AIRLINE HUBBING CONCEPTS

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Abstract

New forms of cooperation between airlines have been in place since nineties. Airline alliances have been formed among network carriers. Before, cooperation of airlines was based on bilateral agreements on code-sharing of their flights. For instance, in 1989 KLM and Northwest agreed on large-scale code sharing. Nowadays, three major alliances might be recognized - Star Alliance, SkyTeam and oneworld. Together, they count for two thirds of total number of available seat kilometres. Airlines in alliances benefit from extended network and economies of scope and are prone to gain competitive advantage over the market by being able to offer more O&Ds and multiple routings via their hubs. Furthermore, they might save cost by sharing their capacity, facilities (gates, premium lounges) and equipment with partner airlines. Airline networks are defined by served markets, number of destinations, their configuration and airline business models. There are two concepts of network structures recognised nowadays: Hub and spoke and Point-to-point. This paper offers insights to the Hub and spoke concept. First of all, it examines hubbing concepts in general, it describes detailed aspects that influence passenger connectivity and on top of that it offers different hub airports wave patterns and airline hubbing concepts.

Keywords

Airline hubbing, Passenger connectivity, Hub and spoke

1. Hubbing concept in general

Airline alliances exploit an advantage of developed networks in multiple geographical regions and strategically interconnect them in order to provide seamless travel for passengers and expanded range of O&D. This is especially important in markets where regulation prevents airlines from entering the market or establishment of hub would be ineffective. Hub airports play a critical role in linking together an alliance network, however they have to be coordinated not only on single network basis, but have to incorporate alliance-imposed connectivity (Aguirregabiria, 2010).

In summary, environment in which airlines are established directly influences their operations. The seventies brought many changes to the regulation and airlines had to quickly accommodate to dynamic market and optimize their activities in order to be competitive and profitable. Legislative changes made rapid growth of industry possible, what led to great advantage for passengers that could enjoy bigger variety of flights, better connections and generally more reasonable fares (Tomová & Materna, 2018).

Nowadays, airlines have freedom to decide on entry/exit of routes in their network and system of their operations. Configuration of networks resulted in two major concepts point to point, used mainly by low cost airlines and hub and spoke predominantly adopted and strengthened by network carriers in US and former flag carriers of Europe (Scharpenseel, 2001). In the following chapter, factors influencing connectivity of passengers will be explained and compared, with hub and spoke model in primary focus.

Airline hubs or hub airports are used by one or more airlines to concentrate passenger traffic and flight operations at a given airport. They serve as transfer (or stop-over) points to get passengers to their final destination (Bazargan, 2004). It is part of the hub-and-spoke system. An airline operates flights from several non-hub (spoke) cities to the hub airport, and passengers traveling between spoke cities need to connect through the hub. This paradigm creates economies of scale that allow an airline to serve (via an intermediate connection) city-pairs that could otherwise not be economically served on a non-stop basis (Novák Sedláčková et al., 2014). This system contrasts with the point-to-point model, in which there are no hubs and nonstop flights are instead offered between spoke cities. Hub airports also serve origin and destination (O&D) traffic.

2. Factors influencing connectivity

2.1. Minimum connecting time

Minimum connecting time (MCT) is the least amount of time that is essential in order to connect between two flights. It takes into account the time needed for passenger to connect and baggage to be reloaded. The length of MCTs is different for domestic-to-domestic (DD), domestic-to-international (DI), international-to-domestic (ID) and international-to-international (II) connections. This is due to the need of passing customs control that often takes more time (Hansson et al., 2002). For instance, MCT for domestic-to-domestic connections could be as short as 20 minutes, while for other types of connections 60 minutes.

Generally, it is airport specific. Smaller airports are usually able to offer shorter MCTs. They are able to provide faster connections than big hub airports, mainly because of less complex infrastructure. This may be an advantage for airlines operating from smaller hubs, so that they can offer faster connections (Hansson et al., 2002).

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2.2. Maximum connecting time

Regarding competitive hits (number of viable and competitive connections that could be made), it is believed that the connections should be made within the reasonable time-frame. Maximum connecting time (MaxCT) is the time span that limits number of possible connections, however it is not strictly framed (Goaetz et al., 2009). Generally, connecting times exceeding 3 or more hours (depending whether it is connecting continental or intercontinental segments, since 3 hours still may be acceptable for intercontinental connections) are less likely accepted by passengers (Novák et al., 2018). Figure 1 depicts the optimal hit window bounded by necessary time for transfer (MCT) and maximal optimal time for departure, with too late departure (dashed line) being unfavourable.

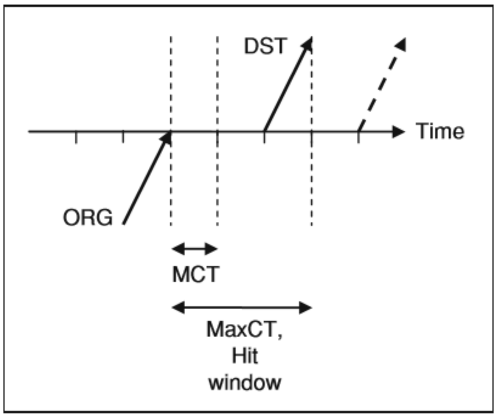

Figure 1: The connection defined by MCT and MaxCT. Source: (Goedeking, 2010).

Since the introduction of global distribution systems (GDS) such as Amadeus or Sabre there has been emphasis put on the reduction of connecting time since these distribution systems count fastest time elapsed for the full itinerary, including transfer. Therefore, connections with shorter elapsed time appear on the top as the most attractive. While, itineraries with long elapsed times are ranked relatively low. Kraus and Koch (2006) say that nearly 90% of bookings are made from the first page of GDS. Airlines that are not able to provide quick and seamless connections, with transfer in optimal time frame, are likely to lose competitive advantage in the market what may result in loss of revenues (Danesi, 2006).

2.3. Turnaround time

The time needed for an aircraft between arrival and another departure is called turnaround time (TAT). It is the time frame from the moment when aircraft parks at the gate “on blocks” until it is pushed back from the gate “off blocks”. The length of the turnaround time depends on the aircraft deployed, airport and airline. Generally, short/medium haul aircraft requires shorter turnaround times than long-haul wide-bodies. Also turns are faster at outstations, while at base some light maintenance may be performed (Burghouwt, 2007). Airlines strive to minimise turnaround times since the time when aircraft is not flying is considered as non-productive time. By minimizing turnaround times airlines increase efficiency, as well as aircraft and airport assets utilisation, which results in significant cost savings. Sometimes by reducing turnaround times, it may be caused that an aircraft is able to make more rotations per day (Figure 2).

2.4. Temporal design of bank

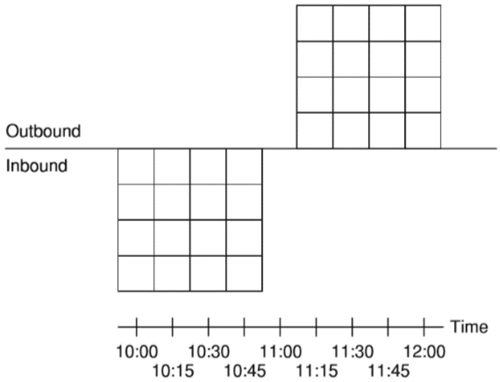

Figure 2: Illustration of inbound and outbound banks. Source: (Goedeking, 2010).

First of all, it is essential to make a distinction between banks and waves. It is frequently assumed that they mean the same thing, however banks are temporal assemblies of flights and they can either be referred to as inbound/outbound or feeder/de-feeder, as well. Usually, arrival/departure patterns at the airports are banked but not necessarily waved. Wave is a combination of inbound bank and corresponding outbound bank, which is separated from other waves by periods of reduced activity (Dennis, 2000). Figure 3 provides schematic illustration of two banks, where each square represents one flight. Inbound as well as outbound bank lasts for 45 minutes. Assuming MCT to be 30 minutes, the time of outbound bank should be shifted by 30 minutes after the arrival of last aircraft of the inbound bank. This would create an ideal wave, reaching maximum number of feasible connections. Note that the first arriving aircraft at 10 o´clock connecting to the last outbound flight at 12 o´clock has a connecting time window of 120 minutes duration which is still regarded as competitive, while the quickest connection lasts for 30 minutes.

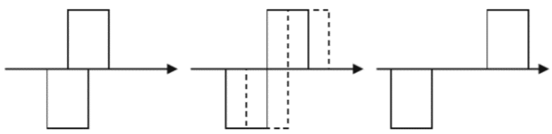

Figure 3: Types of bank. Source: (Goedeking, 2010).

2.5. Directionality of hubs

The wave pattern where one particular direction of inbound flights is prevailing and corresponding outbound bank fits its counter-direction is important driver of connectivity. So the connectivity is negatively affected with increasing number of directions.

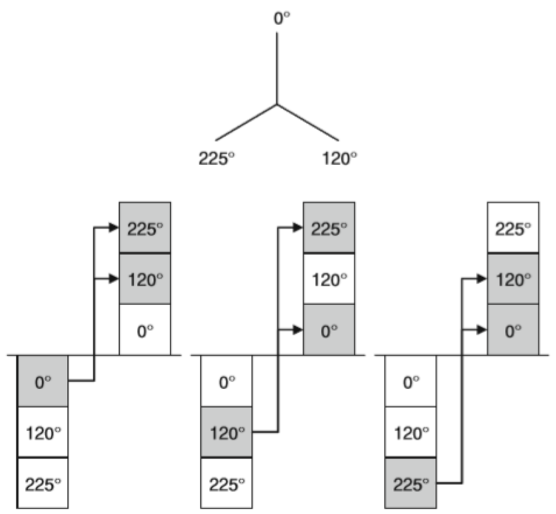

Figure 4: Connectivity constrained with directionality. Source: (Goedeking, 2010).

Figure 4 shows a central airport with three prevailing courses of traffic. Banks consist of inbound traffic from one direction out of three, which connect to remaining two directions. However, this cuts down number of viable hits by 2/3. The issue is relevant when an airport serves multiple directions and should be taken into account when timing flights within banks.

3. Hub airports wave patterns

Bazargan (2004) recognises three distinct categories of hub airports.

3.1.1. Random hubs

These hubs show no peaked banks in their overall patterns but appear flat and structures that are created are random. The timing of the flights is not optimized for connectivity but for other operational reasons, such as rotational patterns of the aircraft, fleet and staff utilisation. The connections that occur are secondary by-product of the timing of flights. These hubs may be predominantly found in LCCs networks (Cook et al., 2008).

3.1.2. Rolling hubs

By the appearance they seem similar to the random hubs however their structure is intentionally de-peaked and the timing is optimized for connectivity. Bank structures are still present however they are not obvious from the pattern, since flights from peak periods were shifted to periods with reduced activity. So banks follow each other immediately what creates continuous hub. Usually, only airports that have reached certain volume of traffic and are well established, serving both short-haul and long-haul routes are able to incorporate continuous pattern at their hubs (M2P Consulting, 2015). On the other hand, airlines facing airport capacity constraints such as British Airways at London Heathrow, which is only two runway airport tend to adopt rolling hub structures.

3.1.3. Spiked waved hubs

In the overall pattern of these hubs a number of distinct waves that are separated by periods of reduced activity are present. These enhance connectivity and number of possible hits. However, they may impose high demand on infrastructure capacity and may prevent robustness of the schedule, where disruption may have enormous impact on the rest of the network.

The other consideration for waved structures is the number of waves. Each airline applies different approach to how many waves it operates. This is especially determined by the average sector length of the routes they fly. For a typical European airport where majority of sector length is within 3 hours airlines may incorporate up to 5 or 6 waves in their pattern, while an airport in Middle East serving long-haul to long-haul transfer traffic can support no more than four waves during the day.

3.1.4. Consequences of wave structures

M2P Consulting (2015) provides comprehensive understanding of how changes in bank design influence four major aspects of hub operations such as connection quality, number of hits, fleet productivity and infrastructure utilisation. (Figure 5)

		Connection quality	Number of hits	Fleet productivity	Hub infrastructure utilisation
Number of banks		↑	↓	↑	↓
Length of banks		↓	↑	↑	↓
Height of banks		↑	↓	↓	↑
Overlap		↑	↓	↑	↑

Figure 5: Characteristics of bank design and its influence on other factors. Source: (M2P Consulting, 2015).

4. Airline hubbing concepts

4.1. Methodology

The previous study of the problem reveals the fact that there is no same hub airport. Each one of them has a certain characteristics and unique wave pattern that is related to its geographical location, O&D flows, airlines operating at this airport as well as market specifications.

Regarding hub performance there are three key aspects that determine overall bank structure (Bieger et al., 2015):

Network structure – connectivity of routes within hub, number of O&Ds, convenience of transfer

Efficient use of fleet and infrastructure – high productivity (for the fleet output expressed in block hours)

Stable operations – amount of time critical connections, recovery from delays

The purpose of this chapter is to offer a simple airline benchmarking and their hub and spoke operations at their hubs. It explains methods that were used in order to assess banked structures of airlines at their respective airports. It provides information on sources of the data as well as methodology that was used in order to analyse this information.

Three European, three American airlines and one Middle East carrier were selected for the analysis of their networks. These airlines were selected in order to represent three important and well developed regions in the world regarding connecting traffic. Furthermore, the basis was placed upon selecting carriers with well-established networks and those that are the major players both in their regions and worldwide. International Air Transport Association (2017) suggests that all selected airlines are in top ten world airlines in terms of operating revenue.

Official Airline Guide (2017) issued World Mega hubs international index, which lists the most interconnected airports in the world. This index ranks the airports according to the highest ratio of possible scheduled international connections to the number of destinations served by the airport. Top airports are LHR, FRA, AMS and ORD. ATL is ranked at 8th position, DXB at 20th concluding with DFW at 27th. Our analysis will focus on specific airlines operating at selected airports.

Region	Airline	Alliance
Europe	British Airways	oneworld
	KLM	Skyteam
	Lufthansa	Star Alliance
United States of America	American Airlines	oneworld
	Delta Air Lines	Skyteam
	United Airlines	Star Alliance
Middle East	Emirates	none

Figure 6: Carriers selected for analysis. Source: Compiled by Authors.

Additionally, selection was made in order to choose airlines that are part of one of three airline alliances or they are not members of any alliance. Figure 6 depicts European and American carriers that are part of different alliances, Emirates not member of any alliance.

Information on their schedules were gained from CAPA – Centre for Aviation. Data were provided in hourly movements where arrivals and departures were given separately. The day selected for the analysis was Monday, 26th of March 2018 as Mondays are generally one of the busiest days of the week.

Furthermore, data regarding network size and directionality were gained from sites openflights.org and gcmap.com.

4.2. Criteria of the analysis

4.2.1. Number of theoretical hits

The number of possible connection within 5-hour window of the current schedules was researched. Minimum connecting time was established at 60 minutes, which is usually standard for international connections and maximum connecting time was limited to max. 6 hours after the arrival. Therefore, a window of 5 hours for connection was created. This is rather restrictive, especially for connections where both sectors are long-haul, however it enhances attractiveness of the connection. It is considered optimal for the purpose of this study (three hours, is too short for this analysis since it would not cover the length of the banks). The number of feasible hits was calculated as follows:

Number of hits = Number of arrivals * Number of departures

Number of arriving flights was paired with all departing flights within the 5-hour connection window. Then numbers of total hits were calculated. This provided rough estimation of the number of potential hits.

Following features were observed from the layout of daily movements:

4.2.2. Number of waves

The banking structures are observed from the overall layout of graphs depicted in figures.

4.2.3. Length of individual banks

The average duration of bank is assessed.

4.2.4. Number of flights in peak hours of banks

Number of flights in peak hour defines the height of the bank.

4.2.5. Overlap

Is the overlap present in the structures or not?

4.2.6. Directional flows

Diagram with directional flows was assessed as well as main flows in it.

Three biggest American carriers have significantly higher volume of flights when compared to the European carriers or to Emirates. When it comes to number of scheduled flights a day, Delta sits at the top (counting for up to 2400 movements per day). British Airways is the only carrier that completely incorporated rolling hub strategy and there are no waves present in their pattern. Lufthansa, United Airlines and Emirates operate patterns with four waves, KLM as well as Delta operate five waves with smaller volume of traffic than LH and UA. The only airline that has more than five waves is American Airlines. However, correlation between number of waves and volume of traffic was not found out. Therefore, the number of waves does not influence volume of traffic. It is rather up to the airline and its scheduling strategies or constraints.

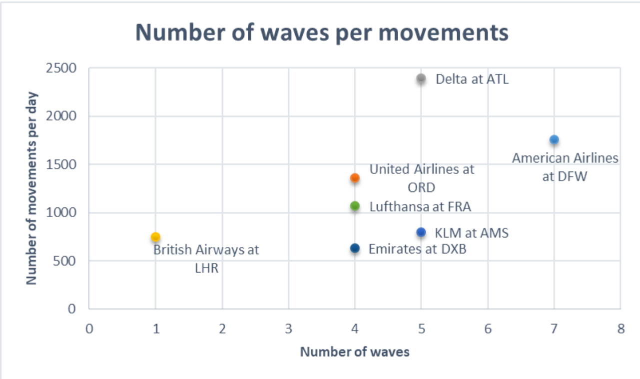

Figure 7: Number of waves to the number of movements for airlines. Compiled by Authors, based on data CAPA data.

4.3. Airline benchmarking

The main criterion for airline benchmarking is the theoretical number of feasible hits in window of 5 hours, which were calculated from the data of hourly movements. Since the number of movements is provided per hour (and not in smaller time frame) the Figure 8 provides just rough calculation of hits per arrival. The accuracy is compromised since the exact timing of the flights is not known.

In this case, connectivity is measured by number of hits per inbound flight (CAPA, 2018). It gives number of flights to which one arriving flight is able to connect. This result was gained by computation in which total possible hits were divided by number of arrivals.

Results show that number of hits per arrival is linked to the volume of traffic, so the more flights an airline operates the more hits are created. Delta has leading position with its 315 hits per one inbound flight in time window of 5 hours, followed by other airlines.

Airline	Arrivals	Departures	Daily number of hits within 5 hour window	Average Number of hits per arrival in 5 hours	Ranking
American Airlines at DFW	875	881	209517	239	2
Delta Air Lines at ATL	1203	1186	378388	315	1
United Airlines at ORD	688	673	116697	170	3
British Airways at LHR	370	376	34176	92	6
KLM at AMS	407	391	43885	108	5
Lufthansa at FRA	537	530	76361	142	4
Emirates at DXB	307	321	25986	85	7

Figure 8: Average number of hits per arrivals. Compiled by Authors based on CAPA data.

4.3.1. European Carriers

Sample of three European carriers shows presence of two patterns, either waved structure or flat. Both Lufthansa and KLM operate waved structures at their hubs with 4 and 5 daily waves, respectively (see Figure 9). Waves of European carriers are less steeply spiked and tend to last for few hours. Both carriers have in common that number of departures is maintained at certain level – around 20 throughout the day.

Lufthansa´s banks are wider and larger and its departure peaks consist of about 50 outbound movements and it falls to around 20 (in the off-peak period). But it is not completely reduced. Exception is the period prior to the last peak, where activity is very low. The same applies to arrivals, where off-peak levels stay at 20 flights per hour, and afternoon peaks are very strong with 60 flight per hour. KLM, which has lower number of flights, schedules 40 outbound flights per hour during peaks.

As per arrivals, morning and evening peaks are dominant with 60 inbound movements. Mid-day peaks are smaller in size and length. Likewise, Lufthansa, has considerable level of traffic in off-peak hours - slightly higher in number of departures. Overlap is partly present, where inbound bank overlaps with its respective outbound bank. This lead to a reduction of potential connections as some flights may not be able to make connection.

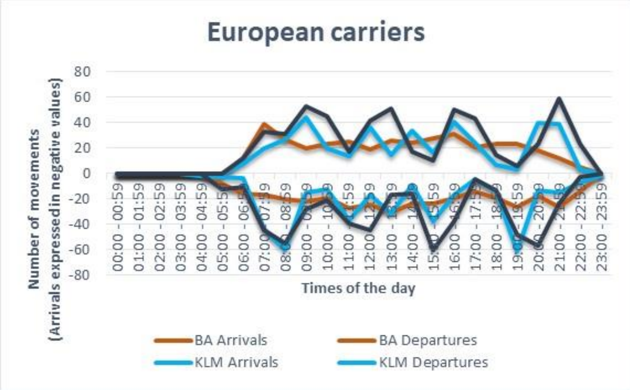

Figure 9: Wave patterns of European carriers. Compiled by Authors based on CAPA data.

British Airways adopted flat structure at its London Heathrow hub – it has evenly distributed flights and no spikes are present. Main cause for it is capacity constraint at this airport which has only two runways. In the morning peak, number of flights reaches 40 and then decreases to 20 and stays between 20 to 30/hour.

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