Design and Application Fields for a Worldwide Air Transport Model

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Abstract
Public Transport companies have been using transport models for strategic planning with great success for many years. This paper describes the implementation of such a model for world-wide air transport and suggests ways in which the model could be applied. The air transport model was constructed using the VISUM software of PTV AG.

Keywords: Airline industry, air transport, assignment, public transport, transport model, VISUM.

Introduction

Public transport companies have been using standard transport planning models to assist in their strategic planning for many years. These transport assignment models allocate estimated transport demand to a network of the available transport supply. For public transport the supply is defined by the system's timetable.

Since these models are so useful for public transport planning, the question arises whether similar models could be developed and used to model the worldwide air transport network. This paper describes the process of modelling worldwide air transport using the VISUM software (PTV, 2006) developed by PTV AG and outlines possible uses for the model.

Model Development and Data

The assignment model is based on OAG, London, (www.oag.com) database of flights. The OAG database contains all reported regular passenger and cargo flights of airlines world wide. This data was converted for input into VISUM.

The air transport model distinguished between the following types of flights (which were defined as different transport systems in VISUM):

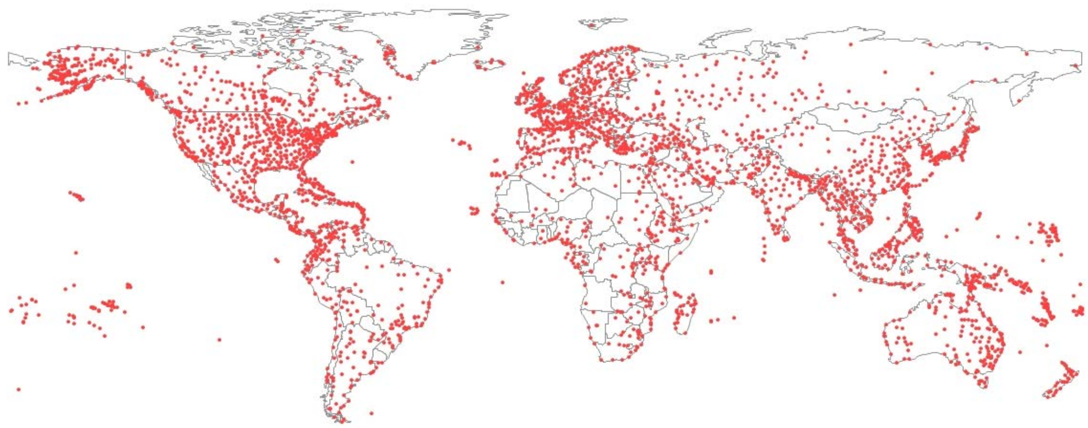
- Domestic passenger flights (D)
- International passenger flights (I)
- Cargo flights (C)
- Public Transport (P) as PuT auxiliary transport system for interchange between airports within an metropolitan area (e.g. London Heathrow – London Gatwick)

The flights with the transport system D and I always provide passenger seats and sometimes also cargo capacity (e.g. belly cargo). The flights with the transport system cargo only offer cargo capacity.

The air transport model's network consists of nodes and links. Each airport was designated as a station on a node, which was geo-referenced in the WGS 84 coordination system (partly provided by Bureau of Transportation Statistics). At airports with several different terminals, each terminal was represented by a separate node and linked to the airport as a station area. The routes between airports were designated as links. This ensures that all flights between two airports are routed on the same link regardless of which terminal is used, and therefore aggregated flight data for a given route (e.g. seat capacity, assigned passengers, …) are correct.

The model contains 3,562 airports (stations or nodes) (see Figure 1) and 3,840 airports and terminals (station areas) with 21,845 links between airports in the network. Further, it contains 132,722 flights (lines), of which 83,988 are domestic flights, 44,433 are international flights and 4,301 are cargo flights. There are a total of 105,569 non-stop flights and 21,734 flights with intermediate stops. It should be noted that 5,444 flights with stops had to be modeled as non-stop flights because the routing information was not consistent in the OAG database.

Figure 1 Airports included in the model



In order to prepare the flight data for VISUM all departure and arrival times had to be converted to UTC times, since VISUM is generally used to model regional transport and is therefore based on a single time zone (however, the local departure and arrival times were saved as attributes in the database). UTC stands for Coordinated Universal Time and is approximately the same as Greenwich Mean Time (GMT). The UTC zone of the airports was also stored as attribute and therefore it was easy to convert the flight schedule data to a given time zone.

Many other flight and airport attributes were added to the database to help increase the model's usefulness for strategic planning. These attributes included day of operation, flight distance (in km and miles), number of seats (differentiated into First, Business and Economy Class), cargo capacity in tons, service type, service effective dates (from … to …), aircraft type and manufacturer, airline, cruise speed, country where the airline is incorporated, routing, restrictions, code share codes, long-leg flights, maximum take off weights, and many others.

An important part of the model is assessing the ability to transfer between different flights at airports. In order to accurately model the transfer process is was necessary to use the concept of Minimal Connection Time (MCT). The MCT is an important restriction in the passenger airline business and is defined as the minimum time required to transfer between flights in an airport. These data were also supplied by the OAG. The data are specified in three ways:

a) As a special walking time in a station (airport) depending upon which type of connection was being made (Domestic to Domestic, Domestic to International, International to Domestic, International to International). If an airport did not have specific MCT reported, than the industry standards were used (DD=20 min, DI=ID=II=60min).

b) If there was more specific information such as MCT for flights coming from a specific region and/or departing with a specific airline, than these data were converted to specific connection walking times between flights, overall 45 million flights specific MCT were produced by the model. If more than one MCT was produced for a connection between flights (because the information is redundant), the shorter one was used.

c) Interchanges between airports in an metropolitan areas were modeled with PuT auxiliary links with reported times (the industry standard is 240 min).

Model Applications

As mentioned earlier, there are many ways that different agencies might use such a model, several examples and ideas of how the model could be used include:

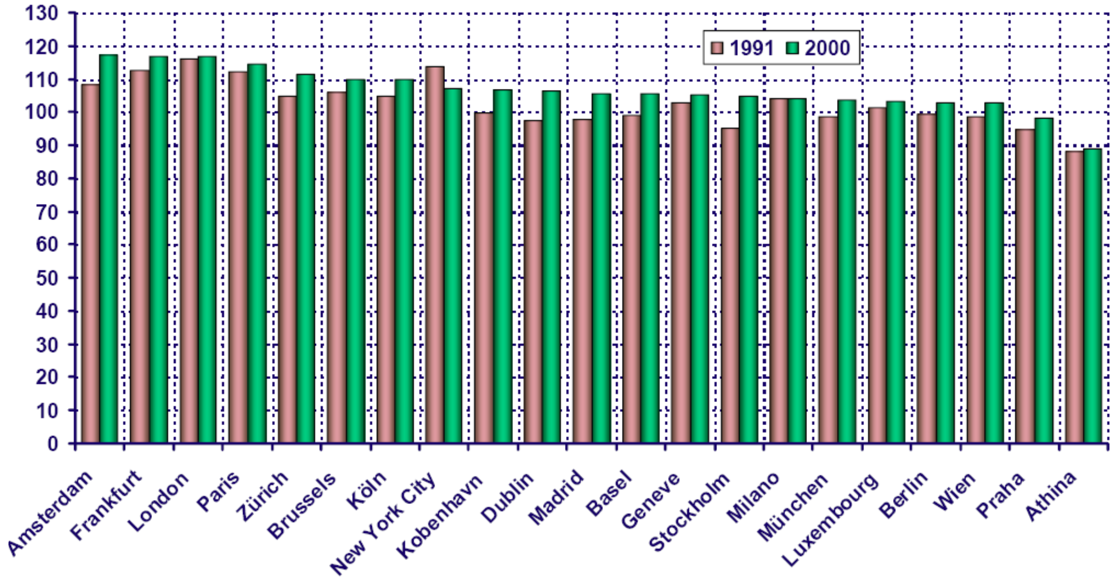
1) Analyze transport service quality

a) Calculate indices such as ride time, in vehicle time, number of transfers, transfer time etc. for all or specified OD pairs (Figure 2 shows an inter-continental accessibility weighted by regional GDP comparison of different metropolitan areas);

b) Develop transport isochrones from a specific airport within an arbitrary time window on a specific day (Figure 3 shows isochrones from Cartagena on a typical Monday); and,

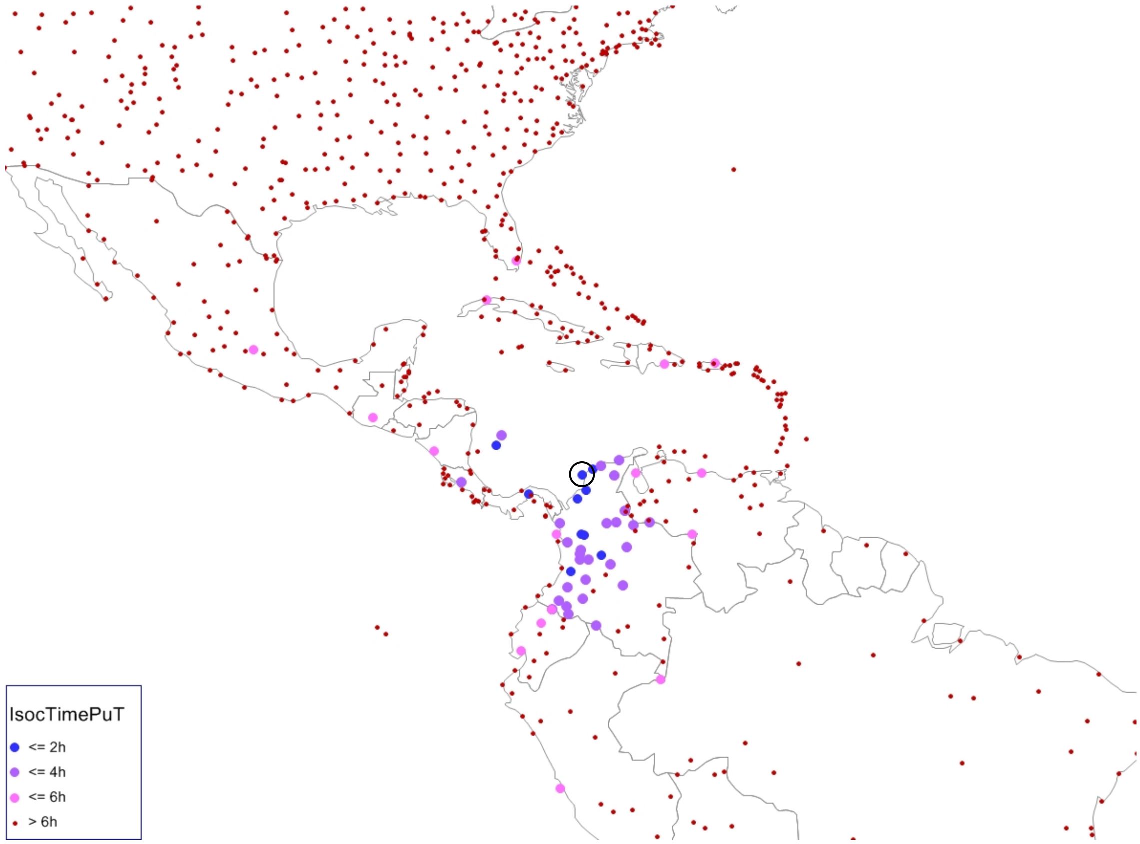
c) Search for connections with specific route choice parameters at different spatial resolutions (OD pair, path, path legs).

Figure 2 Intercontinental accessibility weighted by regional GDP for selected metropolitan areas for the years 2000 and 1991.



Source: BAK (2005)

Figure 3 Isochrones Cartagena (Colombia) on Monday



2) Public transport assignment

a) Assign demand to flights (connections) using several different choice models (Logit, Box Cox,…) and accounting for connection similarity; and (Friedrich and Wekeck, 2002)

b) Calculate loading factors for flights; estimate passenger boarding, alighting and transferring at airports/terminals.

3) Analyze operating costs

a) Calculate variable and fixed costs (airplane, airport,…);

b) Calculate line or route cost estimates; and,

c) Develop block plans.

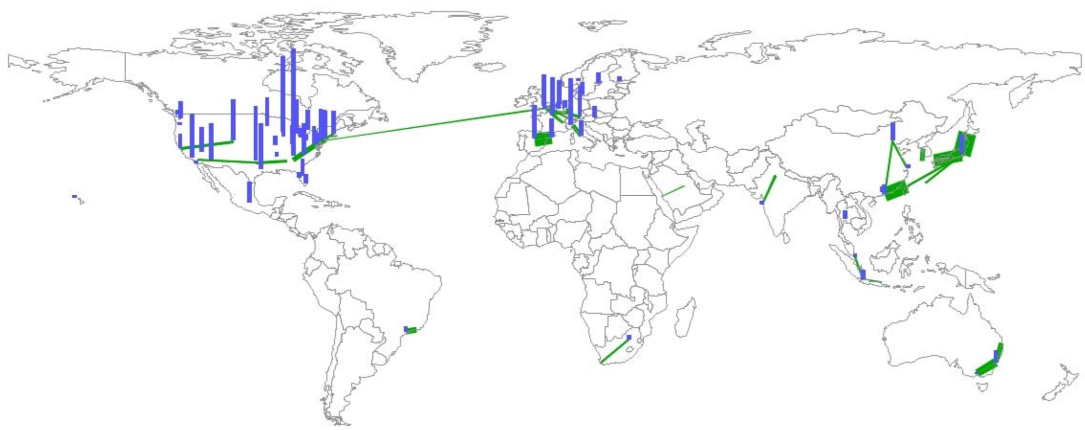
4) Capacity analysis

a) Analyze link based supply indicators including number of flights or seat capacity on specific day (see Figure 4), airline/airline alliance, cargo capacity;

b) Analyze airport based supply including number of arriving and departing flights on given day and time window; and

c) Analyze emissions by link or airport.

Figure 4 Number of passenger flights departing and seat capacity on a Monday (November 6, 2006)



Blue columns: passenger flights departing per day (scale: 250-1'750)
Width of the green lines: seat capacity offered per day (scale: 7'000-18'000)

In summary, the reported work shows that it is possible to model all passenger and cargo airline flights in the world using the VISUM software package and that this can be done with a reasonable effort. There are many possible applications for this VISUM-based air transport model in the strategic planning efforts of airlines, flight authorities and airport operators.

It is planned to integrate this model, at least for Europe, with the equivalent models of rail-based services and road travel. This will allow analyses of the competition between the modes for arbitrarily small geographies; the limit is the availability of suitable demand estimates. In other parts of the world equivalent model extensions are possible involving bus, ferry, ship and road.

Literature:

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