# EXPERIENCES WITH ADVANCED AIR-RAIL PASSENGER INTERMODALITY – THE CASE OF GERMANY

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**Abstract**

As capacity constraints at European hub airports have grown in recent years, policymakers often demand a better integration of different transport modes and cooperation between transport operators. One objective in this regard is a shift of short-haul feeder flights to high speed trains. However, different regulatory, operational and managerial constraints have rendered the cooperation between airlines and train operators rather difficult in the past. In Germany, a new approach was made with an innovative intermodal passenger service dubbed "AIRail", which was created in 2001 with German long distance train operator Deutsche Bahn, network carrier Lufthansa and airport operator Fraport as cooperation partners.

This paper explores general prerequisites for market success of intermodal services, as well as specific characteristics and advantages of the "AIRail" service, but also shortcomings and challenges that have been identified. Furthermore, the results of a case study on the impacts of high speed train services between Frankfurt and Cologne on air services between these cities are presented. Subsequently, the success of air-rail intermodality in Germany is evaluated from the perspective of transport providers, passengers and transport policy. Finally, prospects for the application of elaborate intermodal transport services on other city pairs in Germany are analysed, as well as the development of tools for intermodal packaging.

Keywords: Intermodality, High Speed Railway, Airport Access, Modal Substitution

# 1. Introduction

The integration of air and rail is often seen as a strategy to alleviate capacity constraints at major airports and also as an environmentally friendly way to avoid short-distance feeder flights. However, the integration of both modes is particularly challenging, on the one hand due to costly long-term infrastructure investments as prerequisite to connect airports to the railway system and on the other hand due to the difficulties in developing attractive intermodal services and ticketing options, which will be accepted by travellers. This paper will explore the experiences made in Germany with intermodal services in recent years, as considerable efforts have been undertaken to improve the cooperation between airlines and the railway operator Deutsche Bahn.

Intermodality, as proposed by the European Commission in 1997, can be defined as "a characteristic of a transport system, that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain." (European Commission, 1997). The focus of this paper is laid on the integration of the air and rail modes. Intermodality addresses the integration of transport modes at three levels (European Commission, 1997):

1. infrastructure and transport means ("hardware"),
2. operations and the use of infrastructure (especially terminals), and
3. services and regulation (from a modal-based to a mode-independent framework).

Following this systems-oriented definition, firstly an overview on the infrastructural prerequisites ("hardware") for providing passenger air/rail intermodality will be given. Secondly, a brief outline of both operational characteristics and services offered will be presented, with a special focus on the AIRail service, which offers seamless travel in the form of integrated ticketing and baggage handling. This service and its impacts on the air transport demand and supply on the short-distance route between Cologne and Frankfurt will be analysed comprehensively. The paper will conclude with ideas on the future of air/rail intermodality in Germany.

## 2. Existing railway infrastructure at German airports

In Germany, about 30 airports with scheduled air services exist, ten of them are directly connected to the railway system. A further three are accessible by either tram or subway. However, only four airports are regularly served by long-distance trains. A glance at German transport geography shows that rail is a mode which is particularly attractive for airport access. Germany does possess a very dense train network with more than 5,600 stations that are frequented by about 30,000 daily passenger trains. Investments into the high-speed rail network have considerably reduced journey times between the largest cities in the last two decades.

Currently, four German airports are equipped with long-distance railway stations: Frankfurt, Düsseldorf, Cologne-Bonn and Leipzig/Halle. The railway access at Frankfurt is particularly interesting, for several reasons. Firstly, it was the first German airport with railway infrastructure in Germany. The train station was integrated in the new terminal 1, which was built in the early 1970s. Secondly, it is the largest hub in Germany, with 24.4m originating passengers in 2004 (Fraport, 2006). Thirdly, the airport is conveniently located directly at one of the main long-distance rail arteries, connecting the western part of Germany with the southern and eastern parts. In 1999, in the course of the construction of a high speed line between Cologne and Frankfurt, a new train station at the northern perimeter of the terminal was built. After inauguration, the old station was relegated to serve only regional trains and long distance trains during night-time, while long-distance trains are stopping exclusively at the new station. The new station is insofar remarkable, as it handles about 20,000 long-distance rail passengers daily and is therefore one of the largest long-distance train stations in Germany by passenger volume. This stems from the fact, that not only persons arriving at or departing from Rhein-Main International Airport use this station. Moreover, the station is a transfer point for railroad passengers, as the line from Cologne branches at Frankfurt Airport on the one hand to Mannheim, Stuttgart and Basle and on the other hand to Nuremburg and Munich. The airport train station can be reached by rail passengers from the western Rhine-Main area faster than Frankfurt Central Station and is therefore also an important railway hub.

After the inauguration of the new long-distance railway station, train frequencies have been increased considerably - Frankfurt Airport is now served by 143 long distance trains and 215 regional/short-distance trains daily (see table 1).

Table 1: Daily train frequencies at German airports (weekdays, summer schedule 2007)

| Airport | No. of daily frequencies, regional/short distance trains | No. of daily frequencies, long distance trains | Total daily train frequencies |
|---|---|---|---|
| Frankfurt | 215 | 143 | 358 |
| Düsseldorf | 235 | 13 | 248 |
| Berlin-Schönefeld | 202 | 1 | 203 |
| Cologne-Bonn | 148 | 31 | 179 |
| Munich | 121 | - | 121 |
| Stuttgart | 111 | - | 111 |
| Leipzig/Halle | 57 | 34 | 91 |
| Friedrichshafen | 75 | - | 75 |
| Hanover | 40 | - | 40 |
| Dresden | 39 | - | 39 |

Source: German Aerospace Center (DLR), Air Transport and Airport Research Unit.

A remarkable observation made by Gelhausen and Wilken (2006), which was derived from the German air passenger survey in 2003, impressively reflects the importance of long-distance rail access to Frankfurt Airport: The percentage of passengers from major German metropolitan areas using rail compared to other modes of ground airport access is significant, varying between 36 per cent for Berlin and 83 per cent for Hamburg. Also short-distance trains play an important role with 3,000 passengers, visitors and employees arriving at the airport on local and regional trains during peak hours (Siedenbiedel, 2007).

Table 2: Share of Passengers Using Intercity
Trains to Frankfurt Airport

| Urban Area | Share of Passengers Using Intercity Trains (As percentage of all ground access modes) | Distance to Frankfurt (kms) |
|---|---|---|
| Hamburg | 83 | 495 |
| Bremen | 57 | 445 |
| Hannover | 68 | 350 |
| Berlin | 36 | 545 |
| Dortmund | 57 | 225 |
| Düsseldorf | 70 | 220 |
| Köln | 68 | 180 |
| Leipzig | 82 | 385 |
| Stuttgart | 50 | 205 |
| Nürnberg | 44 | 225 |
| München | 66 | 390 |

Source: Gelhausen and Wilken (2006).

Although the airports of both Düsseldorf and Cologne-Bonn are also conveniently located directly at main routes, the scheduling rationale of Deutsche Bahn leaves only very limited scope for integrating these airports into the long distance train network. The argumentation of Deutsche Bahn is that an additional stop and – in the case of Cologne-Bonn – a longer routing over the airport loop would result in journey time increases for the majority of passengers that do not travel to the airport, which will not be compensated by reduced journey times for the minority of travellers that actually want to travel to the airport. The relative underutilisation of the Cologne-Bonn Airport railway station by long-distance trains is particularly deplorable, as about €360m have been invested in this project for both the subterranean station and the airport rail loop (Zumkeller et al., 2005).

Particularly interesting is that the second largest German hub in Munich, a greenfield project opened in 1992, does not possess a direct connection to the long-distance train network. Although it was once planned to route the new high speed line to Nuremburg via the airport, due to geographical reasons, another line routing has been realised.

## 3. Intermodal services in Germany

After the presentation of the infrastructural prerequisites for air/rail intermodality in the preceding chapter, the following chapter will briefly outline the intermodal services and ticketing options, which have been developed by Deutsche Bahn, airlines, tour operators and airports to increase attractiveness and facilitate the use of the rail mode for airport access and as a substitute for short-haul feeder flights to the hubs.

### 3.1 Rail&Fly
Rail&Fly is a rail ticketing option, which is offered by airlines and tour operators in combination with an air ticket or package tour since 1992. Basically, it is a train ticket, which is offered at a discount price (between €19 and €30 per one-way ticket) or in some instances is even included in the basic airfare. Rail&Fly has gained a high acceptance in Germany by both passengers and airlines/tour operators. A total of 83 airlines and 42 package tour operators do offer this ticketing option to travellers. For passengers, the main advantage of this ticketing option is that it allows

the use of any train from any station in Germany to the airport and vice versa. However, this ticketing option is scarcely available via internet booking engines.

For airlines and tour operators, the main advantage is the low operational complexity, as the product does not require costly investments or major operational changes for Deutsche Bahn or the respective airline/tour operator. Therefore, it can be considered as a "soft alliance" between air and rail (Sauter-Servaes, 2007). Rail&Fly can easily be sold by travel agents via Computer Reservation Systems (CRS), at least in Germany. For bookings made from abroad, availability is limited to 121 services and also very much dependent on the individual knowledge of each travel agent and also depending on the airline, if the airfare is eligible to be combined with Rail&Fly. However, the core market for selling Rail&Fly are journeys originating in Germany. At Frankfurt Airport alone, in 2005 1.6 million passengers used a Rail&Fly ticket, which is about 6.5 per cent of all passengers originating at the airport (Freitag, 2006).

Some foreign airlines even use Rail&Fly as a marketing instrument in the competition with Lufthansa for instance. Frequently, Rail&Fly tickets are included in the airfare, which does encourage passengers to use the train for hub airport access, instead of using a feeder flight on a domestic air carrier. The latter option is disadvantageous for foreign airlines, as for instance Lufthansa gets hold of a substantial part of the airfare through pro-rate interlining agreements. Due to airport capacity constraints, Lufthansa does not face intramodal competition on domestic flights from many German cities to the main international gateway at Frankfurt.

More recently, also low cost carriers have included Rail&Fly into their service portfolio. In December 2005, HLX (in the meanwhile re-branded as TUIfly.com) started offering one-way rail tickets from any point in Germany to the respective airport of departure for €19. More than a year later, Germanwings followed suit. However, the cooperation agreement with Deutsche Bahn limits the availability of the Rail&Fly option to international flights only. The main reason for this limitation can be seen in the avoidance of revenue erosion for Deutsche Bahn, as otherwise it would be possible to combine a one-way domestic trip by air with a train ticket priced far below other train ticketing options for the return segment. Nevertheless, the €19 Rail&Fly train ticket offers a substantial discount on regular fares and supports the attractiveness of low cost carriers which are based at airports that can be accessed easily by train, such as Cologne or Berlin-

Schönefeld. The success of the Rail&Fly-low cost carrier combination became evident very quickly, as already in the first six months after the start of the offer HLX sold 65,000 Rail&Fly tickets in combination with international air tickets.

**3.2 Codesharing**

Interestingly, Deutsche Bahn concluded with a limited number of carriers codeshare agreements on domestic train services. So far, five airlines (American Airlines, All Nippon Airways, Qantas, TAP Portugal and China Airlines) have concluded codeshare agreements with Deutsche Bahn, however, with a varying number of destinations. While ANA offers only three codeshare destinations, passengers of American Airlines can book a total of 17 destinations in the German rail network under an AA code. In comparison to Rail&Fly, the complexity of codesharing is higher, as each destination has to be agreed on and the services of Deutsche Bahn have to be uploaded into the CRS. These transaction costs naturally limit the destinations offered as codeshares. However, the biggest advantage of codeshare intermodality is the visibility of the services in the CRSs and also in most cases can be easily booked over the internet. Additionally, the passenger will be credited miles of the respective Frequent Flyer Programs (FFPs), which is generally not offered with the Rail&Fly ticketing option. This is an important element to encourage train use as an alternative to feeder flights.

However, codesharing is also associated with very special challenges. Travel agents selling trips including a DB codeshare may not be fully aware, which service characteristics are included with the codeshare service. For instance, the reservation systems do not show at the time of booking that no through baggage handling is offered. Moreover, in comparison to Rail&Fly, the limited number of destinations naturally limits the number of passengers for whom the codesharing services are interesting. Nevertheless, the product is interesting for both incoming and outgoing travellers, while Rail&Fly is very much focussed on the German market as point of sale.

**3.3 AIRail**

AIRail, developed jointly by Deutsche Bahn, Lufthansa and Fraport, can be considered as the most advanced intermodal product available to travellers in Germany, if not in Europe (Dionori et al., 2006). It was introduced on the route between Frankfurt Airport and Stuttgart in March 2001 and between Frankfurt Airport and Cologne in May 2003 after the high-speed train line had been

inaugurated several months before, which reduced travel time between both cities tremendously. The service features integrated ticketing and baggage handling. The latter point is particularly important to gain passenger acceptance for rail services. With AIRail, baggage is checked through from the Lufthansa-branded check-in counter in Cologne or Stuttgart main station directly to the final destination and vice versa.

The provision of the AIRail service was associated with a considerable amount of investment expenditures for the facilities at the central stations and at Frankfurt Airport. The costs for the extension of the baggage handling system at Frankfurt Airport alone, which has been extended to the new long-distance train station for the purpose of offering intermodal services is estimated at €115m (Zumkeller et al., 2005).

However, this service is particularly challenging for the participating service providers for several reasons. First, the new ICE 3 high-speed trains do not feature baggage compartments. Therefore, a passenger compartment is converted in a "quick change" configuration to carry baggage on the AIRail segment of the journey. This modification is associated with considerable opportunity costs, as it results in a loss of 10 seats that could otherwise be used for paying passengers. The second challenge is associated with Deutsche Bahn's very dense synchronised timetable, which requires loading and unloading of baggage during the brief stops, regularly not exceeding 4 minutes. From the platform at Frankfurt Airport, baggage is transported in closed containers on wheels to security screening and the baggage handling system which was extended for this purpose into the airport's new long-distance train station. Thirdly, for passengers arriving from third countries, baggage is required to be cleared by customs. For this purpose, small customs offices have been set up at the train stations of Cologne and Stuttgart, so passengers can clear their baggage directly at the train station.

A daily total of 15 regular trains in each direction between Frankfurt Airport and Cologne are designated as AIRail trains as well as 7 trains between Stuttgart and Frankfurt Airport, therefore offering passengers a wide range of frequencies, resulting in reduced waiting time for connecting flights compared to the feeder air services. On average, about 31 seats in 2nd class for economy class passengers and 6 seats in 1st class for business and first class passengers are reserved on each train designated as AIRail service. In total, this results in an available AIRail capacity of

555 seats per day or about 200,000 seats per year on the Cologne-Frankfurt route, with slightly less than half of this quantity for the Stuttgart-Frankfurt route. The "blocked space" agreement of Lufthansa with Deutsche Bahn has evident advantages over the lease and operation of a complete train as it was done with the "Lufthansa Airport Express" from 1982 to 1993 (Ebeling, 2005). On the one hand it is possible to offer more frequencies and on the other hand the airline has fewer problems to achieve an efficient capacity utilisation. Moreover, the agreement between Deutsche Bahn and Lufthansa is flexible so that the number of available seats can be adapted to demand on short notice.

The AIRail service is not limited to passengers travelling on Lufthansa. A total of 27 other airlines have agreements with Lufthansa to use the AIRail service to feed passengers to Frankfurt Airport, among them also airlines not being members of the StarAlliance. For the participating airlines, this service is advantageous, as they do not have to provide own check-in agents at the train stations and also do not need to create an interface between the airlines' and Deutsche Bahn's reservation and inventory systems, as Lufthansa provides this gateway function.

In addition to an attractive number of frequencies, short travel times and convenient baggage services, another incentive for AIRail passengers is the fact that the same amount of FFP points will be credited as when using a feeder flight.

Besides these positive characteristics, which have made AIRail a well-accepted alternative to feeder flights, there are also a number of challenges and problems associated with the service, for both potential users and service providers. First, it is a rather complicated and costly process when a foreign airline wants to make use of the AIRail service. Interested airlines have to apply for approval at their home country's civil aviation authority, as AIRail is a deviation from standard security procedures found in international aviation. For security reasons, airlines from the US are not yet allowed to use the AIRail services on trips originating in Cologne or Stuttgart. A detailed description of the security processes and regulations in the air/rail intermodal setting can be found in Smith et al. (2006). Secondly, until early 2007, AIRail could not be booked on Lufthansa's own website, caused by technical problems with the booking engine of Lufthansa. This inadvertently created incentives for internet users to book a feeder flight instead of the AIRail service. This fact became even more curious as it was possible for years to book AIRail

on other internet-based travel agents such as Opodo. Third, it is rather difficult for foreign travel agents, not familiar with the different intermodal products available in Germany, to identify the service characteristics of AIRail in comparison to other intermodal products, most notably codeshare services described above between Deutsche Bahn and some airlines. While codeshare services include more destinations than AIRail, these services do not include through baggage handling and are therefore less attractive for passengers.

Besides these obstacles for passengers to find information on AIRail and to book actual AIRail journeys, other reasons have been found that limit the acceptance of AIRail. In general, this can be associated with the general perception of Deutsche Bahn in the German public. Although in comparison with many other countries the German railway system seems to be rather sophisticated, it struggles with major acceptance problems by its users and the general public. Contributing to this is a rather problematic fare system reform in several years ago, when a price system loaned from air transport was introduced. Also problematic is the concentration of investment efforts into prestigious projects, such as the new high speed lines Frankfurt-Cologne and Munich-Nuremburg, both with an operational speed of 300kph the fastest lines in Germany and the new Berlin Central Station, while aside the trunk routes and main stations regional services in wide areas are chronically delayed by low speed points and a low track quality. In many cases passengers have to cope with rotten stations in rural areas. These circumstances in general seem to limit the acceptance of air passengers to switch to the AIRail services.

Referring to the particular situations in Cologne and Stuttgart, anecdotal evidence suggests that passengers still using feeder flights prefer air transport due to the better accessibility of the airports of Cologne and Stuttgart by car and due to lower parking fees at the airports than at the central train stations. As both Cologne/Bonn and Frankfurt Airport are directly connected by a high-speed railway line this may lead to the idea to offer AIRail from Cologne/Bonn Airport instead of or in addition to the services from main station. Besides increased customer acceptance this would also help to save costs as check-in and customs facilities are already available at the airport. However, this would require an increase in train frequencies between the two airports from currently three services daily, of which two are operated very early in the morning and one very late in the evening. It may be sufficient to offer four daily services, equal to the current

number of flights which could arrive at/depart from Frankfurt Airport synchronised with Lufthansa's flight banks.

However, with AIRail in its present state, the critical success factors of intermodal services, as identified by Eichinger and Knorr (2001), have been realised, as the service does feature short journey times, high frequencies, low price, seamless travel and the integration into the airlines' FFPs.

**4. Case Study – The AIRail service between Cologne and Frankfurt**

The city pair Cologne-Frankfurt seems to be a perfect example for the benefits of a shift from short distance air services to railway. Since 2002 Germany's fastest high-speed line has reduced railway travel times from Cologne Central Station to Frankfurt Airport from two hours to 50 minutes. Comparing this to the travel time by air, taking into account the time needed for the transfer to the airport, for check-in, security checks, boarding, the actual flight and deboarding it seemed questionable if there was a future for air services on this city pair. Analyses covering a wide range of European city pairs show that journey time is a major driving force in market share of a particular mode (DG TREN, 1998; Smith et al., 2006).
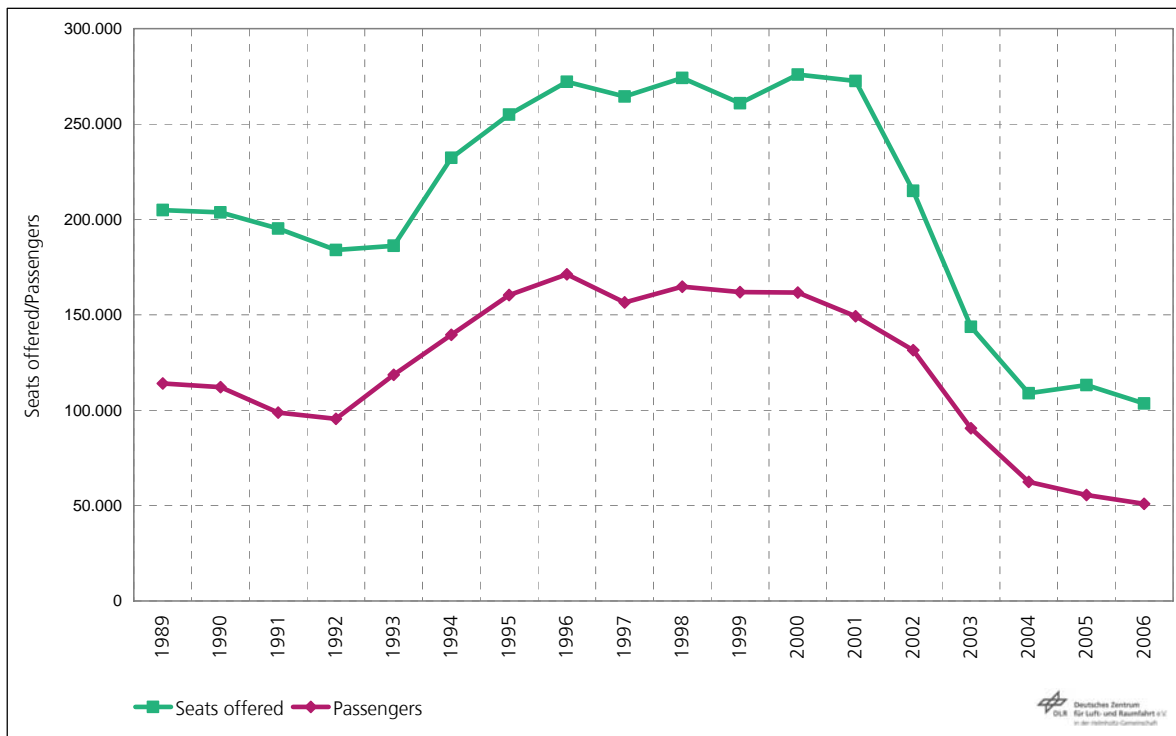The following analysis, mainly based on Federal air transport statistics, should give an insight on the developments of air services before and after the inauguration of the high-speed railway line.

Traditionally, the route Cologne-Frankfurt has been one of the shortest distances flown in Germany, as both airports are only 136 kilometres (great circle distance) apart. Figure 1 shows the number of seats offered and the number of passengers flying between Cologne and Frankfurt from 1989 to 2006.

From the early 1990s up to 2001, the number of passengers was constantly in a range between 150,000 and 170,000 annually. Included in this number are those passengers connecting in Frankfurt to another flight, as well as passengers travelling on the city pair Cologne-Frankfurt only. The latter mentioned group of passengers amounted to a significant number, as in the 1990s on average 20-25% of passengers flying between Frankfurt and Cologne were origin/destination

passengers on this city pair. During the 1990s, Lufthansa offered between four and seven daily services, with an average aircraft size between 105 and 133 seats, mainly Boeing 737-300s and -500s and in peak times also A320s.

Figure 1: Seats offered and passengers on air services between Cologne and Frankfurt



Source: German Aerospace Center (DLR), Air Transport and Airport Research Unit.

Figure 1 shows the dramatic impact of the inauguration of the high-speed line between Cologne and Frankfurt in 2002. The demand for air services was further reduced by the introduction of AIRail in 2003, albeit this effect is less dramatic. The number of available seats was reduced from more than 250,000 to slightly more than 100,000 annually, by means of a reduction in frequencies to a maximum of four per day and a reduction in average aircraft size to 73 seats. The number of passengers has fallen from more than 150,000 to merely 50,000. Load factors have fallen from an average of 60% to less than 50% in 2005 and 2006. There is still a marginal residuum of origin/destination passengers of about 10% of total passengers or about 5,000 passengers annually. The presented effects align with the effects observed on other city pairs, where high speed rail services entered the market (Givoni, 2001). Although demand for air services was considerably reduced, train services did not yet fully replace air services.

Nevertheless, under these circumstances, it is indeed questionable whether air services between Frankfurt and Cologne will be viable in future. So far, Lufthansa has argued that these services are needed to retain especially premium passengers not willing to change to the AIRail service. In addition to the above mentioned problems of asymmetric information and relatively inconvenient access to train stations by car, the reluctance of some passengers to use the train may also be explained by the relatively bad image Deutsche Bahn has in the German public.

However, there are several arguments which would favour the discontinuation of air services between Cologne and Frankfurt. First, Lufthansa should take into account the opportunity costs of the use of slots in Frankfurt. This airport is heavily constrained and operating at its capacity limits during most times of the day. Therefore it is hardly possible for Lufthansa to expand its network from Frankfurt. It is likely that a substitution of the Cologne-Frankfurt route for new long-haul services would have positive economic impacts for Lufthansa, even when taking into account a limited, although possible loss of premium passengers who do not accept the AIRail service. Secondly, opportunity costs of crews and aircraft currently used for the Cologne-Frankfurt route should also be taken into account. It is likely that the use of these aircraft somewhere else in Lufthansa's network could create positive returns, which cannot be generated currently when looking only at the revenues attributable to Cologne-Frankfurt and the disproportionately high costs per available seat kilometre on this by far suboptimal stage length. Thirdly, the strategic situation at Cologne/Bonn Airport has changed considerably in the last few years. As this airport is now dominated by low cost carriers, several traditional network carriers have withdrawn. This can be attributed to the fact that yields on origin/destination markets have eroded and a "degradation" of services merely to feed the hubs of the respective airlines is not seen to be economically viable. After the withdrawal of Air France, Alitalia and – most recently in early 2006 – British Airways, Lufthansa faces only KLM as the last major European network carrier serving Cologne/Bonn. Therefore, the strategic risks of loosing passengers not accepting AIRail to other carriers can be considered very limited. Furthermore, it is highly likely that the frequent flyer program of Lufthansa and the opportunity to accrue miles in Lufthansa's FFP on the AIRail segment of a journey will retain loyal Lufthansa passengers even without air services between Frankfurt and Cologne.

## 5. Outlook – the future of air-rail passenger intermodality in Germany

The future of air-rail passenger intermodality in Germany is two-fold: On the one hand, additional infrastructure investments are required to extend high speed services to new locations. Attractiveness of trains can best be increased by reduced journey times, as proven by the Cologne-Frankfurt high-speed rail link and many other examples in Europe. So far, high speed railway lines in Germany resemble more a patchwork than a truly integrated network (Ebeling, 2005). However, it is also clear that such new infrastructure development is only a long-term solution, associated with immense investments, which are under the current financing scheme in the railroad sector very much dependent on the situation of the federal budget. On the other hand, in the short term, improvements in marketing and product conception could increase acceptance and usability of intermodality. One of such improvements could be seen in the development of facilitated inter- and multimodal packaging (Sauter-Servaes, 2007). So far, building a trip from a plethora of alternative offers by bus and train operators as well as traditional and low-cost carriers is associated with considerable search and transaction costs, overburdens most users and is resulting in non-optimal selection of alternatives.

Very often, intermodal products such as Rail&Fly, if not offered by travel agents, are not even in the awareness set of customers – a classic problem of asymmetric information. One solution to this problem could be the development of an internet based meta-search engine which includes all modes of transport and could offer a great benefit for the booking of door-to-door trips. A further improvement beyond reducing asymmetric information could be a through-ticketing solution from door-to-door. For instance, with AIRail only the air segment and the train segment to Stuttgart or Cologne Central Station is covered. However, as only a minority of travellers have their origin or destination directly adjacent to the central stations, an additional ticket has to be purchased for the starting or final segment of travel to or from the "hinterland". This, however, has a discouraging effect on the use of public transport, as it raises both costs and complexity for the traveller, given the plethora of long- and short-distance fare types. A real door-to-door integrated ticketing solution could be a viable improvement of the status-quo. Nevertheless, this on the other hand would shift transaction costs from the demand side to the suppliers. Forming "hard alliances" between transport operators is associated with considerable complexity due to different technological premises, as for instance the AIRail project has shown.

**6. Conclusion**

The analysis has shown that both the "soft" and "hard" alliances between Deutsche Bahn and airlines have proven to be a considerable success, offering a number of incentives for passengers to switch from air to rail.

However, it has also been shown that the process to introduce and operate a system like AIRail is complex and expensive. The project would probably not have been realised without political support. The first prerequisite to achieve a high level of customer acceptance is through baggage handling, which requires the establishment of check-in, customs and baggage handling facilities at train stations, associated with considerable sunk costs. This, in turn, requires a high level of passenger throughput to be economically viable. In case of Cologne more than 10,000, in the case of Stuttgart about 5,000 travellers per month use AIRail at the moment.

Nevertheless, the decisive prerequisite to offer attractive intermodal products is the availability of high-speed train lines to offer competitive travel times and the integration of airports into the high-speed train network. While travel demand would be sufficient, the former problem is an obstacle to introduce AIRail in Nuremburg and Düsseldorf to connect these cities with Frankfurt Airport. The latter problem hinders to connect Nuremburg and Stuttgart with Munich Airport by AIRail, as this airport is only served by regional trains and the newly built high-speed line between Munich and Nuremburg does not run via the airport. From the perspective of intermodality, the prestigious maglev train connection planned to be built between Munich main station and the airport will be of very limited use for an AIRail service, as it will be an isolated application on a short distance only. Intermodal products with through baggage handling from e.g. Stuttgart or Nuremburg would require an additional baggage transshipping process at Munich Central Station, raising complexity and costs and reducing attractiveness for passengers.

Finally, it has to be mentioned that the objective of transport policy to eliminate short distance air services with the help of attractive intermodal products - as for instance voiced by the European Commission (2001) in its Transport White Paper - has not been achieved with AIRail. In fact,

only 2-3 daily slot pairs at Frankfurt have been released for alternative use due to the reduction in frequencies between Cologne/Bonn and Frankfurt. This compares to 4 daily slot pairs still in use for this extreme short-distance route. Between Stuttgart and Frankfurt, Lufthansa still operates 6 daily frequencies with equipment of a size of up to 150 seats. This fact is an indication that an expansion of AIRail to other cities is likely to have only a very limited positive impact to relieve capacity constraints at Frankfurt Airport. Although theoretically a considerable amount of airport capacity could be freed up with a shift of short-haul feeder flights to high speed trains (as shown by Givoni (2007) for the example of London-Heathrow), in reality operational complexity, high upfront investments, transaction costs and passenger acceptance seem to limit the scope of the integration of air and rail.

The environmental component in the argumentation for an increased shift of short-haul flights to rail has also to be seen rather critical. While on the one hand, greenhouse gases from short-haul flights could be reduced, it has to be taken into account, how the released airport capacity is used alternatively. In case a slot previously used by a short-haul flight is used for an additional intercontinental flight, total greenhouse gas emissions are set to rise, as a long-haul flight typically emits ten to twenty times more carbon dioxide than a short-haul flight.

Overall, the examples from the German experience presented herein show several ways, how the attractiveness of intermodal services in the dimensions journey time, price and convenience can be increased and these services can attractively and successfully be offered in the market.

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