Passenger movement simulation in intermodal air-rail terminal

Antonia COKASOVA, EUROCONTROL Experimental Centre, Brétigny, France

and University of Zilina, Slovakia

There are numerous advantages in transferring some short haul flights to high-speed train, principally that it releases runway and ATC resources, offers immediate relief to congestion, reduce negative environmental impacts, and finally improves ground access to airports. Passenger perspective is the key element; it is rather impossible to develop a well-organized intermodal node if it does not work towards passenger satisfaction. One of the ACARE ‘challenges’ is to ensure that passengers spend only 15 minutes in the airport terminal for short-haul flight and 30 minutes for long-haul flights. Clearly today we are a million miles from this and so if this target is to be approached then we need quantum improvements in passenger flows in the terminal and in particular baggage check-in, passport control and security screening. An intermodal facility can offer enhancements to all of these processes and aim to look specifically at idealised passenger flows in order to get an assessment of the potential benefits. The layout of intermodal terminal can strongly influence the outcome of integrated intermodal services’ efficiency. For this reason detailed analysis is needed allowing the airport to benefit from its intermodal premises and provide user friendly services to passengers.

I. INTRODUCTION

With increasing integration in regional and High Speed Train networks, airports are becoming focal points of landside transport – multimodal interchange nodes. Their network position is a strategic advantage that makes airports new development poles, airports are transforming into centres of activity within them. Drastic traffic growth has several downsides, notably airport delays and congestion are one of the most important threats to the future growth of civil aviation. Travel distances in Europe are such that more than 50% of European flights are of less than 370 N.M.; a statistic heavily influenced by airlines’ use of a hub and spoke operation. European airlines are operating fragmented networks with approximately 50% of the traffic being concentrated on just 10% of the airport pairs.

Airport congestion is seen as a mounting problem and is already a limiting factor at many airports. Many of the international hubs are operating at their maximum throughput; some have already reached their operating limits as prescribed by physical and as well political and environmental constraints. The use of such airports is heavily regulated and future traffic distribution patterns are likely to generate congestion at airports that currently do not experience capacity problems. Since 2000 airport ATFM delays have doubled in proportion (46% vs. 23% of all ATFM delays). In year 2003 in Europe, 66% of airport derived ATFM delays were caused by only 8 European airports (Frankfurt, Rome, Paris, London, Milan, Zurich, Amsterdam and Barcelona), yet these 8 airports handle only 19% of European traffic. [1]

A. High-speed rail connection

Some high speed rail links may improve the capacity of airports for higher-earning long-distance flights, by providing a good alternative to short haul flights. The driving force needs to be a combination of commercial considerations, customer choice and convenience.

The station where people catch an airport train or high-speed train is where the ambience needs to start the transition from railway to airport to airline. The layout of intermodal terminal can strongly influence the outcome of integrated intermodal services’ efficiency, for this reason detailed analysis is needed allowing the airport to benefit from its intermodal premises and provide user friendly services to passengers. One of the ACARE ‘challenges’ is to ensure that passengers spend only 15 minutes in the airport terminal for short-haul flight and 30 minutes for long-haul flights. Clearly today we are a million miles from this and so if this target is to be approached then we need quantum improvements in passenger flows in the terminal and in particular baggage check-in, passport control and security screening. An intermodal facility can offer enhancements to all of these processes and aim to look specifically at idealised passenger flows in order to get an assessment of the potential benefits.
II. PASSENGER MOVEMENT SIMULATION

A. Model input

As air-rail Intermodality is a well known phenomenon only at very few European airports, there is very limited information available that describes passenger movement at intermodal terminals. A general unknown in the field of Intermodality is passenger behaviour. In aim to analyze the impact of an intermodal airport terminal layout on airport services’ efficiency we have chosen a model that will reflect existing passenger movement at an intermodal airport, using several different inputs. Passenger and luggage movement simulation is a complex issue; it is rather indispensable to merge several focal elements in order to achieve comparable results.

In the beginning we have considered only five elements to avoid result bias caused by large number of inputs, with possibility of further update in the future if needed. The model can serve as a starting point for more complex intermodal simulations in the future.

A.1 Passenger requirements

Passenger perspective is the main driving force that will decide on the potential for mode change. Building a well-organized and satisfactory intermodal interchange node is not possible without undertaking sound analyses of intermodal passenger requirements. One of the objectives of our research is to gain a sound knowledge of passenger requirements; a weight to determine the most important travel attributes related to intermodal transport and assign an importance to each attribute. Passenger shift to high-speed rail depends on the level of satisfaction, not necessarily providing better services than air but fulfilling certain needs that stand in priority to others.

After evaluating several methodologies we have decided to undertake a self-administered questionnaire, when the questionnaire is presented and briefly explained to the respondent by someone and then the respondent is left alone to complete the questionnaire. This method of data collection ensured a high response rate, accurate sampling and minimum of interview bias, while providing necessary explanations (but not the interpretation of questions) and giving the benefit of a degree of a personal contact.

The aim of the questionnaire was to address passengers exposed to the choice of undertaking their journey by either high-speed train or airplane, so questionnaires have been collected both at airport terminals and on-board of high-speed train.

Regarding railway transport we have approach passengers travelling on Paris-Brussels-Amsterdam-Brussels-Paris line and Paris-London-Paris line, using services of Thalys International and Eurostar. Airport questionnaire distribution was different from railways, due to dynamic environment at the airport terminal, additional stress and lack of passenger time. Questionnaires have been collected both in boarding gates and check-in areas. We have collected 913 valid samples, after evaluating incomplete and incorrectly filled out samples. Passenger travel preferences vary depending on nationality, purpose of travel and even age. Based on questionnaire results we can conclude that it is rather difficult to find a common denominator for all passengers. About 60% of all passengers agreed that travel time, ticket price and access to airport or station are the three main decision makers. 40% of all passengers consider on-board comfort, schedule & frequency, punctuality & reliability and walking/waiting time crucial when choosing between different transport mode, while on-board services and luggage handling have little or no influence on passengers.

Some factors proved to be important only to a small group of people, although they can be very influential; fear of flying or fear of crossing the Channel Tunnel (Eurostar) will certainly strongly influence passengers’ inclination towards the competitive mode. For detailed results of the questionnaire please see reference articles [2] [3].

A.2 Passenger movement information

There is very little information available concerning airport passenger movement. Most of the information published by airports in based on observations of passengers moving along the terminal. It has been observed that passenger without luggage moves 10% faster than passenger with a luggage and that passenger with a trolley moves 10% slower than passenger carrying his luggage (Frankfurt Airport Expansion Program - undergraduate thesis). In general passengers move about 60 to 120 meters per minute [4].

A.3 Airport Intermodal Terminal

To achieve valid simulation the best is to input an existing airport layout; an international European airport terminal...
instead of a fictive layout, with possibility of extending into an intermodal air-rail terminal. Because of strict security issues it was very difficult to obtain an existing airport terminal layout for research purposes, out of 6 International European Airports only 1 European airport was ready to cooperate and provide us with additional support needed in later period of the study. The airport chosen for simulation is a main national hub; in 1998 it had the world’s highest passenger growth rate. In 2003 the airport processed a total of 9, 63 million passengers and was served by 58 scheduled services airlines.

For the simulation purposes we will design three airport layout scenarios

Scenario A1:  Airports without high-speed rail station
Scenario A2:  Airport with high-speed rail station
Scenario A3:  A2 with check-in facilities at railway station

A.4 Simulation tool
Simulation tool - A human behaviour is often thought to be hard to define in models; simulations of processes with people involved are less common than industrial simulations. After a brief review of existing products we have decided to apply for a fast-time simulation tool including passenger behaviour modelling and enabling a statistically significant number of runs to be performed for a particular set of input parameters representing all the various possible scenarios.

After several month of negotiation the Preston Aviation Solutions have agreed to deliver a suitable product entirely free of charge, strictly for student research purposes. PaxSim is a graphics-based application used for the fast-time simulation of passenger and associated baggage flow at an airport terminal building. PaxSim can be used to simulate flows through discrete areas of a terminal or the entire terminal area. A simulation run using PaxSim can be viewed and interactively controlled on the screen. Further analysis can be performed and a variety of statistical information produced via spreadsheets. The analyst can view the actual flow of passengers, any potential bottlenecks and the ripple effects of passenger delays in other areas of the terminal.

A.5 Traffic sample
Concerning passenger traffic data we have used real traffic data from 29th of July 2005 delivered by airport operations. The data is detailed to such extend that each flight is allocated to certain stand, gate and luggage carousel. As one of the scenarios will reflect an intermodal airport terminal, shifting possibly all short haul flights to a high-speed train services, it was necessary to analyse the exact number of short haul flights operated from/to our sample airport.

Same as for airport layout scenarios we will have three different traffic data scenarios

Scenario B1:  26% passengers flying less than 800 km’s (as in case today)
Scenario B2:  10% intermodal passenger (example of Frankfurt Airport, the best intermodal airport)
Scenario B3:  26% intermodal passengers (all short-haul flights shift to HST)

Airports’ traffic distribution by segments is the following:

- International Movements: 82%
- Domestic Movements: 18%
- International Passengers: 78%
- Domestic Passengers: 22%

B. Simulation objective

The objective of the experiment is to simulate passenger flow at an intermodal air/rail passenger terminal, evaluate the feasibility and efficiency of airport layout, determine typical airport processing times and also detect bottlenecks and constraints in relation to passenger flows.

The benefits identified for our study may be decomposed into several categories, as indicated below:

Reduction of demand on the airport resources – one of the main causes of delay at airports at the moment (in the absence of bad weather) is the saturation at the various choke-points (passport control, security screening and sometimes even check-in). Intermodal way of transport can help to shift passengers from short haul flights to railways, improve airport access, hence freeing up available runway capacity for longer, more beneficial flights and nevertheless reduce the demand on airport resources inside the terminal, due to the change of passenger and baggage flow

Shorter minimum connection time – the study will focus on the potential impact that an efficient layout may have on minimum connection time, assuming that a transfer passenger travelling by air/rail or rail/air instead of air/air should be able to spare significant amount of time due to shorter connection time that can be as little as 30 min

Passenger flow bottlenecks – intermodal way of transport may cause several bottlenecks at congested areas. This study will identify the impact of intermodal passenger flow on these critical airport resources.

C. Simulation scenarios

There are 5 scenarios; composed of 3 traffic samples and an airport layout with 3 different configurations. The different scenarios represent different situation in terms of airport design and airport configuration, with identical airport operation procedures. The main difference between the scenarios is the connection to a railway station at airport terminal and the flow of intermodal passengers. Starting from a basic airport layout without railway station and up-to-date passenger flow, up to a transition where an airport is connected to a high-speed rail station with check-in facilities and 26% passenger intermodal flow.
**Base scenario – Base**
Sample airport as it is known today, without a direct connection to high-speed rail station and with 26% of traffic less than 800 km’s.

**Air/Rail Scenario 10% intermodal PAX – AiRail10**
Sample airport with high-speed train connection and 10% of intermodal passenger flow.

**Air/Rail Scenario 26% intermodal PAX – AiRail26**
Sample airport with high-speed train connection and 26% of intermodal passenger flow.

**Air/Rail Check-in Scenario 10% intermodal PAX – ARCheck-in10**
Sample airport with high-speed train connection and check-in facilities at the railway station, with 10% of intermodal passenger flow.

**Air/Rail Check-in Scenario 26% intermodal PAX – ARCheck-in26**
Sample airport with high-speed train connection and check-in facilities at the railway station, with 26% of intermodal passenger flow.

The aim of the simulation is to evaluate the feasibility and efficiency of a given airport layout, to determine typical airport processing times and to detect bottlenecks and constraints in relation to passenger flow at the intermodal. The analysis will be therefore based on comparison of a number of different scenarios which consider different potential airport layouts in relation to the location and facilities of the intermodal terminal and also the potential volume of passengers who may exploit these facilities. See Appendix for main simulation scenarios and their characteristics.

III. CONCLUSION

In order to better understand the impact of intermodal transport on air traffic different possibilities will have to be considered in the future. The success of Intermodality and hopefully the possibility of easing congestion will depend not only on airports efficiency but mostly on passengers’ willingness to experience new way of travelling and operators business strategy that can develop in two different ways, either co-operation between transport modes or competition at any cost.

Our simulation will offer a valuable starting point to further intermodal studies. Results of the simulation will present an initial idea clarifying the direct impact of intermodal services on terminal resources efficiency. Thanks to tangible conclusions our simulation will present a more transparent view of transition from a regular airport terminal to an air-rail intermodal terminal. As airport layout building and design is a time-consuming process it took us several month to obtain all the necessary data and information needed for our simulation. The final results of the project will be soon available.

APPENDIX
Simulation scenarios, description and objective

ACKNOWLEDGMENT
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REFERENCES
### APPENDIX Simulation scenarios, description and objective

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<th>SCENARIOS</th>
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<th>OBJECTIVE</th>
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<td><strong>Potential impact that an efficient layout may have on minimum connection time. We assume 30 min is sufficient to reach a connection flight in case ARCheck-in10</strong> To detect bottlenecks caused by intermodal transfer</td>
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