

Analysis of Point-to-Point versus Hub-and-Spoke airline networks

Zuzana Zgodavová, Róbert Rozenberg, Stanislav Szabo

Technical University of Kosice, Faculty of Aeronautics, Flight Preparation Department, Kosice, Slovakia

zuzana.zgodavova@tuke.sk

robert.rozenberg@tuke.sk

stanislav.szabo@tuke.sk

Abstract— The article deals with the issue of networking of air carriers. It compares two basic Point-to-Point and Hub-and-Spoke types. It presents their characteristics, describes their pros and cons, networking methodology, calculation of network coverage and provides a graphical representation. It focuses primarily on the operational and economic aspects of both models. The Point-to-Point system is currently applied by low-cost carries and the Hub-and-Spoke model of full-service carries.

I. INTRODUCTION

Air transport system is a complex that consist of large number of different elements that cooperate and interact with one another. Significant elements of the transport process are mainly airports and air carriers. For efficient management of airline connections between individual airports, air carries created airline network. Network management is a very crucial task for route management which decides the scope and focus of the network, sets seasonal schedule and decides on capacity changes or eventual cancelation of routes. For the realization of networking, one of the basic types is chosen, either a line network or Hub-and-Spoke perhaps even the network is formed by combination of both [1], [2].

II. POINT-TO-POINT ROUTE SYSTEM

A. Airline network configuration

The Point-to-Point airline system, also called a direct network or line network, is a model in which flights are operated *directly between two cities*, regardless of distance (Fig.1). Utilization of this model makes it possible to save up 30 % of costs due to direct flights without stopovers. Airlines operating the point-to-point model do not transfer baggage automatically but passengers have to claim their checked-in belongings at a transfer airport and check-in them again for a connecting flight. Although, they connect with the same carrier. Although there are a large number of Point-to-Point airlines, most of them have at least the home base from which they operated most of their flights.

This model became very popular in the United States of America in the 1970s before deregulation of air transportation. Because the government has run the routes that airlines had been operating before 1978, many airlines have flown direct routes between small cities with low demand. Currently, this type is used by low cost airlines such as Ryanair, EasyJet, Wizzair and others [5].

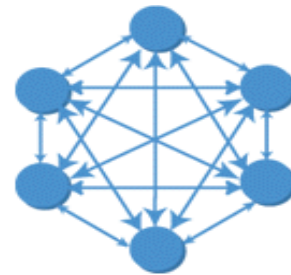


Figure 1. Point-to-Point [5]

This model is optimally used under the following circumstances:

- distance between two cities is small,
- demand between two cities is high,
- total number of cities served by the airline is small [6].

B. Operational and economics aspects of system

One of the advantages of the Point-to-Point model is that direct flights have no interdependence on other flights or hub airports. This minimizes the "domino effect" in case of one flight delay, which may cause multiple delays in the network. In the same way, the closure of the airport won't significantly affect the other schedule. For this reason, the Point-to-Point system is less prone to delays[6].

The Point-to-point model of flying allows to shorten total flight time by eliminating of transfer points. This time can be also reduced by flights in geographically direct directions and increasing the aircraft block speed.

In comparison with Hub-and-Spoke model, Point-to-Point model decreases airport dependency. Hub-and-Spoke featuring airlines represent a very attractive operating structure, but this model absorbs almost all airport's slot capacity and leaves no available for other potential carriers. This dependency also reduces the number of new routes of operating airline. However, the Point-to-Point system markedly reduces this dependence, because each route from each airport is actively important [3].

The realization of direct flights reduces the risk of lost baggage as the passenger is obliged to reclaim their baggage after each flight. Within this system, the total

amount of fuel and pollution per one passenger is also lower [5].

The use of this system brings benefits not only to the airline but also to airports. Maximum utilization of aircraft doesn't only lead to a high use of flight crew, but also to full use of airport staff during the whole day. A single fleet type that is usually used by low-cost airlines, reduces the costs of maintenance and staff retraining [6],[3].

The frequency of flights in the Point-to-Point model depends on the type of market and its density. Most small and medium sized cities do not have sufficient demand to support direct flights to more than a few if any destinations. The reason for the low frequency of flights in this model is also more pairs of airports (origin – destination airport) [3].

If the carrier doesn't offer transportation to the required destinations, the passenger will prefer the carrier with connecting flights or will travel by other means of transport. Without connecting flights or transport connection, the airline has no ability to balance specific demand changes along the route, rather it focuses on changes in flight frequencies, aircraft size, or seasonal routes when trying to balance capacity and demand. The absence of connecting flights can also complicate crew planning in low frequency flight systems [8].

Networking and expanding the number of destinations using the Point-to-Point model needs higher number of routes. For example, if an airline operates flights from five airports it will need 10 routes. If a carrier expands its network up to 1 destination, then other 5 routes will be needed to ensure direct flights (Fig. 2). As a result, the number of routes needed to cover all the cities (airports) in the network is growing very fast. The number of routes is directly dependent on the number of destinations in the network [4].

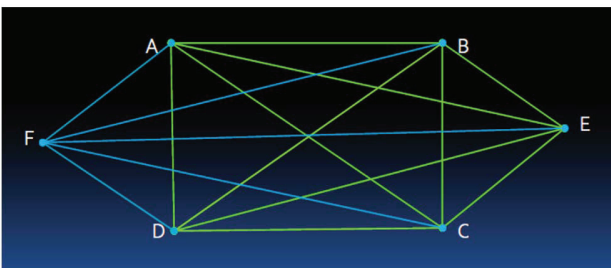
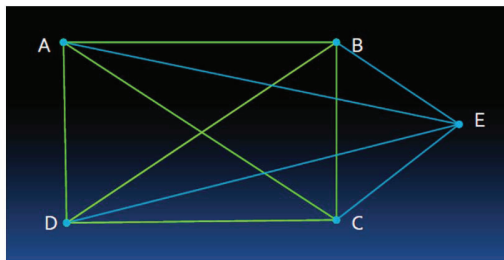


Figure 2. Network planning and expansion (Point-to-Point) [6]

Following the above mentioned, there is a formula of

$$\frac{n(n-1)}{2} \quad (1)$$

to calculate a number of routes where the variable of n stands for a number of Point-to-Point cities (destinations). Actually if airline offers flights to 100 destinations, 4950 routes will be needed to cover all destination in the network [6].

Airlines operating the point-to-point model must not only build a large aircraft fleet and employ numerous staff teams but also establish a challenging management system and bear high operational costs [4]. The following Table 1 shows reviews of pros and cons of Point-to-Point airline system.

TABLE I.
PROS AND CONS OF POINT-TO-POINT SYSTEM

PROS	CONS
High schedule reliability	Low frequency of flights per day
Reduction total travel time	Absence of connecting flights
Decreasing airport dependency	Higher number of routes needed to cover all cities in the network
Reduction the risk of lost baggage	
Maximum utilization of aircraft	Challenging management system
High use of flight crew	High operational costs
Lower amount of fuel and pollution per one passenger	Large aircraft fleet
	Numerous staff teams
Full use of airport staff during the whole day	
Single fleet type	
Reduction of the cost of maintenance and staff retraining	

Fig. 3 shows Wizzair airline network which operates flights to 141 destinations [9].



Figure 3. Wizzair airline network [9]

III. HUB-AND-SPOKE ROUTE SYSTEM

A. Airline network configuration

The second basic type of network, which is used by airlines is Hub-and-Spoke. As its name suggests, it is made up of *hub*, respectively a hub airport, that the airline uses as a transport point to the planned destination of the route and several *non-hub airports* that represent the larger or economically viable destinations in the area. A passenger who departs from any city - a non-hub airport to another destination on the network - first arrives the central (hub) airport from which he continues to final the destination. Thus, passengers can travel between any two cities in the network, with one stop over in a hub airport. The network of Hub-and-Spoke lines resembles the wheel of a vehicle, with several such structures being used in one network, where transport is concentrated on one main airport – main node (to the center of economic and flight activities in that region) from smaller national airports. This system is optimally used to provide air transport to a wide geographical area and to many destinations.

The pioneer of the Hub-and-Spoke model was Delta Airlines already in 1955. This model, however, brought a revolution in the logistics and transport sector. Federal Express airline demonstrated the value of the concept in the early seventies. The start of the development of the Hub-and-Spoke network system was created in 1978, with the adoption of a law on deregulation of airlines in the USA. The purpose of introducing this system was primarily cost-effectiveness. In addition to the two companies, this model is used by many major airlines such as American Airlines, Air France, Lufthansa, Emirates and others [5], [3].

This model is optimally used under the following circumstances:

- distance between 2 cities is large,
- demand between 2 cities is low,
- total number of cities served by the airline is large [6].

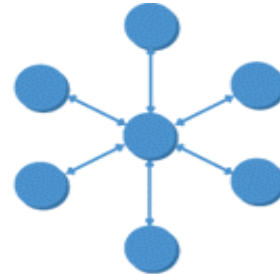


Figure 4. Hub-and-Spoke model [5]

B. Operational and economics aspects of system

The Hub-and-Spoke model requires less routes than Point-to-Point. For example, there is a need for 5 routes to operate flights between 6 destinations in the network (with one main airport and 5 non-hub airports, see Fig.5). However, when applying the Point-to-Point model, 15 routes will be needed for the same number of destinations (see Fig. 2 for comparison).

Following the above mentioned, there is a formula of

$$(n-1) \quad (2)$$

to calculate a number of routes where the variable of n stands for a number of destinations. If an airline offers

flights to 100 destinations, 99 airline routes will be required to cover all destinations in the network [6].

A smaller number of routes leads to a more efficient use of resources. This means that with less routes in the network, the airline will pay lower landing fees and will have lower crew costs. At the same time, less aircraft will be needed [5].

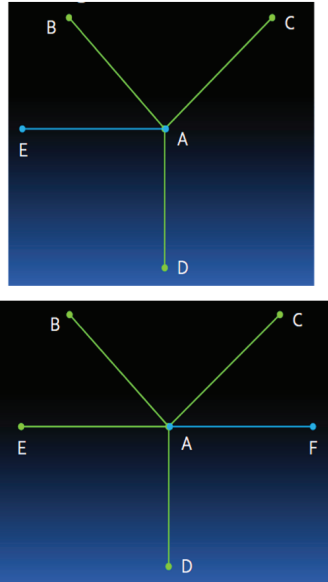


Figure 5. Network planning and expansion (Hub-and-Spoke) [6]

The Hub-and-Spoke network allows airlines to plan their flights effectively around their hub airport, allowing passengers to get from anywhere on the network to most or all of the offered destinations. As passengers often prefer 1 airline for their route, this model also allows airlines to effectively manage their aircraft, staff, passengers and other company's assets. Operating this model provides a simpler expansion [3].

Because of flights are realized with stopover in the main hub, several flights can be scheduled on the route, what allows more options for passengers. With less flight routes and a given number of aircraft, each route can be operated more frequently and with more capacity, because of a demand for passengers can be insured from more than one airport (place of network) [7].

The Hub-and-Spoke model allows to reduce offered available seats kilometers. If demand on the route rises, especially between two hub airports or international destinations, airlines can use larger aircraft. This means that they can carry more passengers between two cities with lower frequency of flights, what allows them to reduce airport fees and crew costs. Lower available seats kilometers (miles) allows airlines to achieve higher profit margins or to reduce their prices to better compete with other airlines. Because of efficiency increase, an airline can choose the suitable type of aircraft for each route according to the demand and offered capacity [5].

If airlines want to limit waiting times and provide a wide range of connections for passengers at the hub airport, it is necessary for the company to schedule as many incoming and outgoing flights as possible during short time. This results in high traffic peaks at these times

and often causes delays due to limited facilities of airside such as taxiways and runways. The total capacity of the network is therefore limited by the capacity of the airport (or several hub airports). Another reason for congestion is the fact that many airports do not have a limited number of take offs and landings. One possibility how to prevent congestion and ensure a growing number of passenger is to use aircraft with more capacity. Delay of large passenger aircraft lead to the loss of connecting flights. Ultimately, it can result in low utilization of connections between hub airports and reduction of the carrier profitability. This problem is particularly important for the operation of A380 aircraft [7].

The disadvantage of the use of this model is the independence of the other flights, which causes the "domino effect", when one flight delay may result in multiple delays elsewhere in the network. Delay which occurs at the hub airport (for example in severe weather conditions), can lead to the flight delays in entire network.

It is characteristic for the flights operated within a network and via a hub that the flown distance is longer. Also at least one airport transfer (two segments) must be crossed. In case of the point-to-point flights the flown distance and flying time are shorter. In addition, the time spent at the hub airport because of stopover or transfer, increases the total flight time [6].

Airlines using the Hub-and-Spoke model, have chosen limited number of airports on each continent, through which they operate their flights. As airport capacity is limited and usually is not sufficient for other extensive networks, and if slots are not available at attractive times, other airlines tend to choose alternative options. Airport dependency brings for hub airport some advantage but also some disadvantages. If the airline is stable and successful on the market, the airport can be sure that this operation is permanent and thus guarantees a stable source of income. If the airline has problems, it also has a negative impact on the airport, which could seriously jeopardize profitable operations at the airport.

The merging of air traffic in the Hub-and-Spoke system means transport structure that consists of high peaks at certain times a day when airport facilities are highly in use. At some airports, additional capacity and infrastructure (such as the construction of a new runway) are required to meet the demands of these peak operations. During off-peak hours, as traffic is less, terminal and airside facilities are used inefficiently. The time difference between capacity and demand will always lead to congestion and delays or inappropriate use [7].

By the reason of the model is centralized, day-to-day operations may be relatively inflexible, and changes at the hub airport even for one route may have unexpected consequences across the network. It may be difficult, even impossible, to manage occasional periods with high demand between two points in the network (spokes). As a result of this, route planning is complicated for the network operator because limited sources need to be used carefully. Also careful traffic analysis and precise timing is necessary to maintain the effective operation at the hub airport [4].

One of the drawbacks of this model is increasing risk of lost baggage during transport through the hub airport[3].

The Hub-and-Spoke model is often used by airlines because it is efficient, flights are cheap and the model

provides simple network expansion. The mission of the hub airport is to merge regional demand of business passengers, international passengers, passengers traveling in free time and cargo, to create multiple airline routes and growth of regular flights. In general, the more connections that have the hub airport, the more passengers use this certain node to reach its destination. This also means that the frequency of these routes increases. It follows that the Hub-and-Spoke model allows airlines to operate flight with high frequency and larger passenger aircraft at higher load factor, thereby reducing costs.

As mentioned above, the application of this model also brings some cons. Facility costs are high and it is estimated that only 60 % of flights pass through the hub airport to make connecting flight [5]. The following table 1 shows reviews of pros and cons of Hub-and-Spoke airline system.

TABLE II.
PROS AND CONS OF HUB-AND-SPOKE SYSTEM

PROS	CONS
Lower number of routes needed to cover all cities in the network	Congestion and delays at hub airport
	Low schedule reliability
Lower costs and efficient use of resources	Longer flight segment and extended flight time
"Anywhere to Everywhere"	Increasing airport dependency
	Non-constant use of airport facilities
High frequency of flights during the day	Complicated route planning
Reduction of the cost of available seats kilometers (available seats miles)	Increasing risk of lost baggage

Fig. 6 shows the Emirates airline network with one hub airport (Dubai) which offers airline connections to 144 destinations. As we can see, superhub of the airline is perfectly located geographically and demographically. It provides easy connections with Africa, the Middle East, Asia and Europe [10].

IV. CONCLUSION

Before the deregulation of air transportation, airlines used the Point-to-Point system. As the government managed flights and routes in the 1970s, many airlines operate direct flights between small cities with low demand. Nowadays, this model is mainly used by low cost airlines, which make it possible to save a considerable amount of costs due to direct flights. Its optimal utilization depends on three factors, such as the small distance and the high demand for transport between two cities and totally smaller number of destinations served by the airline. The advantages which this model brings are mainly high schedule reliability, reduction total travel time and the risk of lost baggage, high use of flight crew, and reduction of the cost of maintenance and staff retraining and so on. However, one of the biggest disadvantages of this model is higher number of routes needed to cover all cities in the network. Moreover, operational costs are high and this model requires large aircraft fleet and numerous staff teams.

However, adoption of the Airline Deregulation Act in 1978 in the USA, played major role in the airline network planning. Instead of the direct flights, some airlines started to operate flights via hub airport. This system is known as the Hub-and-Spoke model and is currently used by full-service carriers. The purpose of introducing this system was primarily cost-effectiveness. Others benefits which Hub-and-Spoke model brings are lower number of routes needed to cover all cities in the network, high frequency of flights during the day and possibility to fly from anywhere in the network to most or all destination in the network of airline. On the other hand, utilization of this model has some cons such as congestion and delays at hub airport, low schedule reliability, longer flight segment and extended flight time, increasing airport dependency and others.

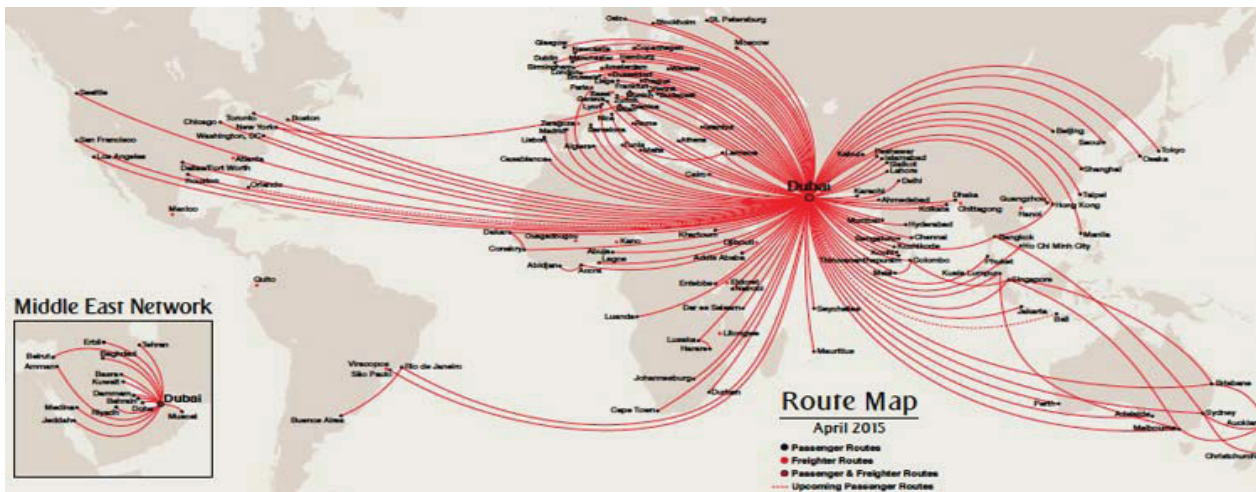


Figure 6. Emirates airline network [10]

REFERENCES

- [1] Pruša, Jiří et al, "Svet leteckej dopravy," Praha: Galileo, 2008. 321s. ISBN 9788080739386.
- [2] Žihla, Zdeněk et al, "Provozování leteckých podniků a letišť," Brno: Akademické nakladatelství CERM, 2010. 302 s. ISBN 9788072046775.
- [3] Cook, G. N., Goodwin, J., "Airline Networks: A Comparison of Hub-and-Spoke and Point-to-Point Systems," in *Journal of Aviation/Aerspace Education and Research*, vol 17, No 2, 2008, p 50-60.
- [4] Lordan, Oriol, "Study of the Full-Service and Low-Cost Carriers Network Configuration," in *Journal of Industrial Engineering and Management* vol 7, No 5, 2014, p. 11-23.
- [5] Mcdermott, John, "The Airline Economics of the Bicycle Wheel: Point-to-Point vs Hub-and-Spoke Flying" [online]. Available on the Internet: aeronauticsonline.com/the-airline-economics-of-the-bicycle-wheel-point-to-point-vs-hub-and-spoke-flying/>
- [6] GARODIA, Prateek: Introduction to airline networks [online]. Available on the Internet: http://www.math.wm.edu/~rrkinc/hmk_current/104airnetsintro.pdf>
- [7] Advantages and Disadvantages of Hub-and-Spoke Operations [online]. Available on the Internet: http://aviationknowledge.wikidot.com/aviation:advantages-and-disadvantages-of-hub-and-spoke-operations>
- [8] Hub-and-Spoke vs Point-to-Point Transport Networks [online]. Available on the Internet: http://blogs.cornell.edu/info2040/2011/09/14/hub-and-spoke-vs-point-to-point-transport-networks/>
- [9] Wizzair [online]. Available on the Internet: https://wizzair.com/#/>
- [10] Emirates [online]. Available on the Internet: https://www.emirates.com/cz/english/>