Chapter 2
Past and Future Developments of the Global Air Traffic

Johannes Reichmuth and Peter Berster

Abstract This paper gives an overview of the development and structure of the global and regional air traffic markets. The number and geographical distribution of flights together with the aircraft types needed to satisfy the demand for passenger and cargo transport are analyzed. Air traffic market developments are described from a traffic-oriented perspective. Environmental and economic aspects are not subject of this discussion. Thus this paper addresses the following six topics: global development of the air transport system, regional distribution of the air traffic, airport development and bottlenecks, airlines, aircraft types, and outlook of air traffic development.

2.1 Introduction – Global Development in Air Transport

Since 1950, a steady increase of passengers and goods transported by air has been observed. This development has only been reduced in times of various crises like the first oil price crisis in 1973, the second oil price crisis in 1979, the Gulf war in 1991, the 9/11 attacks in 2001 and the financial and economic crisis in 2008/2009 (Fig. 2.1). However, these crises have had no permanent effects on the global long term growth of the civil air traffic. For example, between 1978 and 2008 air transport demand has quadrupled.

There are several reasons for this strong increase. One reason is the greater demand for exchange of persons and goods between and within different world

J. Reichmuth (✉) · P. Berster
German Aerospace Center, Institute of Air Transport and Airport Research, Köln, Germany
e-mail: johannes.reichmuth@dlr.de

P. Berster
e-mail: peter.berster@dlr.de

M. Kaltschmitt, U. Neuling (eds.), *Biokerosene*,
DOI 10.1007/978-3-662-53065-8_2

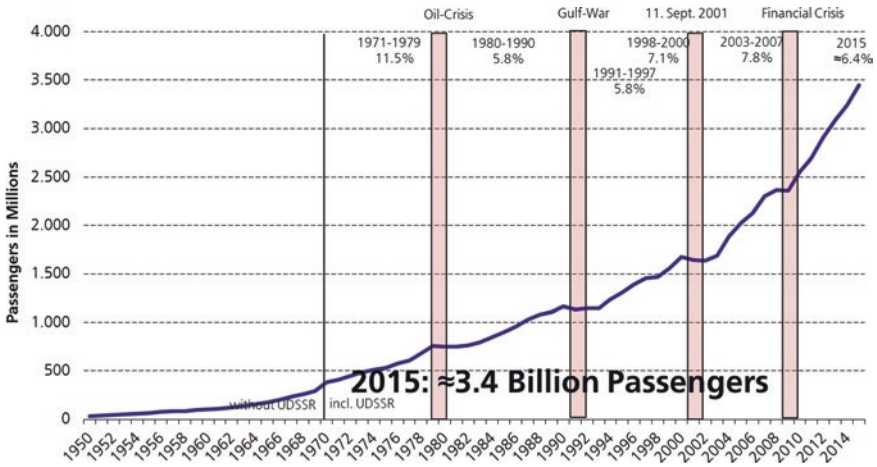

Fig. 2.1 Development of global air transport [1]

regions. This has been primarily driven by an increasing international division of labor of supply chains; i.e. more people with more time and money for air travel purposes need to be transported. This is especially true for developing countries. Additionally, an increasing demand within the more saturated markets has been generated by decreasing ticket prices as a result of increased competition between airlines. This has been realized due to the liberalization of air transport markets in combination with the use of more fuel and operational efficient aircraft types. The Low Cost Carrier (LCC) airline business model enables the development of new, dense point to point networks within many world regions. This development took place especially in Europe but more recently also in Asia, Africa or Australia, in addition to the traditional hub and spoke networks operated by Full Service Network Carrier (FSNC). Many of the latter have been former national flag carriers. About 3.4 billion passengers have been transported in 2015.

2.2 Regional Distribution of the Air Traffic

In January 2016 2.8 million aircraft departures have been scheduled globally (Fig. 2.2). Most of the destinations are located within different continents or within large countries. Asia is the biggest air transport market with 788,000 departures, followed by North America with 753,000 and Europe with 513,000. The main part of the air transport occurs clearly in the Northern hemisphere. Only the air traffic in South America with 253,000 departures reaches traffic values in the same order of magnitude compared to the leading three regions. All other regions and their connections show numbers below 100,000 departures. The exchange between North and South America with 75,000 departures is more than two times stronger than

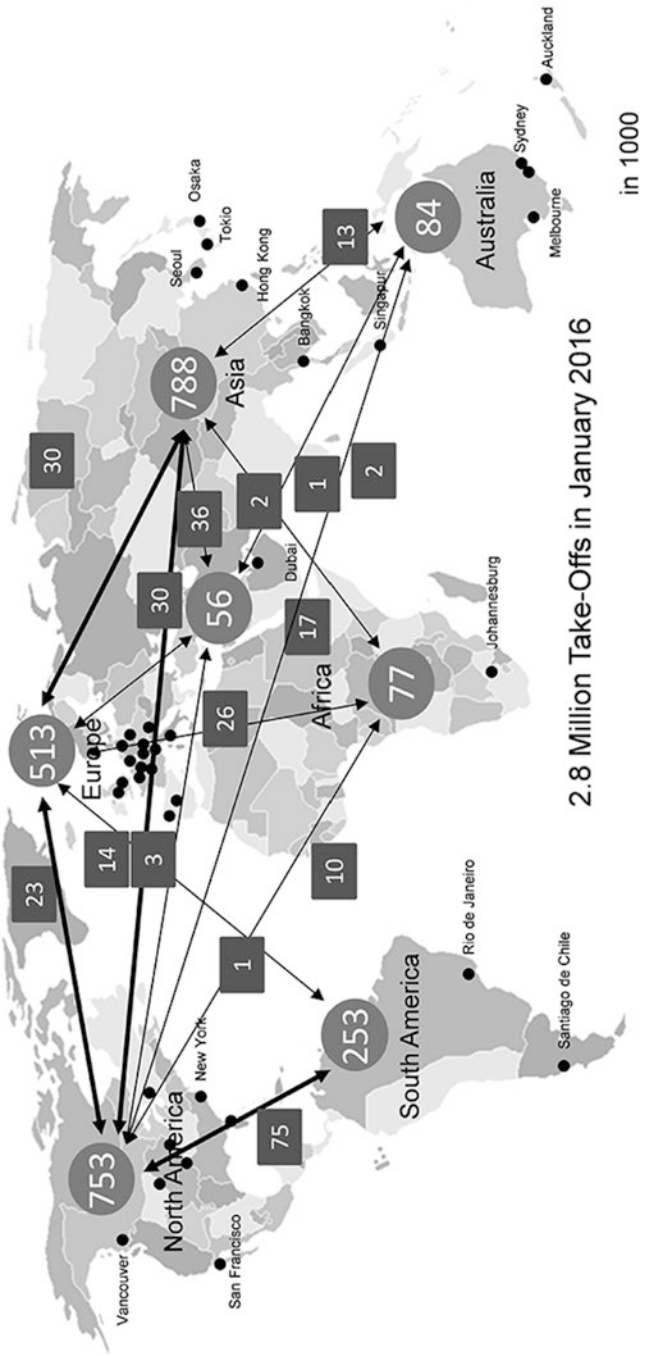

Fig. 2.2 Regional development of global air transport [2]

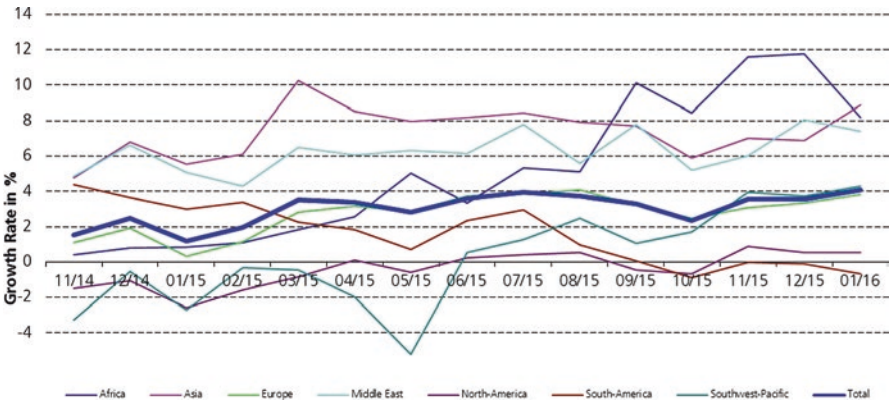

Fig. 2.3 Regional development of the global air transport supply (number of take-offs) [2]

single relations between other regions. In the past the air transport flow between Europe and North America was stronger than the flow from Europe to Asia. In the last years the flow between Europe and Asia experienced a strong growth. With 33,000 departures this traffic has now overtaken the relation between Europe and North America. This illustrates the increasing importance of the Asian economies for countries of the Western world. Furthermore, this contributes to the strong growth of the Europe – Middle East and Middle East – Asia relations.

Additionally Fig. 2.3 shows the developments of different markets in terms of growth rates from November 2014 to January 2016. Coming from a strong increase of growth rates after the financial crisis 2008/2009 the growth between 2011 and 2013 turned into negative numbers. Since 2013 positive growth rates could be reached again. In January 2016 the volume of traffic reached a value which has been about 4 % higher than the year before. Nevertheless, the growth rates vary significantly between different regions. The markets in Asia and Middle East show strong growth rates between 6 and 8 %. But also in Europe the growth rates are positive since 2014 and have now reached the global average of about 4 %. The North American market did not grow in the past; however, since the end of 2015 also there are some signs of growth. The other smaller markets show heterogeneous tendencies.

2.3 Airport Development and Bottlenecks

Airports provide the necessary ground infrastructure for take-offs and landings. Globally there exist more than 10,000 aerodromes and airports. However, scheduled and charter flights are operated at about 3,800 airports. This includes airports which have at least one scheduled flight per year.

Thus, Fig. 2.4 shows the very uneven distribution of the global flight volumes on airports. In 2014, the largest 1,000 airports handled more than 90 % of the global flight movements and the top 100 airports operated nearly 45 % of the global traffic.

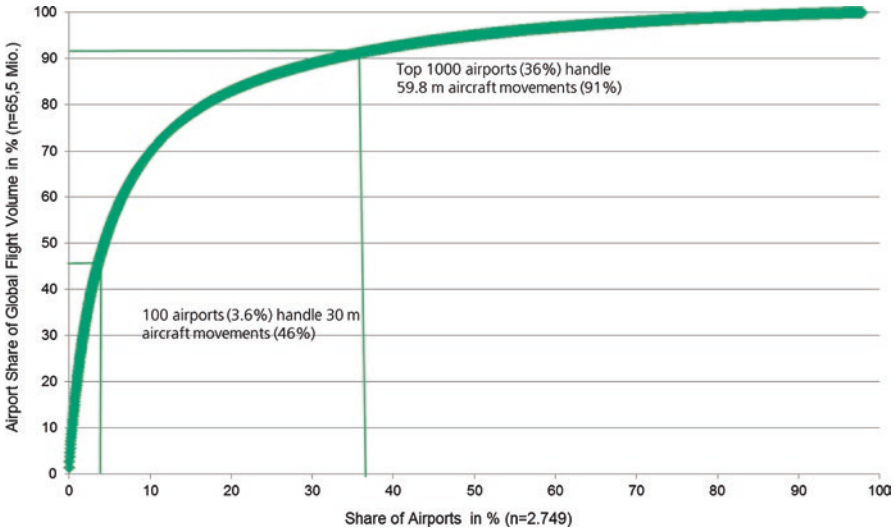

Fig. 2.4 Cumulative distribution of global aircraft movements in 2014 [2]

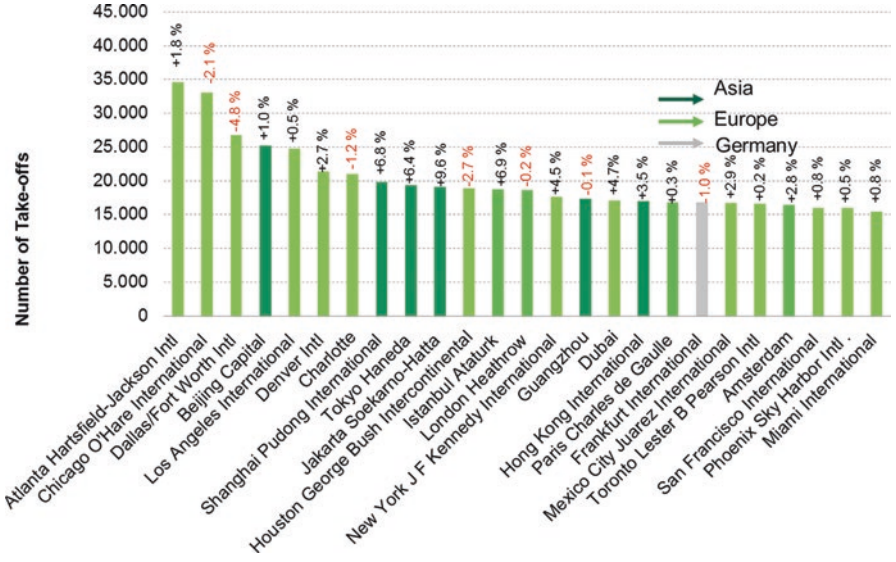

Fig. 2.5 Top 25 airports worldwide in January 2016 [2]

Figure 2.5 shows that in January 2016 the three largest airports worldwide are located in the US. This is Atlanta Hartsfield-Jackson with about 35,000 movements, Chicago O'Hare with about 34,000 movements and Dallas/Fort Worth with around 26,000 movements. Altogether six out of the ten largest airports are located in the US. The airport of Beijing has not been in the top 20 in 2006, but rose amazingly

fast to rank number four in January 2016. This development underlines the rise of the Asian region in air traffic. More examples of this high growth development are airports like Shanghai-Pudong or Tokyo-Haneda. They show yearly growth rates well above 5 %. However, there are other large airports in Asia which currently show a much lower growth or even a decline. On the other hand, there are still five European airports among the global top 25 airports, namely the airports of Istanbul, London, Paris, Frankfurt and Amsterdam.

Air cargo is typically handled at airports with a high degree of connectivity; i.e. mostly hub airports with high passenger transport capacities because of the availability of belly freight capacities in passenger aircrafts. Dedicated air cargo aircraft are especially operated by air freight integrators like UPS or DHL. They operate their bases at airports that enable them to optimize their delivery times by extended operating times at the airport. This is one main reason why smaller airports like Louisville International, Halle-Leipzig or Cologne-Bonn are among the top 30 cargo airports (Fig. 2.6). Even more distinct than in the passenger market, the air cargo market shows a very high degree of concentration on just a few airports. The top 30 airports handle more than 55 % of the total air cargo volume of about 96.7 million t loaded and unloaded in 2014.

Figures 2.7 and 2.8 display the largest airports in Europe and in Germany. The largest airports in terms of flight movements are clearly hub airports. The three top hub airports London Heathrow, Frankfurt and Paris Charles de Gaulle with about 16,000 to 19,000 movements in January 2016 have been slightly overtaken by Istanbul Ataturk airport due to the continued strong growth. The hub airport Amsterdam

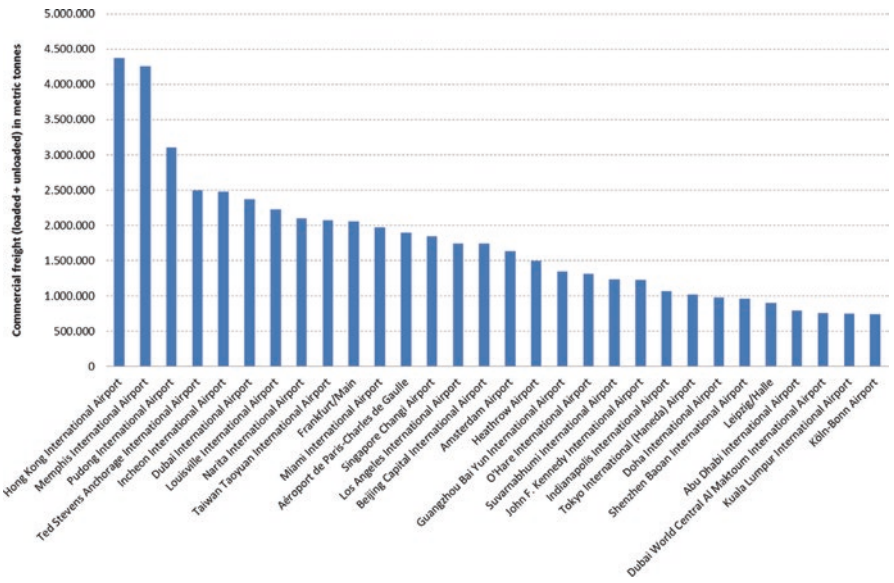

Fig. 2.6 Top 30 cargo airports worldwide in 2014 [3]

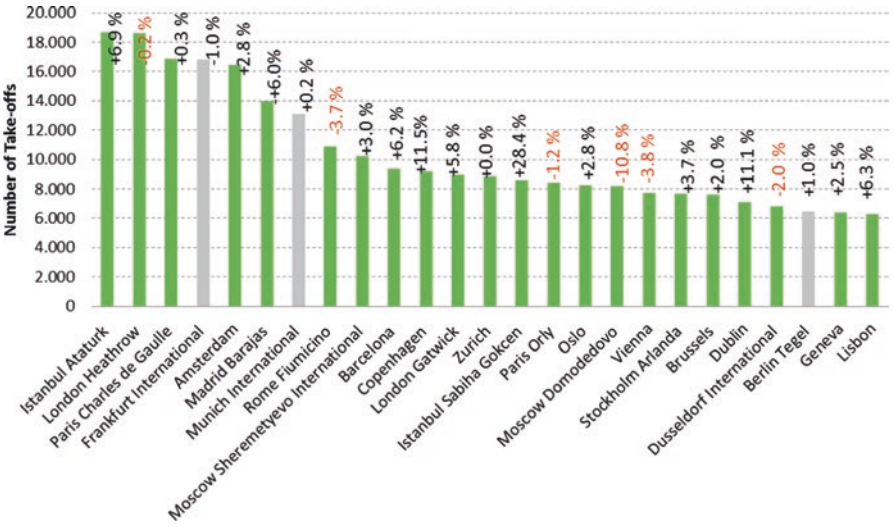

Fig. 2.7 Top 25 airports in Europe in January 2016 [2]

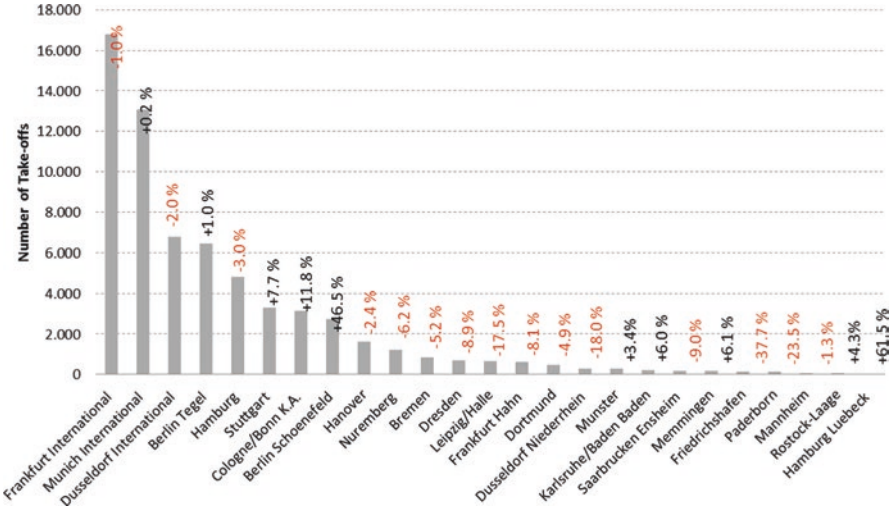

Fig. 2.8 Top 25 airports in Germany in January 2016 [2]

is placed fifth, followed by the airports of Madrid, Munich, Rome, Moscow, Barcelona, Copenhagen and London Gatwick. Many airports of the top 25 ranking are located in a capital city.

The hub airports Frankfurt and Munich are the largest airports in Germany. However, in the first month of 2016 their flight movements are stagnating. Nevertheless, passenger numbers are increasing because airlines are moving towards larger aircraft with more seats.

Other than the two hubs, most German airports have only very little transfer passenger volume and focus more on point-to-point traffic. Non-hub airports with some degree of transfer passengers are Düsseldorf, Berlin-Tegel, Hamburg, Stuttgart, Cologne and Berlin-Schönefeld. 2016 shows a strong growth for Berlin-Schönefeld as well as for Cologne and Stuttgart. This is due to Ryanair increasing their number of flights at these airports. However, the trend of Low Cost Carriers moving to larger airports may threaten regional airports in the future because of a loss of traffic volume.

The temporal flight distribution over a sample day or week at airports is now discussed in more detail. Looking at one of the peak days of Frankfurt airport (Fig. 2.9) clearly reveals the night flight restrictions. Aircraft movements remain at a rather constant level of around 90 and drop only slightly at noon and in the afternoon, so that Frankfurt airport is highly utilized during daytimes. London Stansted Airport is another example of a highly frequented airport, but the distribution over a sample day is rather different from airports like Frankfurt. Traffic peaks reaching the capacity limit develop at three times during a day (i.e. in the morning, during noon and in the evening). The capacity limit of London Stansted corresponds to around 40 movements per hour and there are capacity reserves during off-peak times. This is rather typical for airports that are the home base of a Low Cost Carrier operating on a point-to-point network or for regional airports with a focus on business travelers. In these cases, off-peak times are less attractive for airlines because of their business concept. If airports operate close to their capacity limit nearly the whole daytime, and in particular during attractive peak times, opportunities for establishing a new hub or new destinations in a point-to-point network decrease considerably.

Different capacity utilization levels of airports can be illustrated by means of so-called ranking curves, i.e. the hourly traffic volume of a year is ordered in descending order. For example, the comparison between London Heathrow and Hanover airport in Fig. 2.10 clearly illustrates the high capacity utilization of London Heathrow. In the case of Hanover, the ranking curve runs much steeper indicating more capacity reserves in less frequented hours.

Therefore, the ratio of mean hour to the 5 % peak hour can be used as a quantitative indicator for capacity utilization of an airport. These capacity utility indices were

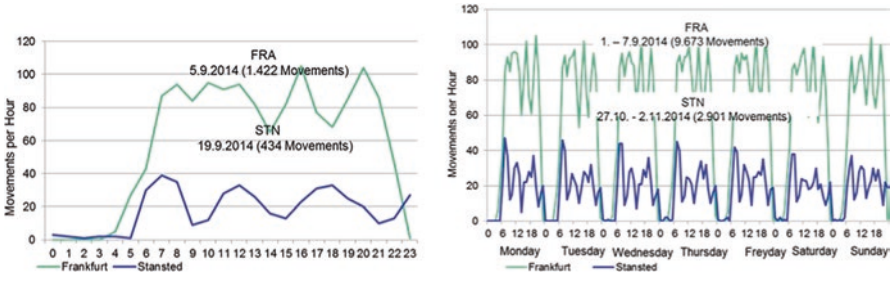

Fig. 2.9 Peak day/peak week: London-Stansted (STN) and Frankfurt International (FRA) 2014 [2]

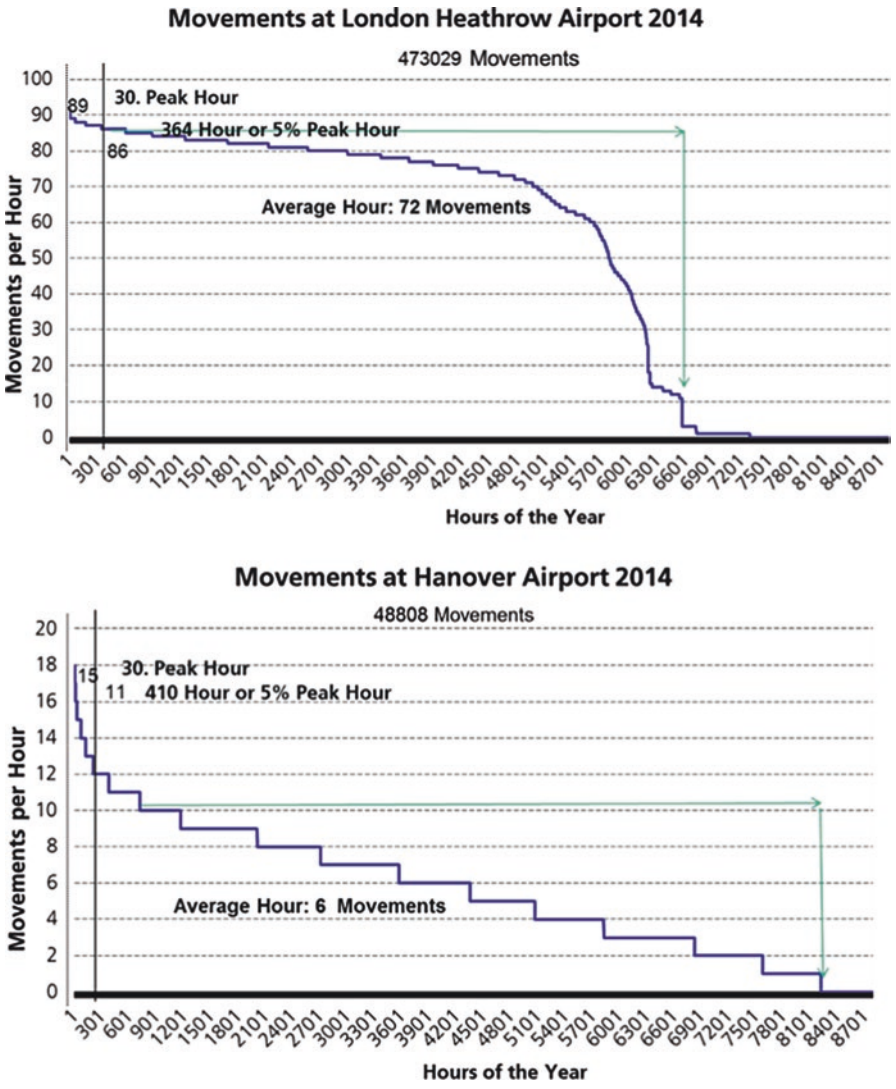

Fig. 2.10 Ranking curves: London Heathrow and Hanover Airport 2014 [2]

calculated for each of the top 1000 airports and are depicted in Fig. 2.11 in relation to the share of aircraft movements of each airport within the global flight volume in 2014. The non-uniform cumulative distribution of airport shares in the global air transport market is clearly visible, resulting in a Gini coefficient of 0.49. Airports with a higher share of aircraft movements typically show higher capacity utilization indices. This could be an indicator for delayed expansion of airport capacity. However, this is not accounted for in the majority of long-term forecasts published by for example International Civil Aviation Organization (ICAO) or aircraft manufactures like Airbus

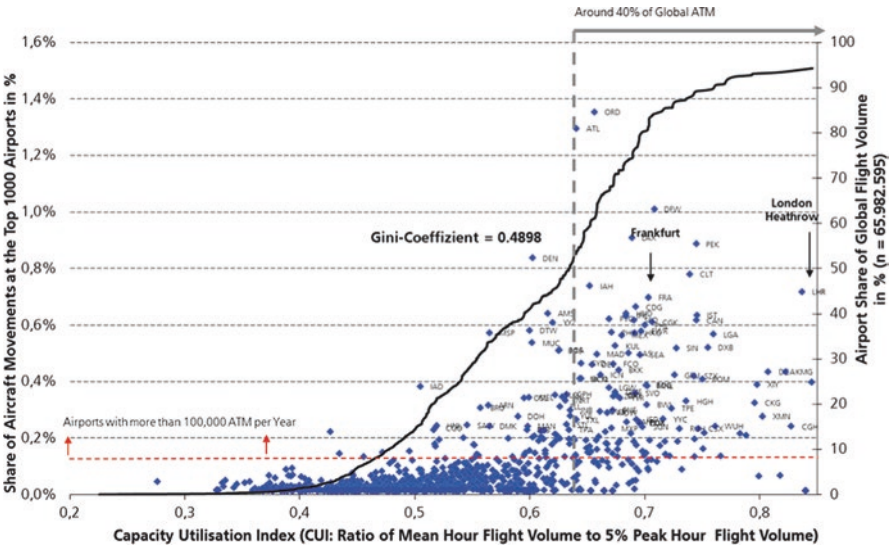

Fig. 2.11 Capacity utilization index 2014 [2]

and Boeing. Airport expansion programs are difficult to realize especially in densely populated areas of well developed countries (e.g. London Heathrow). However, this is where most of the demand for air transport is generated. On the other hand, the majority of airports handles less than 100,000 air transport movements per year and is not expected to suffer from capacity problems in the near future; instead they may struggle with profitability because of a lack of demand.

2.4 Airlines

Airlines provide air transport services for people and goods on a more or less regular basis.

The airline market is very dynamic in terms of new entries, exits and mergers. Delta Airlines became the worldwide leading airline in terms of flights after a merger with Northwest in 2008. The merger with Continental in 2010 made United Airlines the largest airline worldwide. In January 2016 American Airlines is the worldwide leading airline after merging with US Airways (Fig. 2.12). Each of these three leading airlines is a member of one of the three global airline alliances; American of Oneworld, Delta Airlines of Skyteam und United Airlines is part of the Star Alliance. Furthermore true Low Cost airlines like Southwest Airlines, Ryanair, easyJet and Azul rank high globally in terms of volumes of flights offered. Especially Asian airlines but also Turkish Airways and some Low Cost Carriers such as Ryanair grow dynamically. Already five Asian airlines are at present among the largest 25 airlines. With an increase of 70 % over the last 10 years the Indian market is among the fast-growing markets. The global market has grown only by 18 % over the same

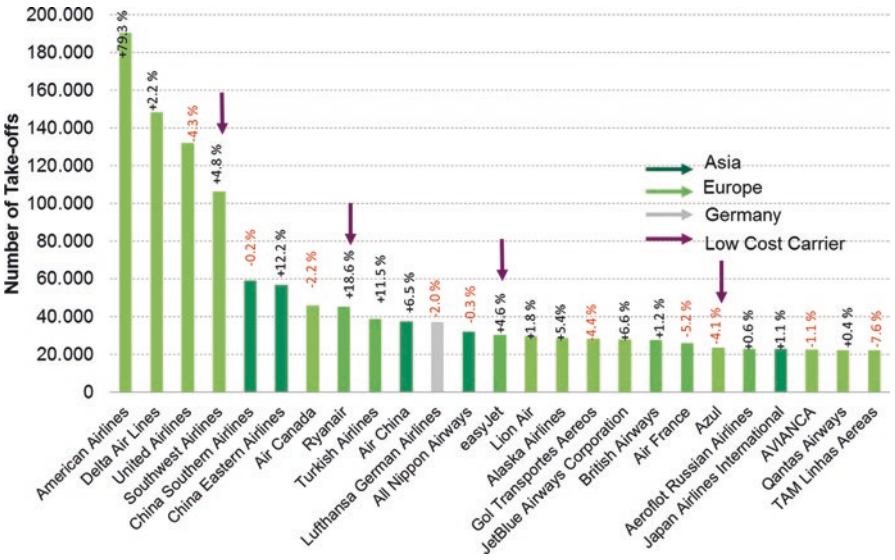

Fig. 2.12 Top 25 airlines worldwide in January 2016 [2]

time period. Between 2006 and 2015 the number of flights decreased in the US and Germany by 16 % and 6 %, respectively. On the other hand, traffic at Russian and Turkish airports increased considerably (+77 % and +225 %, respectively), which helped the development of their national carriers. Turkish Airlines became Star Alliance member and Aeroflot is now part of Skyteam. The geographically advantageous location of Istanbul between Europe and Asia may help to develop a large intercontinental hub, like e.g. the Dubai hub, the home base of Emirates. After a dynamic development and with India as an important market for the future, Air India resulted in becoming a member of the Star Alliance in July 2014.

In 2015 about 34 million departures in scheduled and charter traffic were operated worldwide. Typically, there are four different types of airlines:

- Full Service Network Carriers (FSNC) like Lufthansa or Air France serving 63 % of the total air transport market,
- charter airlines like Condor and regional airlines like e.g. Cimber Air serve only a very small market of around 15 %,
- Low Cost Carriers (LCC) like Ryanair have already a market share of 21.4 %.

The main part of the Full Service Network Carriers (FSNC) is made up mainly by the large airline alliances (Fig. 2.13). The Star Alliance, founded in 1997, currently has 28 member airlines. They cover about 33 % of the Full Service Network Carriers (FSNC) market. Oneworld, founded in 1998 and currently comprising of 15 member airlines, serve 24 % of the FSNC market in 2015. Skyteam was founded in 2000 and currently consists of 20 member airlines. They serve about 29 % of the market. The decreasing number of independent FSNC's account by now for

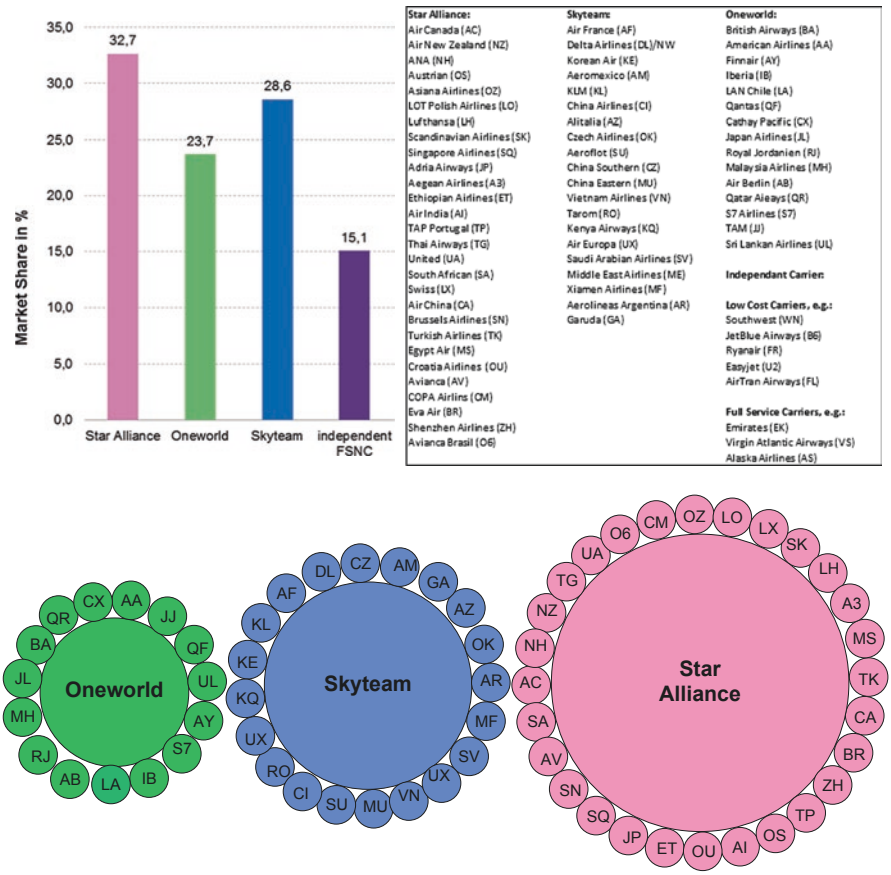

Fig. 2.13 Market share of airline alliances/Full Service Network Carrier (FSNC) 2015 [2]

only 15 % of the market. Well-known examples of large, but still independent Full Service Network airlines are Emirates and Virgin Atlantic.

Low Cost Carriers (LCC) and Full Service Network Carriers (FSNC) are in a heavy competition on short- to medium-haul flights. Because of a homogeneous fleet and only absolutely essential services included in the ticket prices (no frills concepts) allows them to sell these flights at very low prices. This concept was originally developed by Southwest Airline in the US some 30 years ago and swapped over to Europe in the course of the liberalization of the European air transport market in the 1990s and is now established successfully in most regions of the world. In 2016, about 20 airlines offer LCC services in Germany, more than 40 in Europe and more than 100 worldwide.

Figure 2.14 shows the development of the Low Cost Carrier network in Germany from 1998 to 2014. Three different phases can be identified. After a start-up phase with only a few routes from 2002 onwards each year about 100 new routes were added to the network. During the financial crisis in 2008 this development slowed

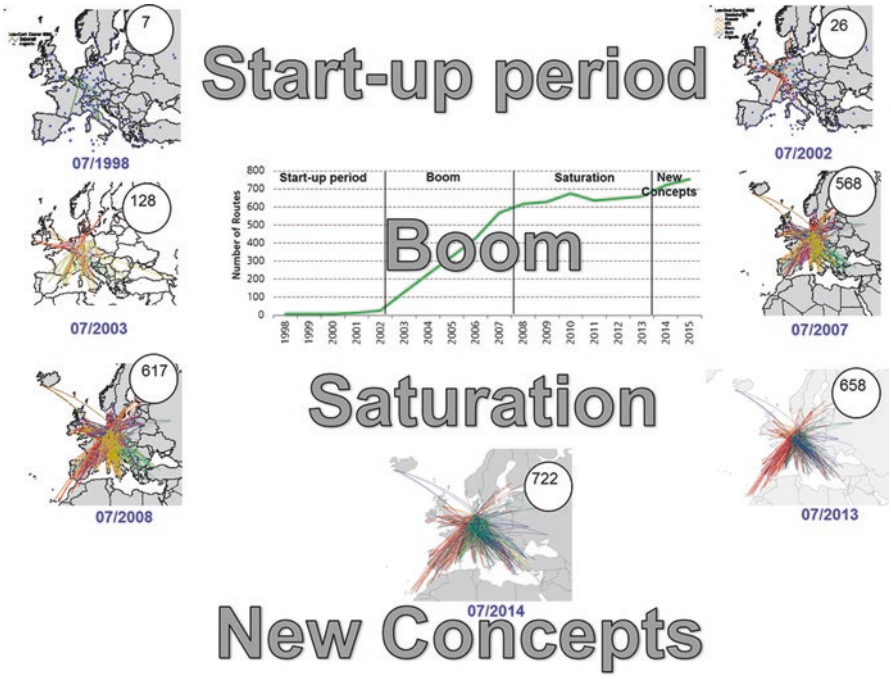

Fig. 2.14 Development of LCC-routes in Germany between 1998 and 2015 [2]

down. However, in contrast to the general market trend Low Cost Carrier traffic still grew until 2011. Moreover, the number of airlines in the Low Cost segment has increased over time.

Since 2013/2014 the Low Cost Carrier (LCC) market has gained again momentum in Germany. The number of LCC flights is increasing and these carrier are moving more and more to larger and hub airports. Furthermore, Full Service Network Carriers (FSNC) are moving part of their short- and medium-haul flights to their own LCC subsidiary. Even intercontinental LCC traffic seems to be within reach on a larger scale. Here, aircraft like the A330 and the new B787 play an important role.

FSNC's and LCC's have partly started to converge in their business models, so that hybrid concepts are emerging: FSNC's have started to use elements of the Low Cost concept, whereas Low Cost airlines have started to offer optional extra services for their customers. Thus, the difference between Low Cost and FSNC concepts has become smaller over time.

2.5 Aircraft Types

Depending on route markets airlines use different aircraft types. Generally, different aircraft are subdivided according to their size. From this viewpoint, larger aircraft are typically used for scheduled and charter traffic, whereas smaller aircraft are

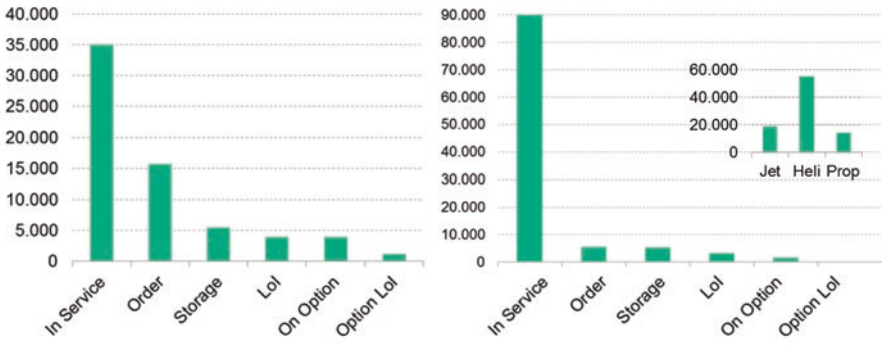

Fig. 2.15 Number of aircrafts in scheduled and charter traffic and business aviation [4]

more common in non-scheduled business aviation, which may be chartered, leased or of own property. As it can be seen in Fig. 2.15 there are currently around 35,000 aircraft in operation (scheduled and charter, as per January 2016). Furthermore, 16,000 new aircrafts are already ordered and there have been letters of intent (LoI) and options signed for another 9,000 aircrafts.

There are about 91,000 aircrafts in operation for business aviation purposes. About 55,000 are rotorcraft, 20,000 are jet aircrafts and 16,000 propeller driven airplanes.

About 23,000 aircraft have more than 50 seats. The majority of aircraft (34 %) are short- and medium-haul (e.g. B737 and A320). There are currently 4,983 B737 and 3,695 A320 in use and they belong to the seat class 125 to 189 seats in Fig. 2.16. They are typically employed e.g. by Low Cost Carriers. The second largest seat class in Fig. 2.16 (18 %) has 50 to 125 seats. Typical aircraft for this class is

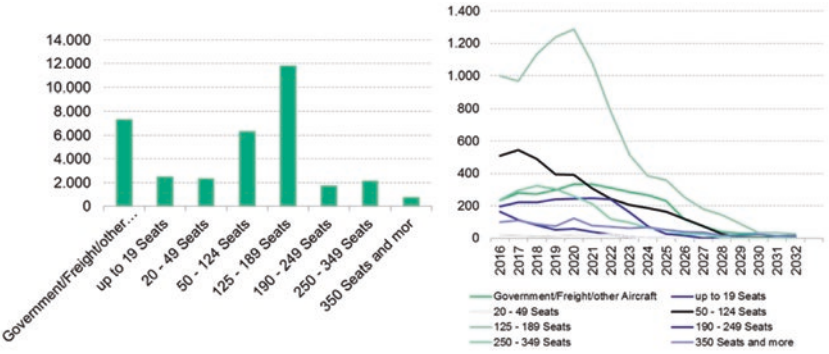

Fig. 2.16 Aircraft types in scheduled and charter traffic in service and planned [4]

e.g. Bombardier Canadair Regional Jet (CRJ) (569 aircraft in operation) or Embraer 145 (504 aircraft in operation).

The 190 to 249 seat and 250 to 349 seat classes comprise 1,700 and 2,200 aircraft in operation, respectively. Typical aircraft are A321, B767 and A330, B777, B787, A340, respectively. The wide body aircraft with a seat capacity of more than 349 seats represent only about 2 % of the worldwide fleet. The B777 makes up for half of these aircrafts, the other half is made up by aircraft like B747 and A380.

2.6 Outlook of Air Traffic Development

Forecasting the long-term development of air traffic becomes more and more problematic because of the growing probability of unforeseen external or internal developments that in-duce breaks of current trends (Fig. 2.17).

To cope with the variability of the different influencing factors, forecast are often published as a most likely outcome within a range of low and high results, growing with the time horizon and reflecting an increasing model uncertainty (Fig. 2.18, solid lines of ICAO forecast). By trying to take a look at the long term future of about 30 years and beyond, it becomes more and more probable that trends from the past, which empirically verified forecast models are based on, are no longer valid. In these cases forecasters may try to describe different future developments in terms of principally possible system configurations, which show different – sometimes

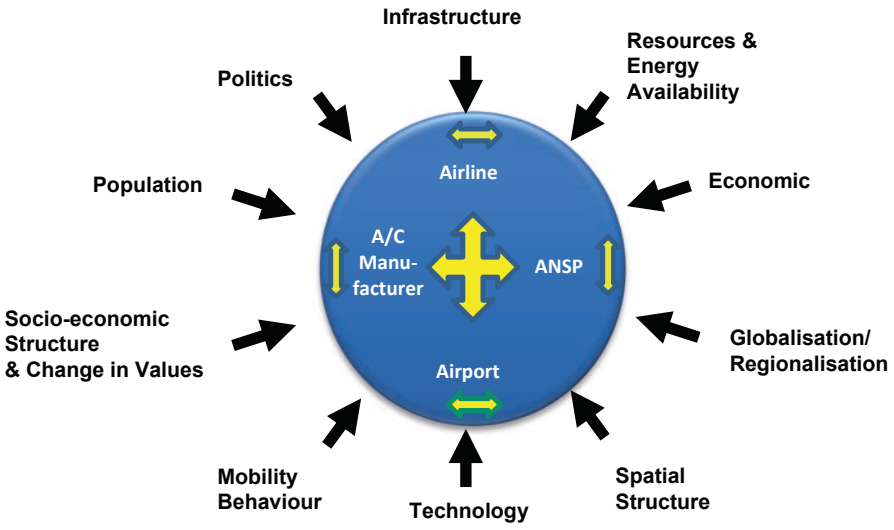

Fig. 2.17 External factors and internal actors influencing the development of air transport system (ANSP - Air Navigation Service Provider)

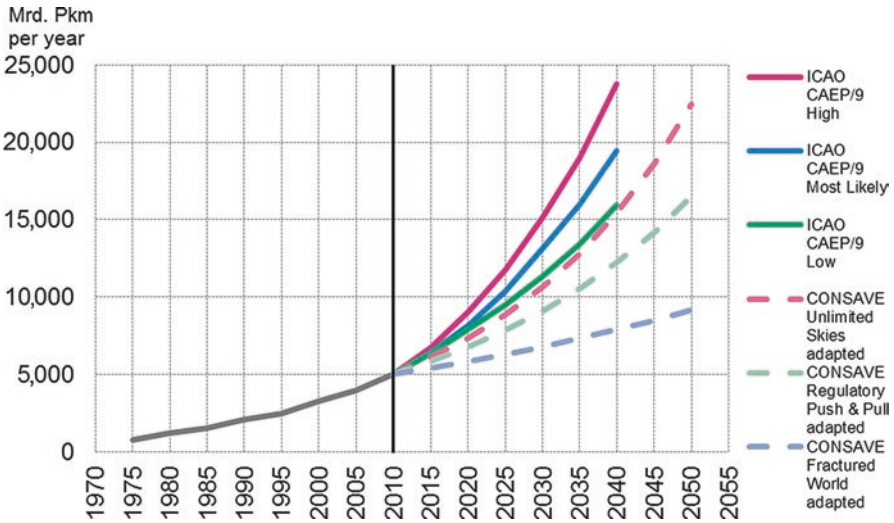

Fig. 2.18 Examples of scenarios and forecasts for the global air transport performance (measured in passenger-km's (PKM) transported per year) [7, 8]

extreme – changes in the external factors, in the internal system organization or technology in use. Those descriptions are so-called scenarios which represent story lines free of inconsistencies regarding those future developments. Scenarios can be described in qualitative terms, however, should preferably be based on system models giving quantitative performance data outputs (Fig. 2.18 CONSAVE scenarios dashed lines).

The scenario analysis allows investigating the elements of a future scenario, in particular those which are missing in the present system, in order to create a preferred scenario. This gives some guidelines on how to either support or avoid the development towards a given scenario. In contrast to forecast models, the scenario technique tries to analyze paths from a future point of view back to the present time.

In general, global air transport has growth potential for the future. This is directly visible when inspecting the propensity to fly that is the number of air trips per capita in different world regions (Fig. 2.19). The propensity to fly is generally growing with increasing GDP. Asia, South America and Africa have the lowest GDP per capita. Air trips per capita are well below values seen in developed countries. However, from a global point of view, those regions have the largest and fastest growing population. As long as positive GDP developments in these regions persists a dynamic increase in air traffic has to be assumed also in the future.

Actual forecasts of aircraft movements by ICAO and aircraft manufactures (Fig. 2.20) estimate an average annual growth of about 3 %/a for the next 20 years. These forecasts do not include negative effects of crises or capacity limitations at airports with high capacity utilization, which might not be in a position of enlarging capacity according to growing demand.

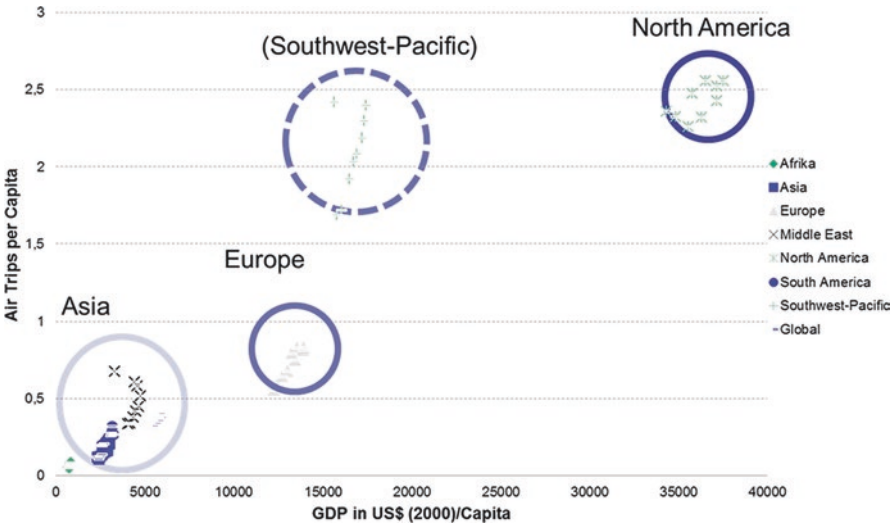

Fig. 2.19 Relationship between air trips per capita and GDP per capita from 2002 to 2014 [2, 5, 6]

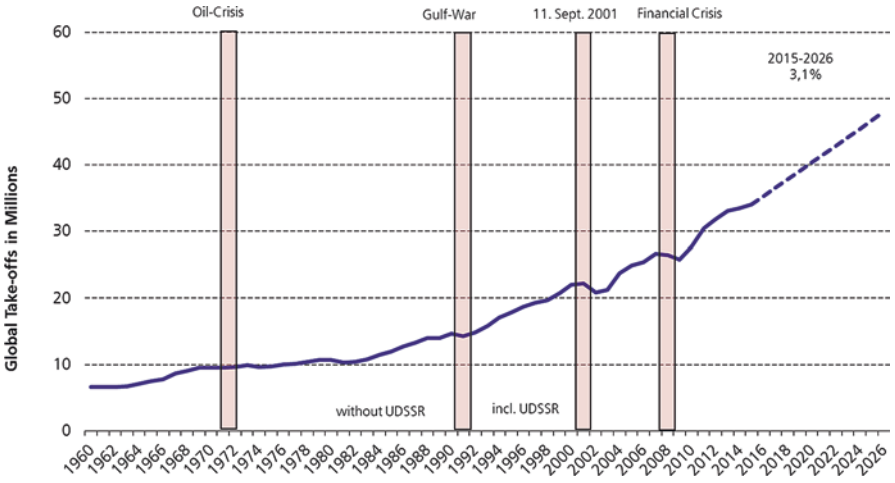

Fig. 2.20 Forecast of the global air traffic [1]

2.7 Final Considerations

The analysis of past developments and trends of the air transport system indicates further potential for growth also in the long term, although first saturation effects can be seen in the US and European markets. Main drivers of future growth are regions with growing population that will reach welfare levels comparable with

today's leading industry nations. This population will expect an air traffic network that allows fast transport of persons and goods over long distances with high connectivity between and within all world regions.

The growth of the air transport demand will be generated mainly within the increasing numbers of megacities. Already today many airport infrastructures located within those areas are working on their capacity limits e.g. London Heathrow. Assuming that with increasing welfare of population infrastructure expansion projects will be under pressure by airport residents articulating their complaints against aircraft noise, we have to foresee a risk that delay in airport infrastructure expansion may lead to a damping of the air transport growth.

In addition to conventional air vehicles Unmanned Aircraft Systems (UAS) may increasingly populate the airspace in the future both with very small vehicles, e.g. operating as sensors, and with heavier vehicles, e.g. operating as freighters flying more and more autonomously. Also activities are undertaken to define supersonic aircraft that may find a way back to the civil air transport market.

In parallel, the dramatic increase in the power of global information exchange via internet towards instantaneous and natural information exchange between individuals, organizations and technical systems may take away some of the necessity to travel by air. On the other hand, however, organizing of travel becomes much easier and may lead to additional induced demand for personal meetings in reality and not only in a virtual world.

A factor limiting growth may be the concern on climate impact of air transport. If the industry fails to overcome this problem politics may install regulations that restrict climate impact to an acceptable level by applying regulations such as emission trading schemes.

Major research and development activities like "Clean Sky" were initiated in Europe searching for technical solutions to increase the environmental performance of air transport and airplanes in particular, resulting in less noisy and more fuel efficient aircraft (http://www.cleansky.eu/).

Many research activities are under way to search for alternatives in aircraft propulsion like e.g. combination of electric propulsion with gas turbines. Even pure electrical propulsion systems are considered. Here the low energy density of batteries presently available prevents the application in larger air vehicles.

The replacement of the whole aircraft fleet by new clean aircraft lasts a time span in the order of at least 30 years. In this context the intensive search for climate neutral fuels to replace conventional kerosene may allow air transport to grow in a sustainable way in the future. These biokerosene and/or synthetic jet fuels could be used in the conventional aircraft propulsion systems which may allow a smoother transition until more revolutionary propulsion systems reach the air transport market.

References

[1] International Civil Aviation Organization (ICAO) (2014) The world of civil aviation. ICAO, Montreal

[2] Official Airline Guide (OAG) (1998–2016) Market analysis, Reed Travel Group. OAG, Dunstable
[3] Airport Council International (ACI) (2014) ACI Annual World Airport Traffic Report (AWATR). ACI, Montreal
[4] Ascend (2016). Ascend fleet data. Ascend, London.
[5] The World Bank (2014) World Development Indicators. The World Bank, Washington
[6] Sabre Airport Data Intelligence (2002–2013) Data based on Market Information Intelligence Tapes (MIDT). Sabre Airline Solutions, Southlake
[7] Hepting M, Grimme W, Kokus P (2015) Welche Glaskugel ist die Richtige? Methoden und Ergebnisse von Zukunftsstudien zur globalen Luftverkehrsentwicklung im Vergleich. In: Deutscher Luft- und Raumfahrtkongress 2015. Deutsche Gesellschaft für Luft- und Raumfahrt – Lilienthal-Oberth e.V. Deutscher Luft- und Raumfahrtkongress 2015, 22.–24. Sept. 2015, Rostock. ISBN 978-3-932182-18-1. ISSN 1868-8764
[8] Berghof R, Schmitt A, Eyers C, Grübler A, Hancox R, Haag K, Middel J, Hepting M (2005) CONSAVE 2050. Final Report. Projektbericht. G4MA-CT-2002-04013 (EU), 213 S.

Prof. Dr. Johannes Reichmuth is director of DLR Institute of Air Transport and Airport Research and Chair of Air Transport and Airport Research at the Institute of Transport Science of the RWTH Aachen University. At DLR he worked on real-time air traffic management simulations but also on fast time simulations for capacity assessments of airport systems. His research focuses on assessment of air transport system development options and on the airport system as a representative of a multi-modal traffic node.

Dr. Peter Berster has been member of the German Aerospace Center scientific staff since 1992. He has developed particular expertise in the analysis of air transport supply and demand and of modal usage of business travellers under consideration of regional air transport services, constraints at international airports, and of low-cost carrier developments.

http://www.springer.com/978-3-662-53063-4

Biokerosene
Status and Prospects
Kaltschmitt, M.; Neuling, U. (Eds.)
2018, XXI, 758 p. 241 illus., 79 illus. in color., Hardcover
ISBN: 978-3-662-53063-4