similarly, the Brisbane Airtrain Citylink consortium forecast passenger numbers at 2.3 million in the first year of operation rising to 5.7 million by 2010 and 16.5 million by 2035 (James McCullough). Estimates of actual ridership levels are 1.5m for Sydney and somewhere in the order of 0.4m for Brisbane – both somewhat short of the forecast.

Table 6 provides a comparison of the two services in terms of operational characteristics.

Table 6 Operational characteristics for Sydney and Brisbane's airport rail links (2001/2002)

	Sydney Airport Rail Link	Brisbane Airtrain
Travel Time	15 mins (to Circular Quay)	22 mins (to Roma St)
Frequency	6 trains per hour	4 trains per hour
First / Last Train	5.00am / 12.00pm	5.00am / 8.30pm
Adult 1-way Fare	$10	$9
Intermediate Stops	5 (to Circular Quay)	4
Rolling Stock	Standard CityRail	Very similar to a standard CityTrain
Dedicated Link	No	No[4]
Patronage		
Forecast & Mode Share*	2.5m (10%)	2.3m (18%)
Actual & Mode Share*	1.5m (6%)	0.3m – 0.6m (3%-5%)

* per annum

Sydney went through a bidding process, with a limited number of private sector consortia bidding against each other for the project. The consortium behind Brisbane's Airlink, had a non-competitive bid, but it was still necessary for them to produce a 'bid' to 'sell' the project to the Government. Each of the consortia will have been required to produce their own independent patronage forecasts, and it is intuitive that pressure may by placed on the patronage consultant to provide forecasts that would both be 'credible' and also sufficient to support a 'winning' bid.

[4] Not classed as dedicated as it stops at intermediate stations and enables intermediate trips (not just to and from the airport).

The previous section provided evidence to suggest that, in terms of supply and demand along with metropolitan characteristics, Australian cities were had qualities that more closely reflected the USA as opposed to the European experience:

- **Metropolitan characteristics**. Sydney, Brisbane and Melbourne are closer to the USA experience in terms of urban density, usage of public transport (mode share within the city), and number of cars per head of population.
- **Airport Isolation**. Additionally, both Sydney and Brisbane airports score low in terms of airport isolation, as with the majority of airports in the USA.
- **Supply-side considerations**. Perhaps linked to the isolation index, the proximity of the airport to the City in Australia and the USA compared to Europe result in low taxi travel times and travel time ratios (taxi time to rail time) that are conducive to lower mode shares.

Also often overlooked, with regard to the forecasts, is that they are rarely revisited after the contract has been awarded. With a gap of several years between this point in time and the opening of the service, there may have been many changes – which were not reflected in the original forecasts. Alternatively, the forecasts themselves may not have accounted for other factors in addition to those covered previously in this document, including:

- ***Competing infrastructure for other modes, namely highways, introduced post planning of the rail link***. In Sydney, for example, the opening of the Eastern Distributor has provided a more reliable and timely journey between the airport and CBD for cars and taxis. In Melbourne, the Transurban Citylink toll-road has significantly reduced car and bus journey times between the CBD and airport.
- ***Cab-charges***. The cab-charge system in Australia makes payments of taxi fares 'hastle-free' for business users, removing the tedious requirement for example to submit company expense claims. A similar facility does not currently exist for rail.
- ***Premium services***. Premium fares are not readily accepted when the passenger is provided with rolling stock that is no different to that on the urban commuter rail network.
- ***Baggage space***. The rolling stock on Sydney's airport rail link does not provide baggage storage space for air travellers. With the airport link being integrated into the CitryRail network, the inclusion of rail commuters on the same trains during peak periods exacerbates the difficulties of travelling to and from the airport by rail with baggage.
- ***Parking***. Marketing reduced car parking rates can only be detrimental to public transport access to the airport. For example, Sydney Airport is currently actively marketing its car parks - A flyer, distributed free to residents in Metropolitan Sydney, sent out in May 2002 offers a $5 discount voucher for parking for more than 1 hour at the International,

Domestic, Express Terminal or Long Term Car Parks. In the same flyer, the Long Term Car Park rates were advertised as being $34 for the first 48 hours and $13 per day thereafter.
- ***Signage***. This was initially non-existent at Sydney Airport (Streeting & Scott).

In terms of the planning of a rail link service, it is important to identify the key market and provide a service appropriate for that market. With a compact CBD and poor competition from taxis, amongst other things, it may be reasonable to assume that the target market may be the business travellers, for which a dedicated, high quality premium service may be considered appropriate. Alternatively, the target market could be the leisure traveller, with a relatively low value of time, and / or airport employees, who would be more sensitive to higher fares and therefore more likely to appreciate a low cost reliable alternative (without the frills). Patronage forecasts for Sydney airport rail link, for example, included a large proportion of airport employee trips. These did not materialize in the short term – this was considered as being due to the slow growth in residential development at Green Square and Mascot.

Conclusions

Based upon the analysis of information obtained for airport rail links in Europe, the USA and Australia, airport rail link mode share is shown, statistically, to be related to a series of different aspects. Not only are the characteristics of the metropolitan urban form important considerations, but also the relative distance from the city (CBD); the competitive travel time; and the passenger (market) profiles. This may infer that 'accurate' forecasts may be achievable prior to construction, However, the airport rail links of Australia in Sydney and Brisbane have fallen short of forecast patronage to date with ridership levels at approximately 1.5m and 0.4m passengers per year respectively, compared with pre-launch forecasts of some 2.5m and 2.3m passengers.

With Australian cities being more akin to the USA example rather than the European case, in terms of metropolitan characteristics of urban density, current usage of public transport and car ownership levels, there would be an expectation perhaps that the mode share for an Australian airport rail link would be of a similar level to those in the US. A comparison of cities in Europe and the USA with airport rail links shows a clear difference in rail link mode share between the two continents, with US airports attracting between 2% and 14% mode share and European examples attracting between 6% and 43%. Assuming that Australia is more akin to the USA example rather than European, and based on the airport size (passengers), this would give indicative "ball-park" estimates at potential patronage at between 0.5m and 3m for Sydney and between 0.3m and 1.8m for Brisbane.

However, in addition, factors such as an improved highway network; cab-charges; perceived lack of quality in service; and reduced parking charges will all compound to further discourage usage. And whilst the individual effect of any one of these factors may, in many cases, be negligible, the combined effect of one or more of these factors suddenly becomes significant. A summary of the factors affecting airport rail link mode share, identified in this document, is provided in Table 7 below.

Table 7 Factors affecting airport rail link patronage (mode share)

Factor	Importance Rating	Notes / Comments
City Population	Low	No significant impact on mode share
Urban Density	High	High density cities advantageous
Public Transport Usage	High	Exposure to PT has a positive effect
Car Ownership Level	Moderate	High car ownership → lower made share
Airport Isolation	High	More isolated airports → taxi is less competitive
Travel time (relative to Rail)	High	Bigger time savings → higher rail mode share
CBD Origins / Destinations	High	Important that the market is there, in the CBD
Trip purpose	Low	Different rail links may serve different purposes
Passenger profile (residents)	Moderate	Non-residents less likely to have the option of car
Modal Competition	High	Disadvantage to rail if alternatives are improved
Fares	Low	Though the fare should reflect the target market

When comparing forecasts with actual outcomes it is also important to ensure that the conditions under which the service actually operates matches those assumed in the forecasts. Otherwise it may be viewed as comparing “chalk with cheese”, and will also reflect unfavorably (and unjustifiably so) on those who were responsible for providing the forecasts. For example, the forecasts might have assumed a dedicated train service with new, high spec dedicated rolling stock, running every 5 minutes, whilst what is actually implemented is a standard commuter train running every 15 minutes. Whilst blatantly obvious when put like that, it is often overlooked and may be overcome, or at least the potential for error to be minimized, by continually updating the forecasts throughout the construction period as more information comes to light and as changes occur.

References

Darren Goodsir (2002) Freeway fuels the big switch to cars, page 1 of the Sydney Morning Herald, 24th June 2002.

Matt Robbins (2001) Deserted airport train heads for the buffers, page 5 of The Australian, 4th October 2001.

James McCullough (2001) Off the rails – will Brisbane’s Airtrain get on track … or crash? page 65 of the Courier Mail, 10th November 2001.

Mark Streeting & Darren Scott 2002, Australian Airport Rail Links – Will they ever take off, Smart Urban Transport, Volume 1, Number 3, 2002

Union Internationale des Transports Publics (UTIP) and Institute for Sustainability and Technology Policy (ISTP), Millennium cities database for sustainable transport, 1995