THE DEVELOPMENT OF NETWORK STRATEGIES IN AVIATION
Abstract
The commercial aviation industry revolves around three fundamental pillars: political, economic and technological developments. Since the start of the jet age, these three pillars have affected the route system architecture that carriers fly. This paper investigates the shift in these three fundamental pillars over the past decade, comparing the operational characteristics of the point-to-point and hub-and-spoke route systems. It also emphasises the importance of recent developments in the commercial aviation industry, resulting in new opportunities for carriers to impact the route system architecture. In addition, a case study has been performed to display the new patterns of air service on long-haul networks – known as hub-bypassing. By applying this route strategy, carriers are able to operate a significant number of additional city-pairs that have been enabled by developments in the three fundamental pillars. This poses a threat to traditional hub-and-spoke carriers, which offer the same city-pairs, including an intermediate stop for connecting flights. However, hub-bypassing can also decrease congested airports and offer passengers faster and more non-stop flights between unique city-pairs.

Introduction
Since the liberalisation of air transport the skies have transformed into one single market, increasing city-pair connections. Airports and regional planners focus on primary airports (major hubs) associated with large cities (e.g. Schiphol/Amsterdam, Heathrow/London and Narita/Tokyo). Traditionally, carriers have concentrated all of their traffic into large markets, flying towards these primary airports where new flights connect passengers to their various destinations. This is known as the hub-and-spoke system. However, recent developments now mean that carriers are flying new routes, bypassing traditional hubs and stepping away from their traditional route architecture. The market has changed, and the industry is adjusting through three fundamental pillars that affect the development of network strategies: economic, political, and technological developments. As airlines connect cities, they are establishing new, highly profitable city-pairs that were first regarded as secondary markets. The importance of a liberal aviation industry is also now widely recognized, resulting in multilateral liberalisation. Correspondingly, new technological advancements have enabled manufacturers to build aircraft that allow carriers to open new long-haul routes and offer passengers the advantage of flying non-stop to their final destination rather than transferring via a major hub airport. To explore this new network strategy, a case study was performed comparing the route network of so-called hub-bypass systems and ‘traditional’ hub-and-spoke networks, in order to gain insight into the differences.
The fundamentals of commercial aviation

The aviation industry can be found in practically every corner of the world, contributing to the world economy on a large scale. Three fundamental pillars affect the way carriers have developed their business model since the start of the jet age (the 1970s). The first is the political element. Before deregulation, technological innovations and governmental policies came before profitability and competition within the industry. The second is the economic element. Global economic growth in combination with urbanisation and increasing city size have resulted in more city-pairs. And third, the technological element. Technological advancements are important in this industry, and have allowed manufacturers to build new, advanced aircraft to meet the demands of carriers for long-haul city-pairs (Airline Industry Overview, 2014).

Political
Prior to deregulation, flag carriers were government owned, serving the public and political interests. The aviation system was based on a set of tight regulatory rules and restrictions. As a result, travellers were deprived of different price/service options. In 1978, the United States (US) re-examined their regulatory system and deregulated the aviation industry in the US (Goetz and Vowles 2009). The European Union (EU) followed the example of the US, and gradually deregulated the aviation industry in the 1980s and 1990s in Europe. By the end of 1995, the US had ‘open skies’ agreements with ten European countries. These agreements allowed services between any point in one country to any point in the other, with no restrictions as to the number of carriers or capacity. Today, the US has open skies agreements with more than 100 regions. However, the benefits of a liberal aviation are not only recognized in the US.

Other examples include the Australia-New Zealand Single Aviation Market and the Multilateral Agreement on the Liberalization of International Air Transportation (MALIAT) between Brunei Darussalam, Chile, the Cook Islands, Mongolia, New Zealand, Samoa, Singapore, Tonga and the US (Tretheway & Andriulaitis, 2015). The most recent example is the implementation of Association of Southeast Asian Nations (ASEAN) open skies policy (ASEAN Briefing, 2015). The EU and the ASEAN have agreed to start negotiations on an air transport agreement between both regions. “The agreement will be the first substantive accord between two major trading blocs, possibly providing an ‘open skies’ or ‘open aviation area’ arrangement with unlimited market access for both sides’ airlines and other significant mutual benefits” (Tan, 2015, p.1). In the 1970s, the aviation industry was conservative and heavily regulated. We currently see a trend in which the benefits of a liberal aviation industry are widely recognized by more countries, as efforts are made to create policies that allows airlines to penetrate more markets with fewer restrictions.

Economic
In recent decades, the world’s population has undergone rapid urbanisation. This has resulted in a dominant urban population that exceeds the rural population (Figure 1).

![Graph: Global urban and rural population, 1950-2050.](Image)

It is expected that this level of urbanisation will increase globally. Africa and Asia are likely to take the lead, as major areas of these continents are still rurally populated. At the same time, global economic and population growth is forecasted to increase by 2050, leading to more metropolitan...
Development of network strategies in Aviation

cities. This increase, in combination with global urban population growth, is propelled by the development of cities of all sizes (Figure 2, United Nations, 2014).

Figure 2: Growth of cities of all sizes

The increase of new and larger cities is also triggered by factors such as liberalisation, consumer spending and the introduction of Low Cost Carriers (LCCs) opening new markets, making flying between cities more accessible for passengers. These factors have created a good environment for the growth of primary and secondary airports (Cain, 2015), stimulating network developments that connect more cities, increasing the number of city-pairs (Figure 3, IATA, 2011).

Figure 3: Network growth of city-pair connections

Passenger volumes are increasing annually, and airlines are starting to fly from and to secondary airports rather than major hubs (Neufville, 2003). A great example is Manchester airport, which was first known as a secondary airport but is now London Heathrow’s number one competitor (Hind, 2014). In 2008, Manchester airport was serving 25 million passengers annually. It is forecasted that by 2050, the airport will be handling a staggering 55 million passengers a year (UK aviation forecast, 2013). Continuous passenger growth and the rising number of new city-pairs will add more secondary airport connections, resulting in further local economic development (O’Conner and Fuellhart, 2015). Moreover, both secondary and primary airports will experience a significant growth in passenger movements due to the increase in regional city urbanization. Traffic is returning, oil prices have dropped and new business models are increasing the return of profitability (PWC, 2014). The next section will examine the high-profitability that enables airlines to fly these long-haul city-pairs from or to secondary airports.

Technological

The hub-and-spoke network has flourished around the world as a consequence of airline liberalization. This liberalization in the 1980s and 1990s saw a significant rise in the European share of transfer traffic at the major hub airports of Air France-KLM, British Airways and Lufthansa. Over time, however, these carriers did not realize the potential advantages of the hub-and-spoke network, and the lower unit cost of the hub-and-spoke operation was especially under pressure. The hubs of major European carriers have become congested over the years. The operating costs of large aircraft were higher than expected in comparison to smaller aircraft. Aircraft such as the B767/A330 were not able to operate on many city-pairs directly at sufficient margins. The increasing congestion at major hub airports demands a debate on patterns of air service (Morrell and Lu, 2007). The evolution of aircraft plays a vital role, by facilitating greater switching ability for airlines. This allows airlines to open new routes and offer the advantage of flying non-stop to their final destination rather than
Development of network strategies in Aviation transferring via a major hub airport (Thelle, 2012). The Boeing 787, for example, is more fuel-efficient, reduces environmental impact and generates lower seat/kilometre costs (Figure 4). In the past, airlines were not able to profitably serve medium to long haul markets of low to medium density. Now, there are opportunities for a large number of profitable non-stop hub-bypass flights at a sufficient frequency (Boeing, 2015).

Advantages when bringing relatively smaller aircraft into secondary airports with similar or improved ASM costs than those of larger aircraft (Figure 5).

**Network strategies**

**Hub-and-Spoke & Point-to-Point networks**

During deregulation, a considerable number of city-pairs were not cost-effective due to underutilized flights authorized to protect domestic/regional airlines (Figure 6). This point-to-point network (Figure 7) required a sustainable economy and adequate passenger flow at origin and destination, both of which were not present during this period. Liberalization transformed the skies into one single market (Scharpenseel, 2001), which led carriers to start making use of a hub-and-spoke system (Figure 7).

**Figure 4: Aircraft fuel efficiency**

As investigated by AirInsight (2012), the Boeing 787 brings advantages in terms of fuel cost per Available Seat Mile (ASM). This creates further advantages when bringing relatively smaller aircraft into secondary airports with similar or improved ASM costs than those of larger aircraft (Figure 5).

**Figure 5: Fuel cost per ASM (Source: AirInsight, 2012)**
Development of network strategies in Aviation

This new route architecture allows carriers to feed passengers from secondary airports into a single airport (the ‘hub’). From this hub, new flights connect passengers to their various destinations (along the ‘spokes’). The goal of a hub-and-spoke route system is to ‘capture’ the passenger from origin to destination at a high profitably rate (Cook, 2008).

Hub-bypass

Traditional European legacy carriers rely on the hub-and-spoke network model, because it offers advantages in terms of demand stimulation by providing a large variety of Origin & Destination (O&D) city pairs, including routes that could never be viable under direct operation (Bailey et al., 1986; Maertens, 2010). While these hubs have become essential to enable carriers to build a dominant market, the congestion that comes with the hubs’ sizes have encouraged carriers to grow their business through hub-bypass strategies. These hub-bypass strategies emerged from the development of jets with enough range to link a substantial number of smaller city-pairs, enabling airlines to operate from and to niche markets (Clark, 2007). However, as depicted in Figure 8, non-European carriers operating flights to European cities can fly to secondary European airports, applying hub-bypass strategies (Maertens, 2010).

Case study

For this case study, a comparison of hub-bypass systems and ‘traditional’ hub-and-spoke networks has been created in order to gain insight into their differences.

Carriers use primary and secondary airports in both network types. A primary airport is defined as an airport that carries 20% or more of the total passengers in that region. Secondary airports serve up to 20% of the passengers in their region (Bonnefoy; Neufville; & Hansman, 2008). The Boeing 787 Dreamliner was marketed as a ‘hub-buster’, enabling carriers to open new routes that would operate in thinner markets. It has been concluded that 20% of the routes operated by this aircraft are new routes. This does not mean that these routes could not have been opened with other aircraft types, but there are indications that the lower cost and smaller capacity are conducive for these routes (CAPA, 2014).
The routes used for this case study are listed in Table 1 as either a hub-and-spoke route or a hub-bypass route. These routes are not solely operated by Boeing 787s (Table 4).

For this case study, the route provided by Hainan Airways (HU) from Beijing (PEK) to San José (SJC) is operated by a Boeing 787-8, and has been selected as an example (Figure 6).

San José Airport is located within the Bay Area, in which San Francisco International Airport (SFO) and Oakland International Airport (OAK) are located (Ishii, Jun, van Dender, 2009). In terms of passenger numbers, San José airport accounts for 14.5% of all traffic within the region (SJC Airport, 2015; SFO Airport, 2015; OAK Airport, 2015). This percentage indicates that San José airport is a secondary airport in the region (Table 2).

San Jose has two daily connections between Beijing (PEK) and San Francisco (SFO) by Air China (CA) and United Airlines (UA) and is also connected by Hainan Airways (HU). San José accounts for 14% of all available seats on flights between the Bay Area and Beijing (Table 3) (Flightmap Analytics, 2015).

### Table 1: Hub-bypass and hub-and-spoke routes

<table>
<thead>
<tr>
<th>O&amp;D</th>
<th>Hub-bypass route</th>
<th>Hub-and-spoke network</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD-PVG</td>
<td>ADD-PVG (ET) 788</td>
<td>ADD-DOH-PVG (QR) 320 – 77W</td>
</tr>
<tr>
<td>BHX-JFK</td>
<td>BHX-JFK (AA) 752</td>
<td>BHX-AMS-JFK (KL) F70 – 744</td>
</tr>
<tr>
<td>DUS-HND</td>
<td>DUS-HND (NH) 788</td>
<td>DUS-CDG-HND RJ85 – 777</td>
</tr>
<tr>
<td>HND-BOS</td>
<td>HND-BOS (JL) 788</td>
<td>HND-SFO-BOS (UA) 777 – 738</td>
</tr>
<tr>
<td>HND-SJC</td>
<td>HND-SJC (NH) 788</td>
<td>HND-LAX-SJC (DL) 777 – E175</td>
</tr>
<tr>
<td>LAS-PEK</td>
<td>LAS-PEK (AA) 788</td>
<td>LAS-YVR-PEK (AC) 319 – 77W</td>
</tr>
<tr>
<td>LHR-AUS</td>
<td>LHR-AUS (BA) 788</td>
<td>LHR – DFW – AUS (BA – AA) 744 – MD80</td>
</tr>
<tr>
<td>PEK-BOS</td>
<td>PEK-BOS (HU) 788</td>
<td>PEK-DTW-BOS (DL) 744 – 320</td>
</tr>
<tr>
<td>PEK-SJC</td>
<td>PEK-SJC (HU) 788</td>
<td>PEK-SEA-SJC (DL) 763 – CRJ900</td>
</tr>
</tbody>
</table>

### Table 2: Airport passenger numbers

<table>
<thead>
<tr>
<th>Airport</th>
<th>Annual (2014)</th>
<th>pax</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJC</td>
<td>9,600,000</td>
<td>14.5%</td>
<td></td>
</tr>
<tr>
<td>OAK</td>
<td>10,336,788</td>
<td>15.6%</td>
<td></td>
</tr>
<tr>
<td>SFO</td>
<td>46,191,454</td>
<td>69.9%</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>66,128,242</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Airport passenger numbers

Table 3: Route seat numbers (July 2015).

<table>
<thead>
<tr>
<th>Route</th>
<th>Seats/month</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFO-PEK</td>
<td>23,000</td>
<td>86%</td>
</tr>
<tr>
<td>SJC-PEK</td>
<td>3,834</td>
<td>14%</td>
</tr>
<tr>
<td>Total:</td>
<td>26,834</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3: Route seat numbers (July 2015).
Mayor Liccardo of San José has indicated that because San José lies in the heart of Silicon Valley and is the home of the world’s high-tech industry, it can facilitate business travel for the area’s multi-national companies (PR Newswire, 2015).

These routes have either their origin or destination at a hub or primary airport (Maertens, 2010). This hub airport at either side of the connection provides connectivity to more destinations, and therefore more city-pairs. These pairs enable more connections for passengers with fewer transfers (Table 4). This type of routing creates a hybrid version of the hub-and-spoke network and the hub-bypass network (Maertens, 2010).

The three fundamental pillars of the aviation industry are developed in such a way that enables Hainan Airways to operate between Beijing (PEK) and San Jose (SJC). Political bilateral agreements between the People’s Republic of China and the US enable flight operation between the two countries. The economy has developed in both Beijing and San Jose. And technological advances in aircraft operating costs have enabled a viable operation between the two markets.

### Table 4: Hub-bypass and hub-and-spoke network hybrid

<table>
<thead>
<tr>
<th>O&amp;D</th>
<th>Hub-bypass (airline) aircraft type</th>
<th>Traditional hub-and-spoke network aircraft type</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDI-HKT</td>
<td>EDI-DOH-HKT (QR) 788 – 788</td>
<td>EDI-LHR-BKK-HKT (BA – PG) 763 – 77W – 320</td>
</tr>
</tbody>
</table>

The routes in the table above are examples of connections that passengers can make due to hub-bypass strategy routes, with only one transfer compared to two transfers in the traditional hub-and-spoke network flights (Figure 10).

This figure shows that Qatar Airways operates directly to both Edinburgh, UK (EDI) and Phuket, TH (HKT). This bypassing of the main hubs of London Heathrow and Bangkok enables passengers to travel between EDI and HKT via Doha, Qatar (DOH).
Conclusion

The aviation industry has been characterized by its fundamental pillars which have been thriving since the 1970s: political, economic, and technological developments. Developments in all three of these areas have influenced the long-haul route architecture system of carriers. The benefits of a liberalized aviation industry are now widely recognized by more countries, and efforts have been made to create policies that allow airlines to penetrate more markets with fewer restrictions. We have seen an increase in the use of new and larger cities, triggered by factors as liberalisation, consumer spending and the introduction of LCCs. This has created a good environment for the growth of primary and secondary airports stimulating network developments, connecting more cities and increasing the number of city-pairs. At the same time, new types of aircraft have increased long-range capabilities and lowered seat per kilometre costs, enabling airlines to open new routes and achieve more profitability. This in turn has created new opportunities for a large number of profitable non-stop hub-bypass flights at a sufficient frequency. Airlines are discovering new, highly profitable long-haul routes with a low seat per kilometre cost, which enables carriers to shift to a market of economies of scale. Today’s passengers are offered more direct flights towards their final destination and shorter journey times. These recent developments bring opportunities for carriers applying the new the hub-bypass strategy – they have the advantage of directly operating on routes which were not viable in the past. However, this also poses a threat to competing, traditional hub-and-spoke carriers, who offer the same city-pairs with an intermediate connecting flight.

References


Development of network strategies in Aviation


long-haul markets. Research in Transportation Economics, 24(1), 68-74. doi: http://dx.doi.org/10.1016/j.retrec.2009.01.009

Maertens, S. (2010). Drivers of long haul flight supply at secondary airports in europe.16(5), 239.
Development of network strategies in Aviation


*Hainan airlines opens non-stop route from beijing to san jose, CA*. San Jose: Hainan Airlines Co., LTD.


http://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1543&context=njilb


Tretheway, M., & Andriulaitis, R. (2015). What do we mean by a level playing field in international aviation? *Transport Policy, 43*, 96-103. doi:http://dx.doi.org/10.1016/j.tranpol.2015.05.007


ASEAN Briefing. (2015). ASEAN open skies policy to be implemented in 2015. Retrieved from


Image references (top to bottom, left to right)

1 Cover – Jeffrey Schäfer
2 Boeing – Fuel efficiency of aircraft
3 Gert Meijer – Fundamentals of Aviation

Dutch Summary


This is a Luchtvaartfeiten.nl / AviationFacts.eu publication.

Authors: Thomas Berntsen, Jeffrey Schäfer, Hares Wardak
Editorial staff: R.J. de Boer PhD Msc, G. Boosten MSc & G.J.S. Vlaming MSc


Luchtvaartfeiten.nl is an initiative by the Aviation Academy at the Amsterdam University of Applied Sciences (HvA). Students and teachers share knowledge with politicians and the general public to ensure that discussions are based on facts

May 2016