Module 3

AIRLINES, AIRPORT AND INFRASTRUCTURE

3.1 Airline types

- In the beginning of commercial aviation air transport was considered as a strategic national task to provide trading opportunities for the national society.
- The core business of an airline is carrying people and/or cargo over long distances to enable business and trade.
- Today four main market segments in commercial air transport are considered:
  - National or Flag Carrier (FC)
  - Charter Carrier (CC)
  - Low Cost Carrier
  - Air Cargo Provider (ACP)

Fig. 7.4 Overview about principle airline market segments

3.1.1 National or Flag Carrier

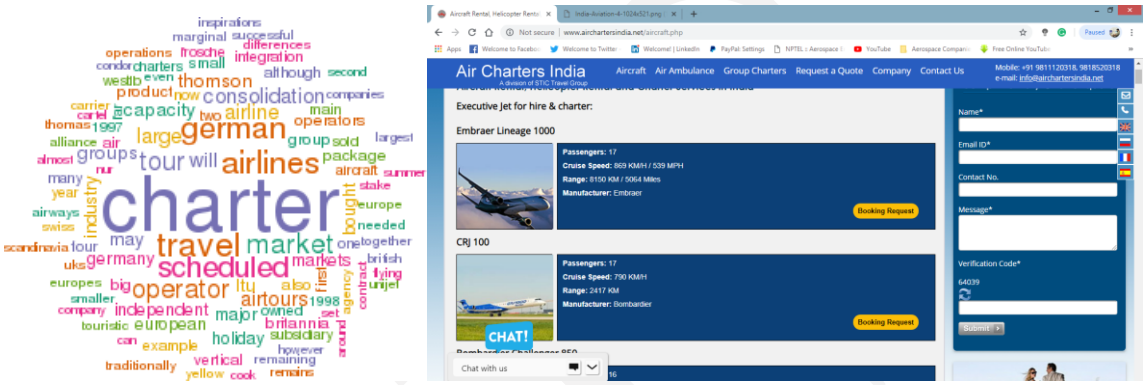
- The core business of civil aviation is air transportation of passengers and cargo between countries and continents, which is organized by FC. Due to their operational setup they are also recognized as network carrier.
- They operate complex global network systems with very different flight legs in terms of capacity, length and frequency.
- Central airports called hubs, where the long-haul flights start off, characterize the network structure of a Flag Carrier. These hubs are fed by a lot of short and medium-haul flights from so-called spoke airports.

- Further specialized terminals in hub airports as nodes for connecting the flight legs are operated to ensure a more or less seamless transfer from these feeding short haul flights to the long-haul flights.

- The concentration on long-haul flights is the key market for Flag Carrier, where they get maximum yield. The short haul market is mainly to feed this profitable long-haul flights. Therefore the business is set up by the following attributes:
  - **Customer segment**
    - International and intercontinental passenger and cargo
    - Concentration on time sensitive business travelers and intercontinental flights
  - **Product and service**
    - Flights from main airports with good accessibility and airline lounges
    - Connecting flights at hubs
    - Seat reservation
    - At least two cabin classes, three on long-haul flights
    - Highly differentiated on board services
  - **Production**
    - Use of main airports and hubs, therefore high airports fees and risk of delays
    - Highly differentiated fleet to cope for different flight legs
    - Aircraft utilization of feeder flights limited by connectivity requirements at hubs
    - More and better paid crew to provide adequate service
    - Ticket sales through computer reservation systems and own website
    - Utilization: varying (75 % (Feeder) – >90 % (long haul))

3.1.2 Charter Carrier

- Airlines delivering air transport services for passengers and goods on occasion for a specific demand are denoted as charter carriers.
- In international air law the notion is “non-scheduled traffic”, because these carriers do not provide a regular public scheduled transport service. Charter operation is very common in holiday traffic.
- Travel agencies buy seats in flights from a CC at own risk in order to combine them with hotel stays and transfer transport services to a vacation package, which is sold to travelers for a lump sum.



- Typical attributes of a CC include
  - **Customer segment**
    - International and intercontinental passengers
    - Concentration on holiday and leisure travelers
  - **Product and service**
    - Flights offered on a seasonal basis mainly
    - Flights from airports with good accessibility and seasonal capacities
    - Direct flights mainly
    - Seating considerably more dense in comparison to scheduled flights
    - Minimum or on request board services only
  - **Production**
    - Aircraft capacity block wise sold to travel agencies
    - Seats are guaranteed for whole or part of aircraft capacity
    - Ticketing mainly done by travel agencies
    - Utilization: Very High (load factor of 80–90 %)
- Recently the boundary between charter and scheduled carriers diminishes as charter carriers progressively position themselves as scheduled airlines by selling seats directly via their own websites like LCCs.

3.1.3 Low Cost Carrier

- Low Cost Carrier were only able to develop due to the liberalization and strong economic orientation of civil aviation in late seventies. Therefore special importance has gained the differentiation of low cost and network carriers.
- While LCCs concentrate on providing continental air transport passenger services to selected destinations, network carriers organize the intercontinental transportation of passenger and cargo.
- The reason for the compelling success of LCCs is the consistent business model. They address mainly price sensitive customers, provide only transportation as core service and reduce complexity and cost on the production side to a minimum.

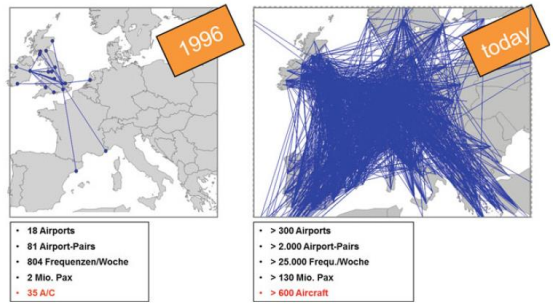


Fig. 7.7 Low cost carrier network development in Europe

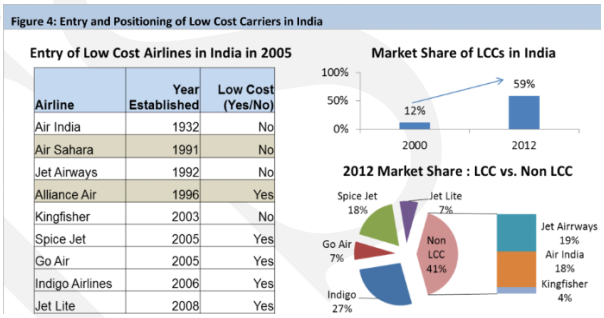


Figure 4: Entry and Positioning of Low Cost Carriers in India

Entry of Low Cost Airlines in India in 2005

Airline	Year Established	Low Cost (Yes/No)
Air India	1932	No
Air Sahara	1991	No
Jet Airways	1992	No
Alliance Air	1996	Yes
Kingfisher	2003	No
Spice Jet	2005	Yes
Go Air	2005	Yes
Indigo Airlines	2006	Yes
Jet Lite	2008	Yes

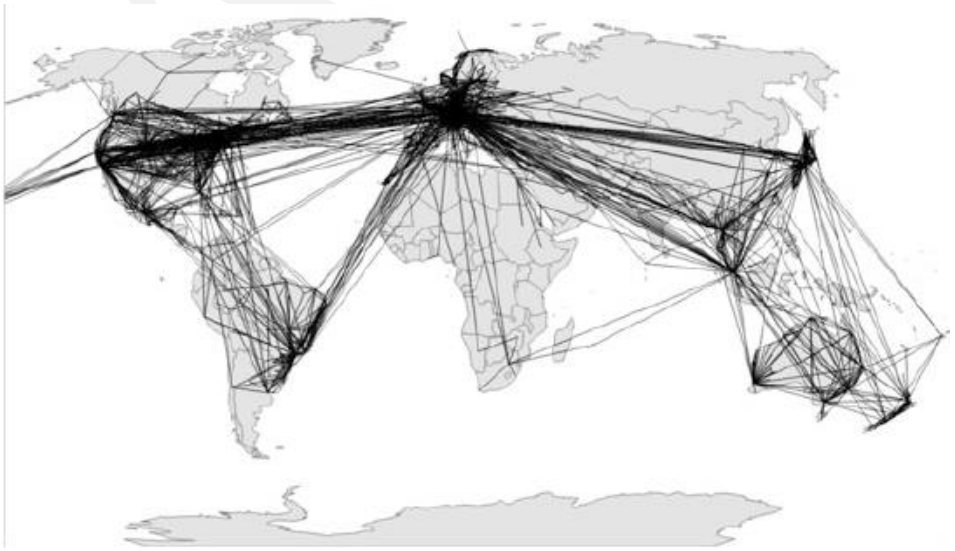
- Typical attributes of a LCC, where the numbers in brackets indicate cost savings compared to network carrier, include:
  - Customer Segment
    - Only passengers (no belly cargo)
    - Concentration on price sensitive travellers (best price strategy)
  - Product and Service
    - Only one cabin class at high seat density (16 %)
    - No seat reservation (3 %)
    - Catering and other services on board only against additional pay (6%)
  - Production
    - Use of smaller airports in the vicinity of metropolis for lower airport fees and less delays (Lübeck (Hamburg), Frankfurt-Hahn, Gerona (Barcelona) Paris Beauvais-Tillé),
    - Fast aircraft turnaround (6 %)
    - Used airport often less accessible, but provision of airport shuttle from city center

- Standardized fleet with only very few aircraft types, often only 1 (2%)
- No connecting traffic
- Minimum crew (3 %)
- Distribution of tickets on own internet websites (8 %)
- High utilization of aircraft >80 % (3 %)
- Simple price structure

- Both, reducing the scope of the product and delivering the remaining core product more efficient, result in only 40 % of the cost per passenger kilometer compared to a network carrier.
- Looking at the typical leg length LCC flights concentrate very much on short and partly medium ranges of 600–5000 km mainly.

3.1.4 Alliances

- Due to the freedoms of the air it was not easy or possible in the past for a national airline to operate in another country.
- One way to extend its own network and to enter new markets is the creation of alliances. Alliances like **Star Alliance, One World or Sky Team** were created in the past on this basis and allowed the member airlines to extend their flight product portfolio significantly.



'.9 Star Alliance global network

- As an example Lufthansa as one founder of Star Alliance is now able to extend their own destination network from approximately 400 to about 1200 destinations provided by the other 24 partners.

- It is a common strategy of all alliances to cover all globally interesting market segments by selecting partners with appropriate networks.
- Based on common quality standards member airlines adapt their flight plans to each other in order to make operations more efficient. Such cooperation is also useful to manage slot limitations at airports and provide access to destinations without own flights.
- Fleet sizes of individual airlines can be reduced and individual flight load factors are increased. Also market presence of an individual airline is increasing through the brand of the alliance.

Table 7.2 Airline alliances and market share

	One World	Star Alliance	Sky Team
Members	28	13	19
Destinations	883	1328	1024
Countries	195	151	178
Daily flights	21,900	10,117	15,207
Overall fleet size	4701		2853
Passengerp.a.	727 Mio. Pax	353.5 Mio. Pax	569 Mio. Pax
			
Members	Aeroflot	Adria Airways	Air Berlin
	Aeromexico	Aegean Airlines	American Airlines
	Air Europa	Air Canada	British Airways
	Air France/KLM	Air China	Cathay Pacific
	(Northwest)	Air New Zealand	Finnair
	Alitalia	ANA	Iberia
	China Airlines	Asiana Airlines	Japan Airlines
	China Eastern	Austrian Airlines	LAN
	China Southern	Blue 1	Qantas Airways
	Czech Airlines	Brussels Airlines	Royal Jordanian
	Delta Air Lines	Croatia Airlines	S7 Airlines

- It is vital for the success of airline alliances that a common culture of work is established, which is really challenging and critical because of the partly different national cultures and attitudes of the various airlines. This affects for example:
    - Vision and strategy
    - Quality and standards
    - Market positioning and orientation
    - Establishing a win-win-situation
    - Through cooperation trust in place of dominance

- Looking at the US market actually three major airlines exist despite the LCC.
- Also in Europe first mergers are observed like Air France/KLM and Lufthansa with Swiss, Austrian Airlines and SN Brussels Airlines Other flag carrier like Alitalia will follow.

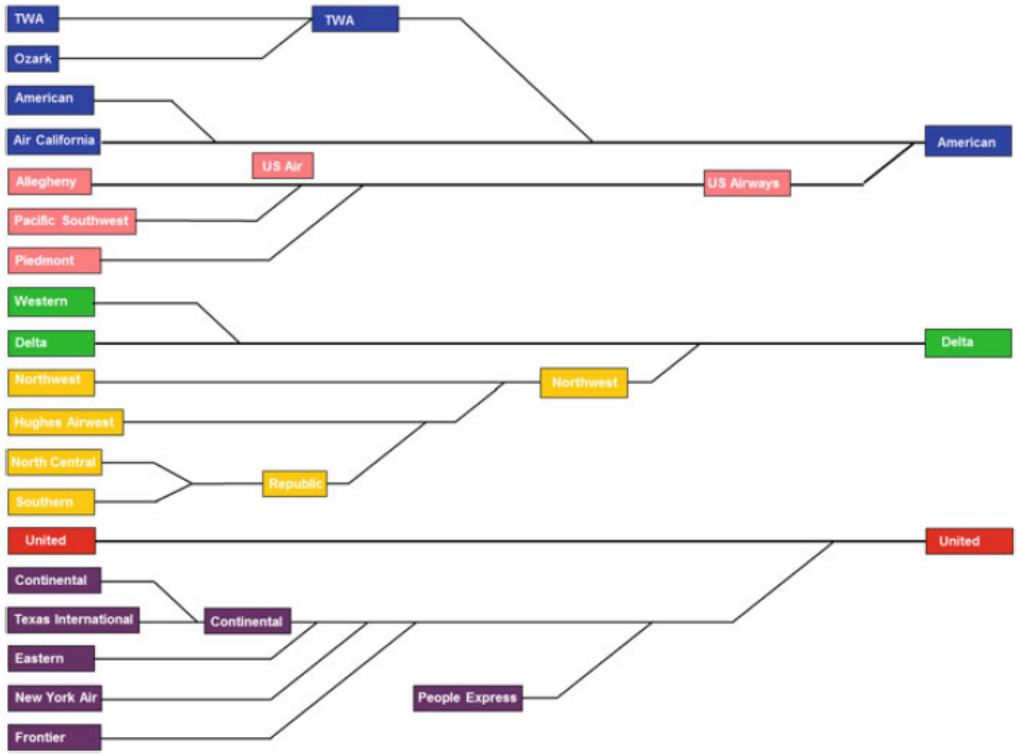


Fig. 7.10 Consolidation of the US airline market

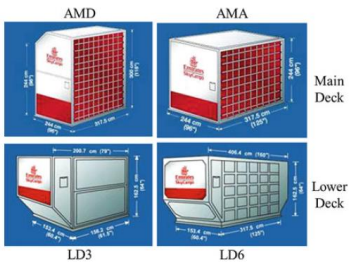
3.1.5 Air Cargo Provider

- Air transportation of cargo is a relevant business in civil aviation. It is done via designated cargo aircraft or in combination with passenger transport, when the lower deck cargo compartment (belly cargo) is used.
- Only a small share of worldwide cargo aircraft are newly built aircraft. Remarkably air cargo covers only 1 % of the worldwide amount of goods being carried. But this very small share represents about 40 % of the worldwide cargo value.
- Typical goods for air transport are those, which lose their customer benefit over time quickly like:
    - physically perishable goods would not sustain a transport process for weeks.
    - news papers, mail, movies.
    - seasonal clothes, and products with a high frequency of new models due to rapid technology development.
    - goods of high value per weight and volume in general.

Fig. 7.11 Worldwide air cargo flow in billion tons, [6]

- Air cargo greatly reduces the capital lockup cost and the risk of thievery for these goods while being transported. Some examples are:
    - Electronic consumer articles like smart phones or HiFi equipment
    - Aircraft spare parts
    - Medical goods like medicine and medical technical equipment
    - Chemical products
    - Soft goods
    - Flowers
    - Animals
- Fruits Also the business of mail-order companies (integrator) creates a significant part of air cargo.
- Most of the air cargo is carried as belly freight with passenger aircraft, while pure cargo aircraft transports approximately 40 %.
- Actually global air cargo is growing about 5–6 % per year, which is slightly higher than the passenger transport growth.
- Air transportation of cargo is more costly and has a bigger environmental impact than transportation on ground by truck, rail and ship. Nevertheless, the competitive advantages of air cargo versus ground transportation are:
    - **Speed**—lowest runtime in comparison to ground transport
    - **Reliability**—outmost in time transportation due to fixed flight schedules
    - **Security**—low possibility of unauthorized intrusion and lower exposition to environment and vibrations.

Fig. 7.12 Examples of air cargo container



3.2 Network Management

3.2.1 Traffic Flows and Networks

- The way the airline is offering its service depends directly on the business model. Since network or flag carrier had its historic origin in the national wish to link foreign countries over long distances, they typically offer long range flights across and between countries and continents.
- In order to fill them as much as possible they are typically operated from a limited set of very big airports. As those airports never have a catchment area, which provides sufficient passenger, the passengers have to be carried to and redistributed from these very big airports—the hub airport, Fig. 7.13. This logic leads to the so-called “hub and spoke” airline network concept, which is typical for flag carriers.

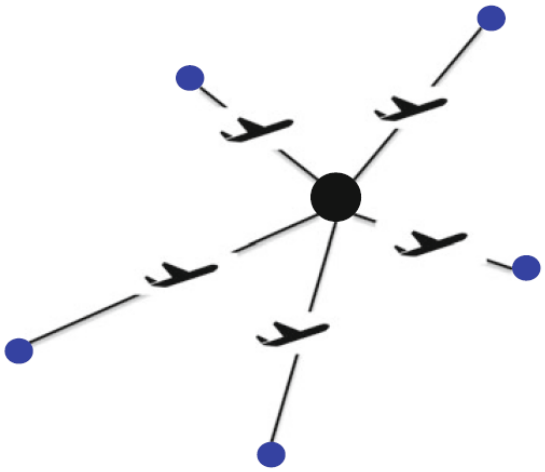


Fig. 7.13 Principle structure of a hub and spoke airline network

- The principle of such a network is to feed central hub airports with passengers by using short range aircraft. Those short range aircraft pick up people in a certain area, which may have different destination targets and bring them to the hub. Here these passengers can transfer to the long range flights, which bring them to the final destination.
- The incoming and outgoing flights are batched in two waves following each other with an adequate time lag to ensure a balance of a short transfer time and the safeguarding of the passengers connection. Following this strategy short range feeder and long range flights are connected. This pattern of in- and outgoing waves repeats at different times of a day, especially early in the morning, afternoon and in the late afternoon.
- There is no unique hub type, but rather three different models as shown in Fig. 7.14 for reasons related as much to the markets as to geography [4]:

- United States
- Europe
- Asia Pacific

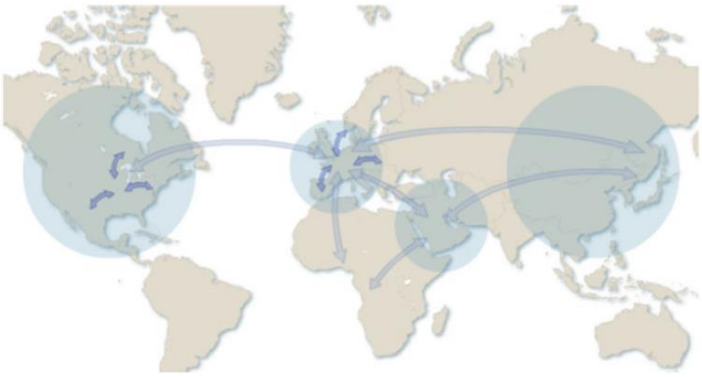
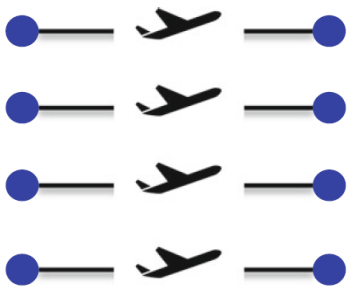


Fig. 7.14 Three hub models—global overview

- The American model is essentially connecting medium-haul flights with other medium-haul flights, primarily domestic. This enabled national carriers to grow over many years, but it seems no longer appropriate today. In a market where very large volumes of traffic between major cities exist, direct flights are economically viable. Taking over these routes and bypassing the major hubs, let low cost carrier have successfully penetrating the U.S. market.
- A second family of hubs is found in Europe, connecting medium-haul flights with long-haul routes. The European model links medium-haul flights with long-haul flights, thus enabling operators to channel small traffic flows which alone would not justify the opening of new services.
- Third, carriers in Middle East and Southeast Asia, linking up three continents, Europe, Asia and Africa, develop the third type of hub. Connecting long-haul flights with other long-haul flights was developed first by carriers in Southeast Asia (particularly Singapore Airlines), due to their specific geographical situation. Today also Emirates and Qatar Airways are using this model, which concentrates on linking several continents.
- It must be mentioned at this point that the upcoming Middle East region will change the world air traffic flows. Within 8 h of flight Middle East airports and related airlines cover 2/3 of the world population, which is a clear geographic strategic advantage of this area.
- Today and much more in the future especially European and American airlines will be in strong competition to these airlines, offering a lot of attractive flights between Europe and Australia/East Asia.

- A further major advantage of Middle East airlines (Emirates, Etihad, Qatar et alii) is a very low fuel price, as their home countries are holding major crude oil reserves. Since airlines, airport and oil resources are in one hand, the operational business model of those airlines can have some significant advantages.
- A different network business concept is the so-called “point-to-point” concept, as shown in principle in Fig. 7.16. It is very typical for continental operator and especially LCC.

Fig. 7.16 Principle structure of point-to-point airline network



- In general the point-to-point model is the preferred option for all passengers. The passenger prefers to have a direct flight from O to D. But for direct long range connections in most cases there is no sufficient demand on such a single leg to create a viable business with an adequate load factor, justifying a daily connection with a long range aircraft.

3.2.2 Flight planning

- Flight planning can be divided into four time scales with increasing accuracy, which are described in Fig. 7.17.
- The first scale focuses at long-term market considerations 2–10 years ahead and offers a high degree of freedom to elaborate the flight schedule.
- Traffic flow information is retrieved from mass raw data by extensive data processing. Based on this market and competitor information, targets on market shares are defined for the strategic traffic flow bundles.

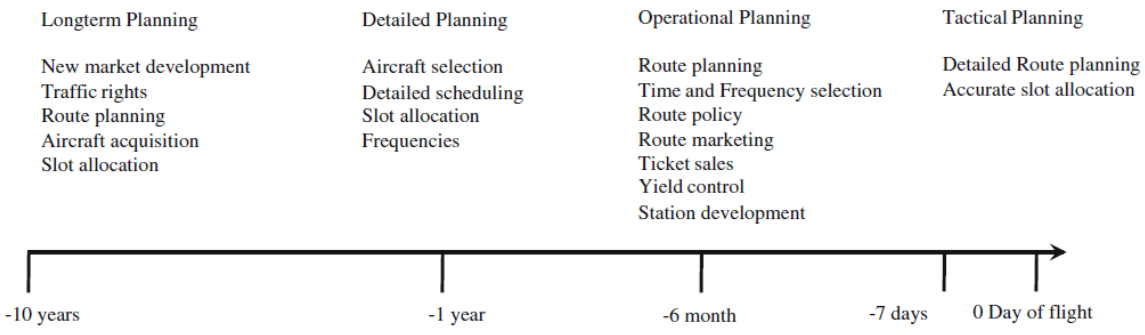


Fig. 7.17 Time horizons of flight planning

- One year to six month before operation the strategic flight planning creates real global production scenarios (scenario flight schedules). Balanced airport and airspace capacities, slot allocation, traffic rights and curfews between airlines and airports are the major objectives of this planning phase.
- The ability to change the individual flight being offered decreases as the publication of the schedule approaches.
- One year prior departure of respective flights ticket sales begins according to the published schedule. Now the offered flights are fixed, an aircraft type has to be selected for each flight and the aircraft turnaround plan has to be established.
- The focus of the airline switches from "setting capacity" to "control the demand". A new station might be developed, marketing for the new route has to be started, demand has to be controlled, the development plan for this new route has to be established and ticket sales have to be carefully monitored and incentives have to be defined.
- The third time scale aims at the pre-tactical planning some days before the day of operation. Detailed slot allocation is performed and ticket prices have to be adjusted in order to maximize seat utilization of aircraft (aircraft load-factor).
- The fourth time scale is the accurate planning of the flight at the day of operation. Here the actual weather situation, airport capacity, aircraft status and ATC capacity are considered to operate the flight as close as possible to the scheduled flight plan.
- Different factors have an impact on flight planning and have to be coordinated. These factors can be related to demand, operations and restrictions as described in Fig. 7.18.

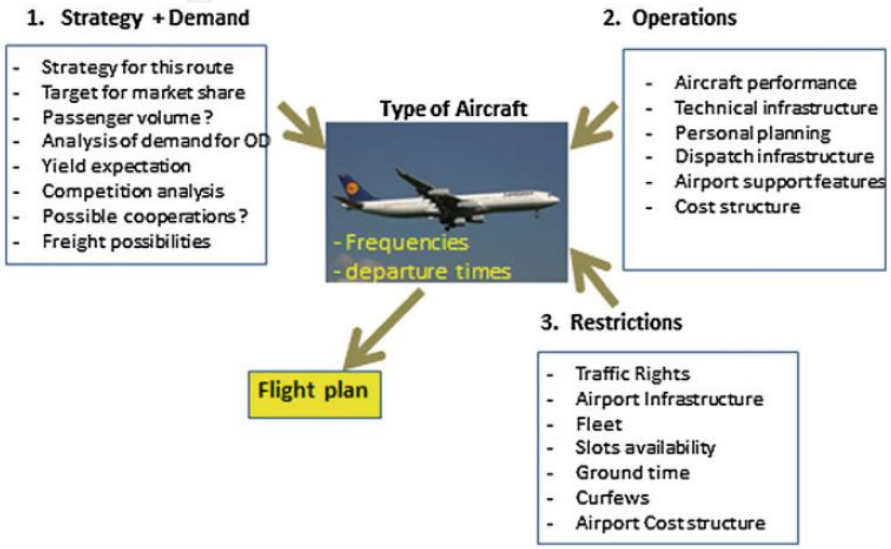


Fig. 7.18 Influencing factors for flight plan development

3.2.3 Flight Plan Utilization and Ticket Pricing

- Airlines strive to maximize revenues by offering customized transportation products and controlling demand and price with sophisticated IT-driven systems. “Product” means in this context the flight itself with a certain level of comfort and the associated services.
- It is characteristically for a travel product, that this product is produced in time of travel.
- From the time the schedule is published an airline is committed to its planning. Although some aircraft assignment may still be swapped, the capacity on most legs and therefore ODs is fixed.
- A main characteristic driving the airline industry, but also other transportation sectors and, e.g. hotels, is the fact that it produces non-storable goods. When an aircraft departs every seat is a “produced” available seat kilometer (ASK).
- If the seat has been sold it turns into a revenue passenger kilometer (RPK). If not, the flown empty seat kilometers create economic losses, since they affect fuel burn by their weight, but cause no revenue. Moreover, the marginal cost of taking on board an additional passenger on an otherwise empty seat is very low.
- This is the main reason an airline partly sells its tickets for very low ticket prices, far below average production cost, to ensure a sufficient aircraft load factor.
- Inevitably, the airline has to sell another part of the tickets—the major part—at normal and much higher prices to achieve average revenue for the whole aircraft, which exceeds the costs of the flight. Hence, airlines sell seats of a flight at different prices, even in the same cabin class.

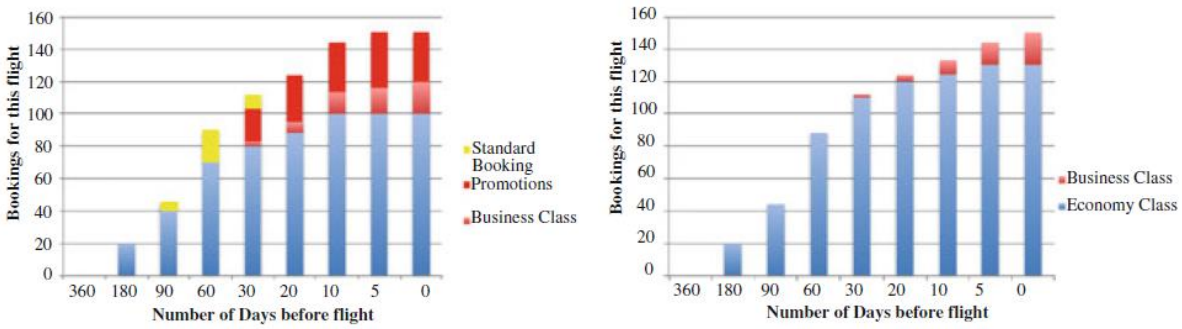


Fig. 7.20 Booking pattern for economy class

- During the flight planning process airlines try to forecast the demand of passengers for each flight and cabin class with complex demand modelling (QSI, logit).

- After the schedule is published ticket sales are monitored continuously and compared to historical booking patterns Fig. 7.20 left. At the right side of Fig. 7.20 the reactions to under booking situations are shown, where especially promotions drive the booking rate to a higher load factor.
- If the current booking level is below the historical value for the respective day before departure, the offered ticket price is lowered and some specific promotion campaigns will be launched and vice versa.
- In order to maximize airline revenues a price should be charged the passenger is barely accepting to take the flight. This economic concept is called full price discrimination, which seeks to capture the differing maximum willingness to pay from every single customer.

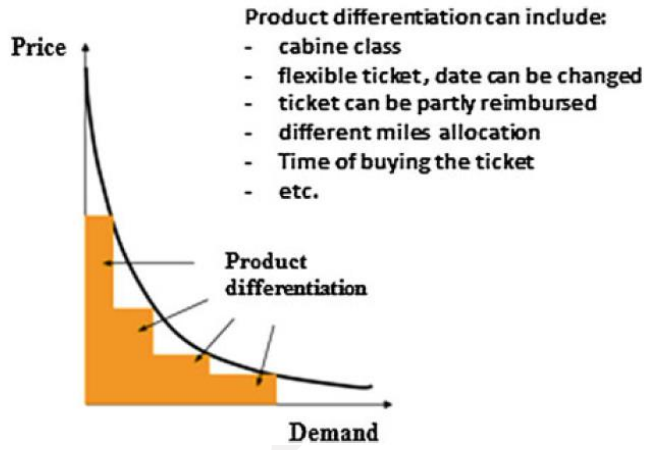


Fig. 7.21 Product differentiation and price allocation

3.3 Fleet Strategy and Aircraft Selection

- The airline operates an aircraft fleet on a certain route network to produce its travel services.
- Depending on the leg length share, the different destinations, and the expected demand of passengers and cargo different types of aircraft are needed for economic profitable operation. The aircraft selection process is therefore a very important and difficult task for each airline.
- While LCCs are typically operating fleets of one or a very few types of aircraft (Ryanair uses only B737 and Easyjet only A319), network carriers operate very heterogeneous fleets with many different aircraft. For example in 2012 Lufthansa operated 12 different types or variants of aircraft.
- Depending on the overall route network, several types of aircraft are needed, regional and short range aircraft for the continental routes and medium and long range aircraft for the intercontinental routes.

- Also the size of aircraft will differ, depending on the demand at different routes. The shortage of slots and busy airports may force airlines to use bigger aircraft with lower frequencies at their preferred “best routes”.
- The philosophy of each airline, how to choose the different types of aircraft can be quite different.
    - Some airlines prefer to have only one aircraft manufacturer, which may lead to special purchase deals with this preferred manufacturer.
    - Some strategies go to use aircraft from several manufacturers, but use as much as possible always engines from the same engine manufacturer.
    - Some airlines try to be open and just choose the best product of the market as defined by their specific network requirements.
- There is no general strategy, as a lot of parameters, sometimes very soft and difficult to quantify, are involved like national, political, traditional aspects.
- If different capacities are needed a more rational approach is possible. Depending on the route a certain aircraft size is used. If now demand will increase further, there will be a time where a bigger aircraft may be reasonable in order to fulfil the increasing market demand.
- This graduation in capacity is economically best if the next aircraft offers 20–25 % more capacity. As shown in Fig. 7.22 each aircraft needs a minimum load factor to cover the cost of the flight. More seats additionally sold are leading to a profit on this route.

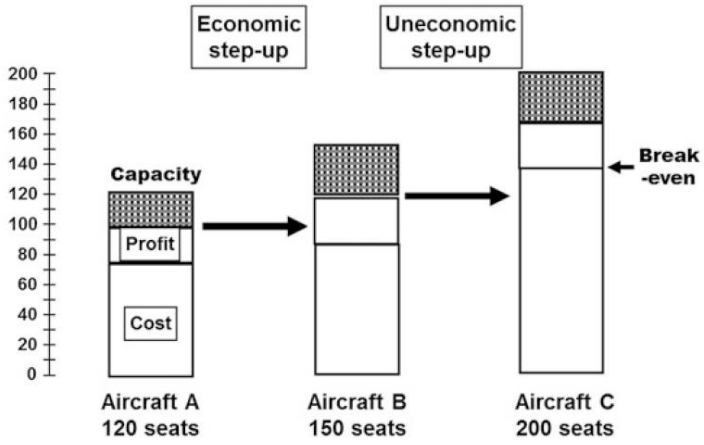


Fig. 7.22 Economic graduation in aircraft capacity

- If the load factor will increase so strongly, that a lot of demand can no longer be fulfilled, a bigger aircraft has to be used. If the aircraft is too big, the basic cost will not be covered and the bigger aircraft will create no profit.

- An optimal step up in capacity can be achieved when the bigger aircraft will still be capable to earn money with the max. load factor of the smaller aircraft. This staggering in aircraft size is normally in the order of about 25 %, which can also be seen by the family concept of Boeing B737 family as well as Airbus A320 family concept.

3.4 Flight Operations

The flight operation of an airline is closely linked to the airports and their capabilities, which are used in the airline network. The airline has their home base, which is the hub, but can also have several hubs in their network.

3.4.1 Stations

- At each airport an airline is operating at various services must be fulfilled. This is done either by the airline itself with own staff or, if by cooperating airlines or service agencies.
- The following services need to be provided at a station (Fig. 7.23):
    - Passenger services, sales and special services
    - A/C handling
    - Cargo handling

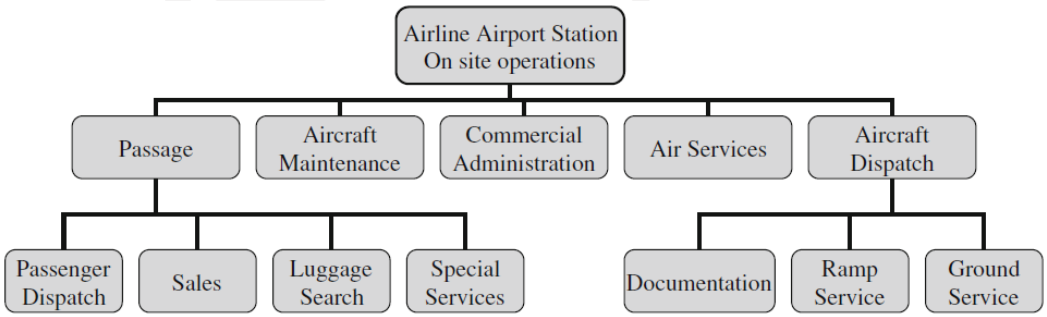


Fig. 7.23 Principle setup of an airline airport station

- The airline station must be clearly visible to the passenger, when he is arriving at the airport by whatever transport mean. There must be a check-in counter to provide the boarding pass and baggage drop off. A ticket counter for all rebooking, baggage overweight, children support or similar passenger requests is also needed.
- All ticket and check-in counter infrastructures are normally part of the airport, but these facilities will be rented to the airlines upon their needs.

- If the airport is an airline hub, the airline will dominate the overall operation at this airport. Sometimes complete terminals will be owned and operated completely by the hub-airline.
- The headquarter and airline administration will be located here as well as other major functions like crew training, maintenance center, training simulators, etc.
- In case the airline requires only a small operation activity at the airport the question of "make or buy" occurs. The airline has to decide, whether own staff will be needed at this airport or the airport or other services might provide all required functions.
- If the airline is part of a global alliance, they may negotiate with another partner airline to take care or join the efforts for their operational services at this airport.
- One advantage of a global airline strategy is the provision of common services at outside stations and also the standardization of service quality.

3.4.2 Passenger Services, Sales and Special Services

The whole package of workload can be listed as follows:

- Passenger handling (check-in)
    - In Europe most of the airlines have installed machines where the boarding pass will be issued automatically.
    - The passenger has to type in either his reservation code, his E-ticket number or his passport/identity Card, and the machine will react and ask for a seat selection and provide the boarding pass.
    - The baggage still has to be registered at the baggage drop off counter.
- Ticket sales and Customer support
    - A counter for ticket sales is always required, to help and support the passenger in case of flight confirmations and rearrangements, if overweight or outsized baggage hast to be transported, if unaccompanied children (UMs) are travelling, if handicapped persons need a special support etc.
- VIP-service, lounges
    - For the VIP persons, special lounges are normally offered. Even differentiations of lounges for frequent travellers and VIPs (Very Important Persons and Honorary members) will be offered at the airport.
    - This feature is often provided in cooperation with other members of the global alliance.

- Baggage handling “Lost and Found”
    - A specific service at the baggage arrival hall is required, where all passengers can address their problem, if a baggage did not arrive at the final destination.
    - This service will then check and inquire, where this specific baggage has stranded and take care to send the lost baggage when finally arriving at the airport to the hotel or the address of the owner.
    - This service is a unique service at the airport and normally handled for all airlines. However, this service is part of the airline operation and has to be paid by the airlines.

3.4.3 Aircraft Handling—Turnaround

Besides the passenger related services there are quite a lot of other functions and services, which an airline need at an airport station like:

- Timely preparation of all necessary handling documents for the crews (e.g. weight and balance, e.g. load plan of the aircraft with loading space for baggage and freight)
- Apron services: coordination of fuel, cleaning, water, control of loading and catering as prescribed (often done by the airport or other service providers)
- Aircraft handling has to be carried out during the scheduled ground time.
- A flight does not start just when the passengers are entering the aircraft. Before each flight several preparations are necessary, amongst others also planning and calculation of the best route for the flight.

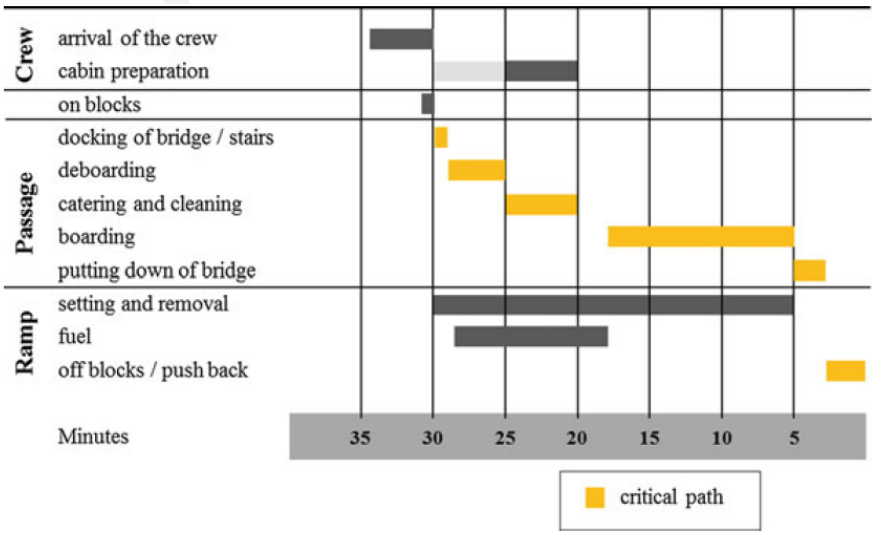


Fig. 7.24 Minimal ground time for a short range aircraft

- The flight route can change depending on wind and weather conditions and on traffic situations. Target of the route planning is to arrive at the destination on time, but also economic considerations have to be taken into account.
- Besides the fuel consumption on the different routes, there can also be quite different fees for en-route charges, which will be considered. In areas with high traffic volume, there may be less freedom for detailed optimizations.
- But on long-haul routes there are more operational options and the optimization process may bring some benefits to the airline. The shortest route may not always be the most efficient route to fly.
- The process for dispatching a flight is rather complex, as there are several partners involved:
    - the airport with their personal like bus drivers, drivers of aircraft push-back vehicles, gate bridge personal
    - the ATM personal for flight clearance processes who are optimizing the slot distribution for takeoff and landing
    - the airline who are trying to minimize the down-time at the airport.
    - the “no-show” of passengers, who have registered their baggage but are not showing up at the flight gate are providing additional trouble for the airlines.
- There is no generalized unique process for this dispatch process. It depends on the airport and its gate-apron structure, on the actual traffic situation on the airport, weather conditions, etc.

3.4.4 Cargo and Baggage Handling

- Air cargo transport is a very specific area, which is part of aircraft ground handling. For completeness it is listed here.
- Air transportation of cargo is a relevant business in civil aviation. It is done via designated cargo aircraft or in combination with passenger transport, when the lower deck cargo compartment (belly cargo) is used.
- Only a small share of worldwide cargo aircraft are newly built aircraft. Remarkably air cargo covers only 1 % of the worldwide amount of goods being carried. But this very small share represents about 40 % of the worldwide cargo value.
- Typical goods for air transport are those, which lose their customer benefit over time quickly like:
    - physically perishable goods would not sustain a transport process for weeks.

- news papers, mail, movies.
- seasonal clothes, and products with a high frequency of new models due to rapid technology development.
- goods of high value per weight and volume in general.

Fig. 7.11 Worldwide air cargo flow in billion tons, [6]

- Air cargo greatly reduces the capital lockup cost and the risk of thievery for these goods while being transported. Some examples are:
  - Electronic consumer articles like smart phones or HiFi equipment
  - Aircraft spare parts
  - Medical goods like medicine and medical technical equipment
  - Chemical products
  - Soft goods
  - Flowers
  - Animals
- Fruits Also the business of mail-order companies (integrator) creates a significant part of air cargo.
- Most of the air cargo is carried as belly freight with passenger aircraft, while pure cargo aircraft transports approximately 40 %.
- Actually global air cargo is growing about 5–6 % per year, which is slightly higher than the passenger transport growth.
- Air transportation of cargo is more costly and has a bigger environmental impact than transportation on ground by truck, rail and ship. Nevertheless, the competitive advantages of air cargo versus ground transportation are:
  - **Speed**—lowest runtime in comparison to ground transport
  - **Reliability**—outmost in time transportation due to fixed flight schedules
  - **Security**—low possibility of unauthorized intrusion and lower exposition to environment and vibrations.

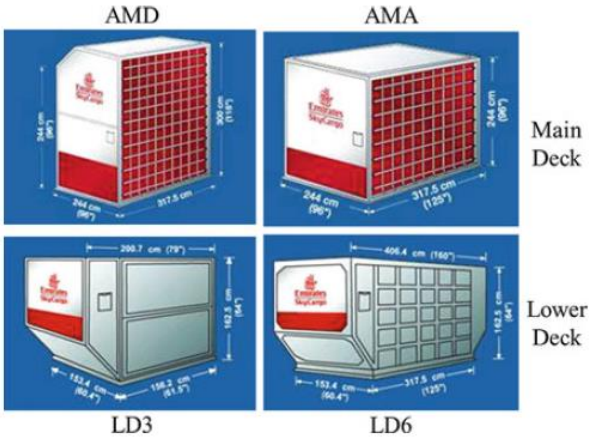


Fig. 7.12 Examples of air cargo container

3.5 Aircraft Maintenance

- Keep aircraft safe and operational is a fundamental pre-requisite of aviation. Therefore, legal baselines laid down in certification requirements like EASA CS25 1529 for continued airworthiness and the related appendices request for a detailed description of all relevant maintenance actions.
- Accordingly EASA part 145 “Maintenance Organization Approval” sets standards for the company, which is performing maintenance tasks.
- Often aircraft maintenance is a division of an airline but today also independent maintenance companies are acting especially for smaller airlines. Ensuring safe and seamless operation of the entire fleet is also a fundamental economic interest of an airline.

3.5.1 Maintenance, Repair, Overhaul (MRO)

- Aircraft maintenance in general covers all activities to keep the aircraft safe and operational. This includes inspections, services, repair but also modifications of components. All these activities are summarized also as Maintenance, Repair, and Overhaul (MRO).
- More in detail inspections cover pre and aft flight checks of aircraft and systems status and functions. These activities are performed at aircraft during turnaround. Mainly the cockpit and ground crews are in charge of this task. But also during hangar checks components are investigated concerning its operational health state.
- Aircraft services comprise refill of lubricants, cleaning, and intensified functional checks of the aircraft and its systems. Also exchange of defect parts or components are part of maintenance services. The airline ground station maintenance crew in a hangar performs these tasks typically overnight on a regular time base.

- Repair of defects is a further level of maintenance where defect parts or components are either replaced or overhauled. Depending on the affected component repair tasks are performed on or off aircraft by the maintenance organization.
- Modifications and improvements cover small adaptions of components and parts but also software, which are initiated by the aircraft design organization due to safety reasons, life time, functionality or performance improvements. Those modifications are finally requested or recommended by the certification authority.
- Overhaul of aircraft and engine systems, components and parts summarizes all activities mentioned above to recover the safe operational state. It also includes exchange of material and equipment.

3.5.2 Maintenance Management and Organization

- Maintaining an aircraft to keep it air worthy and operational is a time and resources consuming task. As mentioned before there very different activities, which have to be performed either on aircraft or off aircraft, Fig. 7.25.
- Off aircraft maintenance tasks refer to components, parts and systems, which are removed from the aircraft and maintained in dedicated shops.

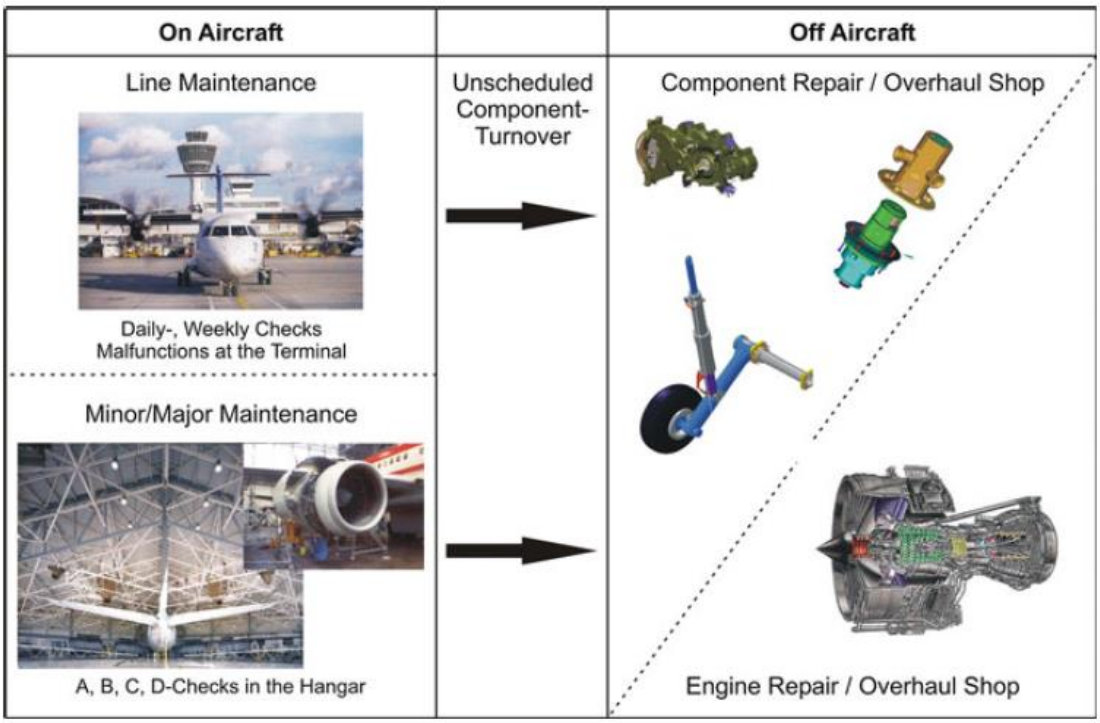


Fig. 7.25 Overview of On and Off aircraft maintenance activities

- Further these activities are distributed over long time schedules and also summarized to various maintenance blocks.

Line Maintenance and Technical Handling:

- Line Maintenance covers mainly services to keep the aircraft operational. Mostly daily maintenance is connected with aircraft rotation planning (ground times, turn around)
    - Visual checks and analysis of the documented measures values of the integrated systems during the flight
    - Fueling, oil supply
    - Cabin cleaning
    - Electricity supply
    - Removal of small claims
    - Removal of so-called No-Go-claims.

Light Maintenance (A- or C-Check):

- For light maintenance activities the aircraft will be taken out of operation. The following tasks are performed:
    - All work orders, which have to be done in intervals of 50–1000 h of operation
    - Controlling of the essential components and removal of findings
    - Limited change of spares
    - Development is only possible on special stations and home bases.

Heavy Maintenance and Aircraft Overhaul (D-Check)

- The D-check is the most comprehensive maintenance block being performed every 8 years with
    - All work orders, which have to be done in intervals of 1000 operation hours
    - Detailed control of components which are difficult to access (structure parts, cells) partly with special equipment and test methods
    - Layover days lasting several days at the dock

Scheduled Maintenance:

- Traditionally maintenance tasks are performed as defined by the design organization according to section 1529 of the design standards on a scheduled basis. That means after fixed flight hours inspections, services, replacements, etc. are defined.

- This approach is used to monitor the component state development and life time consumption.

On Condition Maintenance:

- Over time life time consumption of various components is reduced but also sometimes increased and during the overall aircraft life the scheduling of components is adapted.
- Very often maintenance of components can be shifted to a later block and component life time can be used more efficiently leading to more operation hours and less maintenance cost.

Unscheduled Maintenance:

- Although for all relevant components life times, mean times between failures (MTBF) and main time between overhaul (MTBO) are defined, components can fail before due to over load and over stress or simple material failure.
- In such cases unscheduled repair, replacement or overhaul has to be performed. Unscheduled maintenance causes often additional ground times and cost.

Table 7.4 Overview of different maintenance blocks

Event	Interval	Volume	Ground time	Effort (h)
Trip-check	Before each flight	• Walkabout the aircraft • Cabin and cockpit checks • Control of lubricants • Cabin cleaning	35 min	0.5
Service-check	Weekly	• Refill of lubricants • Thorough cabin cleaning	4 h	20
A-check	Every 230 Fh	• Service-check • Additional cabin and systems check	6 h	40
C-check	Every 13 month	• A-check • Detailled structural overhaul and system tests • Removal of fairings	30 h	700
R-check	Every 15 month	• Cabin overhaul	in parallel to other checks	10
IL-check (Intermediate Layover)	Every 4 years	• Thorough structural and cabin overhaul • Repair and polish of painting	2 weeks	12,000
D-check	Every 8 years	• Fucelage overhaul incl. all systems • Large parts exchange • New painting • Intensive cabin overhaul • All tasks of the previous checks	4 weeks	30,000

3.6 Role of Airport

- Analogous to other transport modes, the airport has a similar role in the air transport system like the harbor in the maritime transport system or the railway station in the railway system or the bus terminal in the road transport system.
- The air transport system has a clear differentiation. The airlines—mainly international airlines—have no direct financial or organizational link with the airports they are operating.
- They have a clear commercial link with the airport by negotiating the time slots at the airport for their flights to and out of the airport, the services the airport will provide, and the airport fees for landing, take-off and station cost at the gates or apron positions.
- The airport plays an important role for a city or a region. It is the window to the outside world. It allows and facilitates easy access to other cities, regions, countries or continents. Therefore, the city and the region have a very clear interest to develop their airport and most of them have direct shares in their airport or are the owners of the airport.

Fig. 8.1 Munich airport and its connection to road and rail

- The airport is also a source of annoyance for a lot of persons living in its vicinity. Persons living close to the airport suffer from the take-off and landing noise, have a less positive view about the airport and are very skeptical with further air transport development and air traffic increase.

- This classical conflict—the users of the airport live away from the airport while the criticizers of the airport live close to the airport —is a constant challenge leading to a lot of conflicts, especially with the still expanding air traffic and causing major problems if an airport wants to further increase the capacity and develop its infrastructure.

3.6.1 Location of the Airport

- The best location of an airport is close to the city centre, with direct access to the railway station and the underground transportation system. But, as the airport needs a certain development potential, the city centres will not accept such a location where the noise impact will be too severe.
- In one word, the best location does not exist. A compromise solution has to be defined, depending on the following constraints:
    - The airport should be as close to the city as possible.
    - The airport needs a development potential for the next 20 years, allowing at least a duplication of air traffic.
    - A fast public transport system (Underground, metro, Maglev, etc.) is needed to connect airport and city centre with a travel time of less than 20 min!
    - No obstacles for aerial development
- As most airports already exist and are located close to the big cities, it is the main task of the airport and its shareholders to ensure the growth, development potential of the airport and the optimal connection to the city centre.
- But also the link to the motorways and the direct connection to a high-speed train system should be envisaged.

3.6.2 Intermodality Aspects

- Intermodality is a very important aspect in transportation. It is always announced as major research topic for the further development of transport systems in the world. But first of all, we have to define the word intermodality precisely:
    - Intermodality is defined as mode change between air, rail, road and water transport systems. Intermodality means a seamless transfer/connection from one transportation mode to another mode with a minimum of time delay and a maximum of comfort for passenger and/or payload.

- It is mandatory for an airport to have access to the road system (motorways, highways, autoroute, whatever you name it!) and to a railway system (metro, tram, railway, high-speed railway). Harbour and airport are in normal operation not connected.
- Maritime transport and air transport are normally in direct competition only for freight transport, especially on medium and long range routes.
- In the freight market, air and maritime transport are alternatives which have to be carefully selected by the shipper, depending on cost and time criteria.

3.6.3 Classification of Airports

- There are different systems to classify airports: It can be done either by the size of the airport, number of runways, number of passengers, number of intercontinental flights, number of international airlines, users (military, civil, etc.) or the number of employees in the airport.
- ICAO, FAA and EASA are specifying the airports in the following way:
    - International airports
    - National airports
    - Military airfields
    - Heliports
- Each airport has a Code number, which is used as “location identifier”. At the beginning, the ICAO airport Code consisted of a three digits code. But in the meantime, the number of airports have increased drastically and a 4 digit code was required.

#	Airport Name & City	IATA	ICAO
1	Bagdogra Airport Bagdogra	IXB	VEBD
2	Bajpe Airport Mangalore	IXE	VOML

- In this 4-digit code the first digit defines the region of the globe; the second defines the country and the third and fourth digits are chosen by each country individually. The US however has a problem of not having sufficient free codes and they use their own codes, the FAA codes.
- But for the daily operation of airlines, there is still the three-digit IATA code which is used. For details, the website will provide all major civil airports with the country code, airport code and specific information about each airport.

3.6.4 Important Airport Elements and Characteristics

- The most important characteristics of an airport are the number of runways, the apron space, the number of passengers and the number of aircraft movements handled per year.

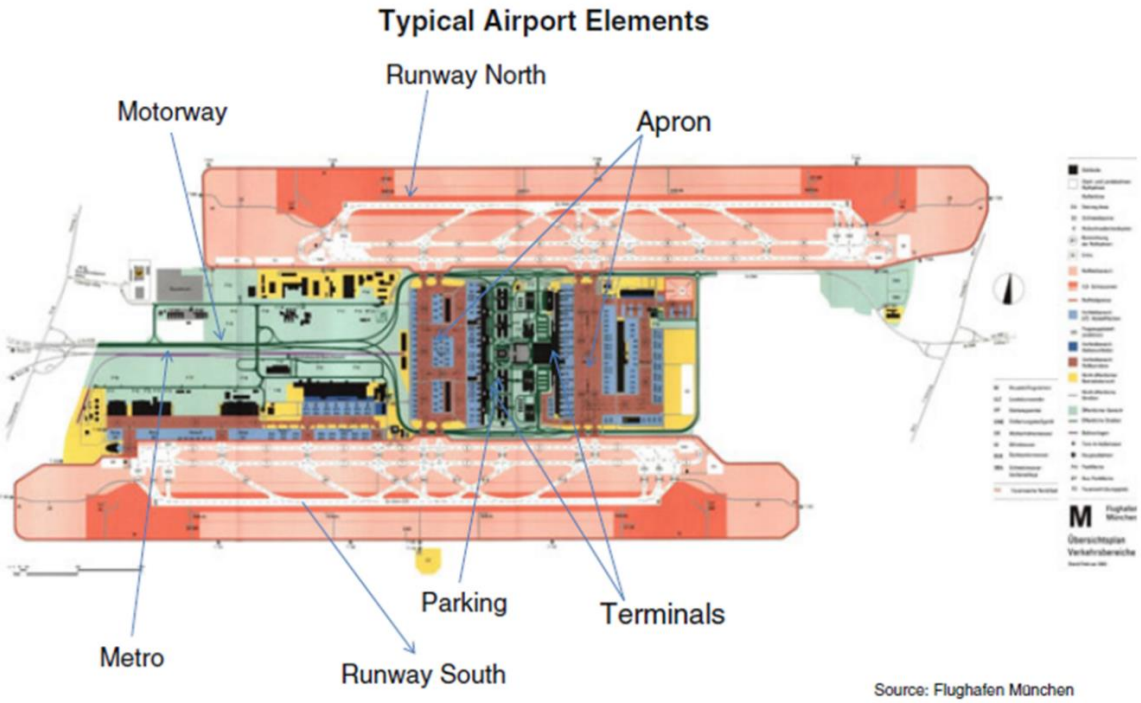


Fig. 8.2 Schematic view of airport Munich in Germany

3.6.5 Airport as Economy Driver

- The airport is a strong economic driver for his region due to:
  - Generating new jobs directly at the airport and indirectly in the region.
  - Offering good international connectivity, a prerequisite in a region to attract and settle new enterprises, develop tourism and becoming a strategic element to add economic value.
- Statistical data show that the development and growth of an airport will also lead to an increase in jobs at the airport. For an increase of additional one millon passengers at an airport, the airport roughly needs an additional 1000 jobs to handle the additional volume of transport.
- Most of the tasks at an airport, such as positioning the aircraft at a parking position, offloading passengers and baggage, refueling the aircraft, providing all sorts of services on the aircraft (water filling, waste deployment, galley loading, etc.) are all

work to be done by trained personal. There is little chance for additional automation for these timely constrained processes at the airport turnaround.

- If the airport is also increasing its capability to attract more long range flights, there will be additional jobs for the operating airlines at the airport.
- In addition to the created jobs at an airport, the airport plays an important element in the selection of a site for a new company. In the worldwide trade environment, fast connections are an important factor for each industrial company. So a well-functioning airport is a prerequisite for a company's installation in a region.
- A lot of reports can be found which have analyzed the situation of specific airports and its economic impact on the region. The summary of most of these reports is lead to the conclusion that the airport plays a crucial role in the development of a region and country.
- A study was initiated by the European Commission in 2011 under the theme "Airports as drivers of economic success in peripheral regions" (ADES) and the results are published. The report states that the answer is not a clear yes or no, but depends on the regional factors. The main conclusions indicate:
    - accessibility in general is an important location factor;
    - for some remote regions, airports with enough scheduled flights are crucial for economic development;
    - the bottleneck usually is not lacking infrastructure, but lacking scheduled flights to relevant destinations;
    - the limiting factor (or bottleneck) for economic prosperity is often not accessibility but rather the availability of qualified manpower;
    - it is better to use a larger airport in a neighboring region than to develop an airport of its own (if accessible within some three hours);
    - not all existing airports are needed—some of them can be closed and the territory can be used for something more efficient;
    - the airports can often be improved (to make them more attractive);
    - good airport policy and strategy can make a huge difference.

3.7 Regulatory Issues

- The airport council (ACI)—an international organization, representing all airports in the world—has set up a lot of committees and regulatory rules for their customers—the airports—to follow the international standards.

- Safety seminars are run and offered to their customers to inform, update and train the personal of their customers.
- In a similar way, the airlines take responsibility for their safe operation and also provide safety seminars. The following two websites provide additional details about the airport and airline approaches.
- The national law is on one hand following the national historical legal development and on the other side including the international rule-making procedures. Specific airport regulations deal with
    - Safety management
    - Security
    - Local airport emissions
    - Airport noise emission

3.7.1 Airport Safety and Security

- Airport safety figures from ACI Europe for the year 2010 show that there have been 62 emergency landings, four major accidents and more than 40 bird strikes during take-off and landing.
- The analysis of several flight accident reports clearly indicates a lack of safety discipline and culture. This can be improved by applying an active safety management system.
- The airport has an obligation to invest in a safety structure, which brings the awareness of risk involved in all sort of activities in an airport to all personnel working at the airport.
- If all incidents are openly reported in a system (at an airport or at an airline) an active safety management system can be installed, to analyse these incidents and to draw conclusions for further operational improvements.
- This incident reporting system has to be set up in an open way, encouraging people to report and not to give them the blame that they have done some strange things.
- Normally, this safety management system has to be set up parallel to the operational system with good links to the working staff, providing an atmosphere of openness and developing and encouraging training courses for all safety critical domains.

3.8 Airport Operation and Services

- The airport operation has to be done in a way that the services that are provided will be at least balanced by the fees the passengers and airlines are paying for these services.
- Each airport is forced by their shareholders to operate efficiently and provide reasonable benefit. This pushes the airports to look for other income sources and most airports are changing today their character from pure passenger and cargo handling to modern service providers.
- Several modern and big airports prepare specific events—cinema areas, fair and trade events, show rooms for luxury cars and beauty articles, etc.—and attract a lot of public, who are not travelling but only using the entertainment possibilities of modern airports.

3.8.1 Aircraft Handling Process at the Airport

- Basically, the passenger embarking and disembarking process can be divided between the airside and the landside part.
- As shown in Fig. 8.6, the airside cycle starts with the landing of the aircraft, taxiing, docking at the gate or at the apron.
- Once the aircraft is parked safely, the landside part starts. It begins with the gate or staircase positioning.
- After opening of the doors the passengers disembark either through the passenger bridge directly to the terminal or via a staircase and a bus in front of the aircraft, which will bring the passenger to the terminal.
- When the passenger arrives at the terminal there are two options:
    - The transit passengers will be directed either to the transfer desks or directly to the departure zone, where they will look for the gate for their next flight. This process is normally handled within the security zone and no additional security check for the passengers is required. There are however some countries and depending on where the passengers are coming from, an additional security check is required.
    - Those passengers who have arrived at their final destination will be guided to the baggage claim zone, pass through customs and immigration controls and will then arrive with his baggage at the open airport side. Here he will

find information desks, which will guide him to car parks, the bus- or metro-station, the high-speed railway or the taxi stand.

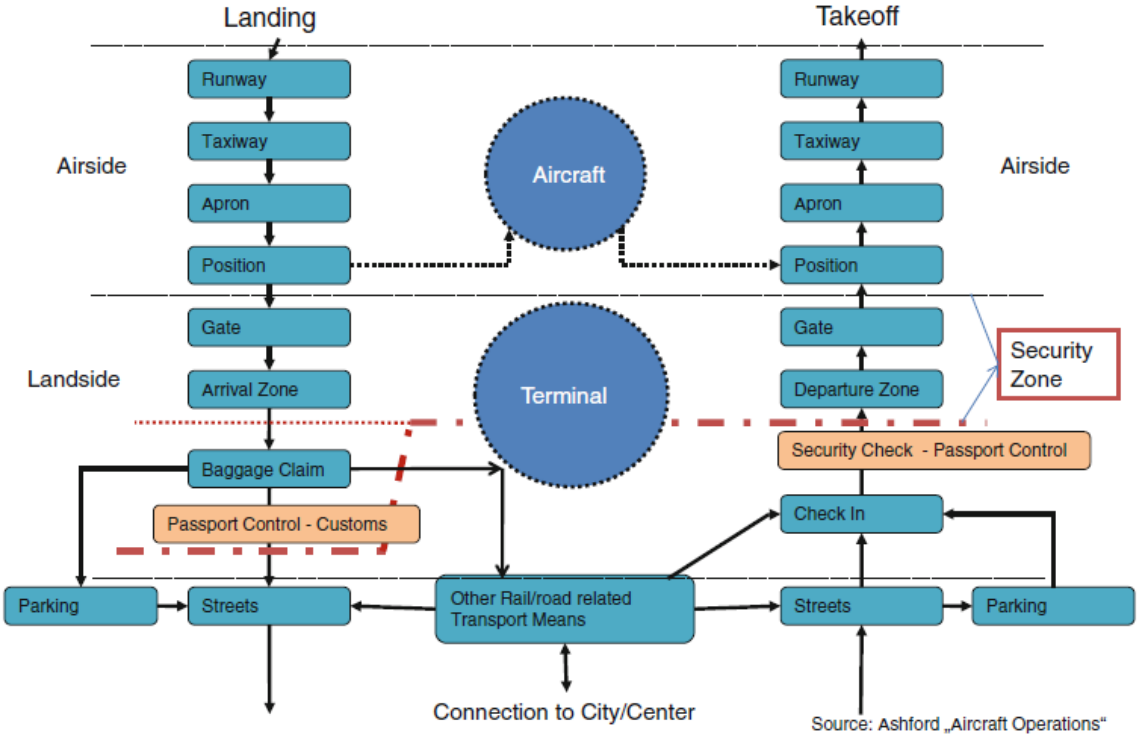


Fig.8.6. Passenger/aircraft process during take-off and landing cycle

- The embarking process is reversibly happening. The passenger is arriving at the airport by bus, taxi, metro, private car etc. and will go to the registration zone.
- The airlines have here their check-in counters, which will have either machines to distribute the boarding pass and/or have counters, where the “baggage drop” will happen and baggage will be checked in for the flight, but also controlling the allowable weight and outsize baggage.
- With his hand luggage, the passenger will then pass through the security check, which today is still a fairly time-consuming step and can take up to 30 min at big airports during peak times.
- Behind the security check, the passenger will then have to go to his gate and wait for the start of the aircraft boarding. In this area of the airport, a lot of small bistros, shops and service providers are located.
- As the normal passenger will take quite some reserve time as he is not so familiar with all the time delays for security check and finding the right gate for boarding, he normally has quite some time behind the security control zone to walk slowly to his departure gate, have a look at some shops, take a snack and is ready to spend

some money! This is quite an important element for the airport to install sufficient space in this area for all sorts of shops bistros etc.

- When all passengers are on board, the pilot will request from the ATC (air traffic control) the necessary instructions for his take-off procedure.
- The air traffic control will check his destination and will clear the aircraft for take-off at a certain time slot.
- The aircraft will either need a push-back vehicle to leave his gate position or will need a person to check and release the parking brakes before the wheels and give the pilot the green light to start the engines.
- Then the pilot will follow the instructions from the ATC till the aircraft reaches the indicated runway and his take-off position.
- He will then switch to the air traffic control and follow the instructions for take-off and the instructed flight path after take-off.
- When the aircraft is at the runway and cleared for take-off, the pilot will then apply full take-off thrust, accelerate the aircraft till it has reached the rotation speed, rotate the aircraft and follow the predefined route out of the terminal area to the upper airspace.
- When the aircraft has reached its climb phase the pilot will already follow his flight path to his final destination, while negotiating during his cruise phase with the air traffic services the optimum speeds and altitudes for the best cruise performance for his flight.

3.8.2 Definition of Major Airport Elements and Services

- The smooth operation of an airport during day and night during all seasons of the year will require specific equipment and services.
- the most important elements of an airport are the
    - runway, which is needed for take-off and landing
    - taxiway which is allowing the aircraft to access the apron and the terminal gates
    - apron, which is the area for parking the aircraft during their downtime
    - terminal which is providing the access of passengers to the aircraft
    - parking area, allowing the private parking at the airport
    - access of metro/public transport, trains, integrated in the terminal area
    - road connection (car, bus taxis) to the motorway and fast city link

Table 8.3 List of all elements, mandatory for a smooth operation

• Take off/Landing-Runway(s)
• Taxiways • Terminal and aprons for passenger-, cargo- and General Aviation transport • Tower for Air Trafic Control • Navigation means and installations • Illumination of all airport areas and buildings • Kerosin Reservoirs • Aircraft maintenance hangars • Airport maintenance and winter service • Shortterm-, Longterm-parking • Catering-Services • Motorway-, Railway-, Metro-connection • Energy systems (electricity, air, heating, etc.) • Water and waster system • Safety fences and doors, surveillance cameras • Medical Care system • Fire brigade • Services like hotels, restaurants, meeting rooms, etc. • Etc.

3.8.3 Turnaround Process

- A very important feature for the operator—the airline—is the "turn around"-process for each aircraft at an individual airport.
- For the airline the turn-around starts when the aircraft has left the runway and has arrived at the parking position which could either be a gate position or an outside parking position, where staircases have to be provided to disembark the passengers.
- When the aircraft has been parked at its position and the engine is shut off, the real turn-around process starts, which is mainly related and limited by the aircraft, its doors, and can be used for disembarking the cabin arrangement.
- The aircraft manufacturer is already providing for each aircraft a certain master plan for the turn-around process.
- This turnaround process starts when the engines are shut off and the ground power is connected to the aircraft.
- Then the bridges or staircases will be brought close to the aircraft door(s), the door will be opened and when the safety check is done, the passengers will be allowed to disembark the aircraft.
- There are a lot of statistical data available for all different aircraft types to account the mean time for this disembarking process for a fully loaded aircraft. The aircraft deboarding process can be also be simulated and this simulation capability can also be used to calculate the disembarking time for newly developed aircraft types.

- Parallel to the deboarding of the passengers, the cargo doors will be opened and all containers will be taken off, similar to the baggage located in the bulk room. In parallel the waste recovery can start, followed by the water refilling.
- When the passengers have left the aircraft, the cabin cleaning process can be started and all the catering trucks will be put in position to offload the used trolleys and will provide the new trolleys for the next flight.

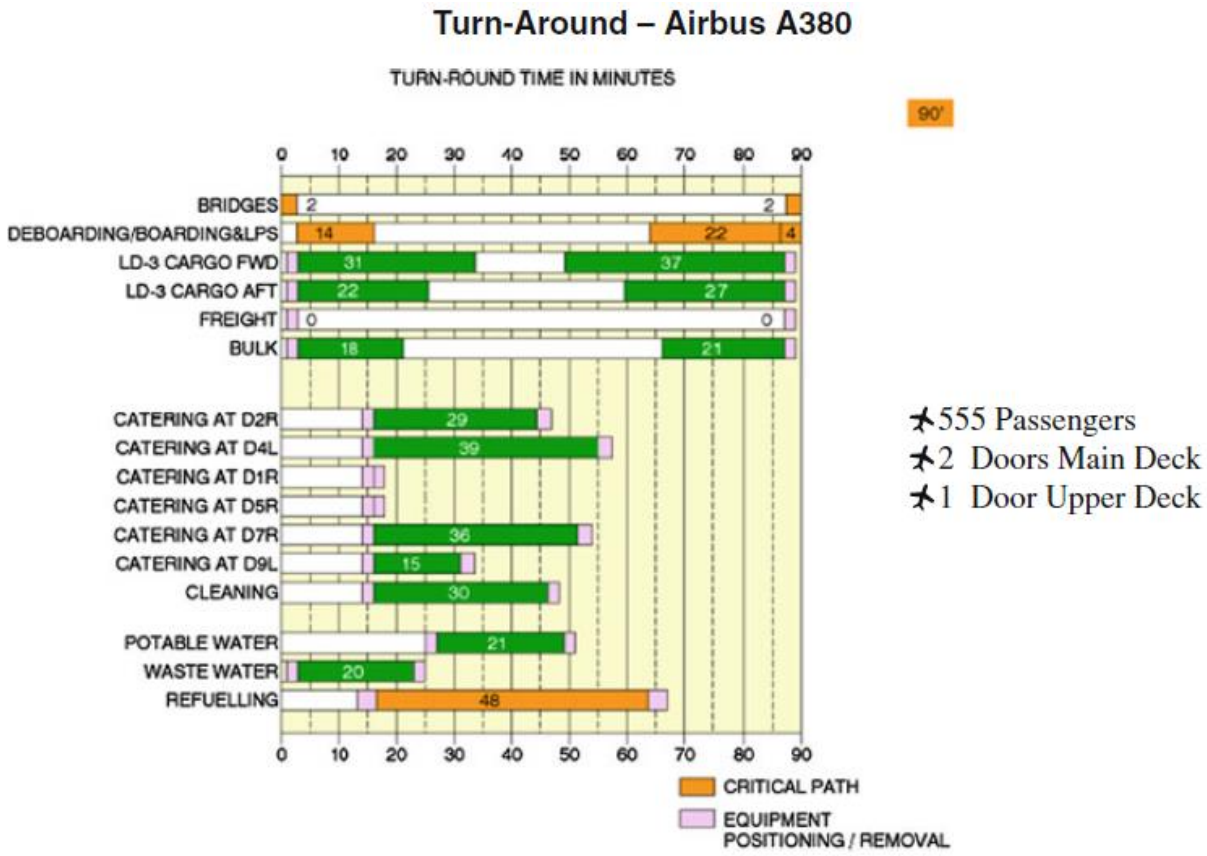


Fig. 8.5 Typical Turn Around process with the time critical path

- Also the refueling process will start. The refueling process is often on the critical path, but it can be only started, when all passengers have left the aircraft. It is a safe feature and is defined in the ICAO operational rules!
- After the aircraft is cleaned and refueled, the passengers can board the aircraft again for the next flight. Depending on the size of the aircraft, the time for boarding can be calculated and is fixed for each type of aircraft.
- However, all these time for boarding, deboarding are very much depending on the experience of the passengers, their knowledge about their seat location, the hand baggage to be stowed in the overhead bins, their cooperation to free the aisle as quickly as possible to allow others to pass etc.

3.8.4 Airport Check-in

- Check-in is usually the first process for a passenger when arriving at an airport, as airline regulations require passenger to check-in by certain times prior to the departure of a flight. This duration differs from 15 min to 3 h depending on the airport, the destination and the airline.
- The check-in is normally handled by the airline itself. At outside stations the check-in can also be subcontracted to a handling agent working on behalf of the airline.
- Passengers are normally giving their travel documents to the airline, showing their passport or identity card to receive the boarding pass.
- The check-in for the airline is the point, where bigger baggage items—the passenger do not wish or the airline do not allow to carry on to the aircraft's cabin —are separated from the passenger and are transported separately to the aircraft and stowed in the lower baggage compartment.
- During this check-in process, the passenger has the ability to ask for special accommodations such as seating preferences, inquire about flight or destination information, make changes to reservations, accumulate frequent flyer program miles, or pay for upgrades.
- Check-in is often possible or even required to be done at specific machines, which are issuing the boarding pass and then only the baggage has to be given to specific baggage drop-off counters.
- Even automatic luggage check-in counters are in use, supporting the airlines to reduce further their personal.
- Check-in options and procedures vary per airline, with some airlines allowing certain restrictions, other airlines have in place, and occasionally the same airline at two separate airports may have different check-in procedures.
- Such differences are usually not noted by the average passenger and occasionally lead to service interruptions when one carrier refuses to abide by the procedure that another carrier normally would be willing to do.
- But the automatic check-in can only be done for normal passengers. There should always be a need to provide a specific service for children, elder persons, disabled persons, which has to be done by qualified personal.

3.8.5 Baggage Handling at the Airport

- The word baggage is used in this book simultaneously with the word ‘luggage’. In the air transport system, there is a clear principle, that at the airport and specifically the check-in counter, the baggage and the passenger have to be separated.
- The passenger is only allowed to take one piece of hand luggage with him into the cabin.
- The big baggage will be separated and stowed in the lower cargo compartment of the aircraft. This is partly due to the aircraft design, where the cabin is used to the maximum for passenger seating and the lower cargo compartments will be used to store all baggage, first of all the baggage from the passengers and if there is empty space, also some containers with additional cargo items.
- This separation of passenger and baggage at the airport terminal requires a fairly sophisticated system, which will ensure that all the baggage items from the check-in counters will be transported to specific places, where all baggage for one specific aircraft will be collected and then transported by small baggage wagons to the dedicated aircraft.
- At big airports, this baggage handling system (BHS) is fairly complex and sophisticated to guarantee a more than 99 % correct delivery to the right aircraft. In addition, the baggage handling and transportation system (BHS) will also be used for the arriving aircraft.
- All baggage is then taken from the aircraft—partly containers, partly individual suit cases from the bulk area—and will then be brought to the BHS again, which will distribute all baggage from one flight to one specific belt or baggage distribution system in the arrival area.
- Of importance is also the technology, which is used to give each luggage a specific code and then track the luggage during its way throughout the system to the final point for the dedicated aircraft. Several systems and technologies can be used like RFID technology.

3.8.6 Freight Handling

- Most of the large airports are also handling specific cargo aircraft. The airport has normally a specific area dedicated for all cargo preparation, loading and off-loading the cargo aircraft and handling the incoming and outgoing freight.

- The airport has often own service providers or they are renting specific areas of the cargo area to airlines or Ground handling Agents (GHA). The following items have to be offered from the GHA:
    - Handling of import, export and transfer cargo, including all documentation
    - Complete handling of special freight such as hazardous goods, express and courier shipments, perishable and refrigerated goods, animals, valuables and airmail
    - Picking and deconsolidation services (“fast lane” accelerated handling)
    - Interim storage and “ready-to-go” preparation of freight consignments
    - Provision of trucks
    - Last-minute services for urgent freight
- The air cargo supply chain is a bit more complex, compared to the passenger handling at the airport. Cargo has no own intelligence and has to be managed in all details.
- Due to the different partners involved, IATA has issued an initiative, called “Cargo 2000” or abbreviated C2 K.
- This C2 K initiative provides a quality management system for the worldwide air cargo industry to standardize and optimize the transportation process within the air cargo supply chain from shipper to consignee with the overall objective to increase service performance and thus satisfy customer expectations.
- Members of the C2 K are carriers (airlines), freight forwarders, Ground handling agents, airports, trucking companies and IT-providers, who committed themselves to implement agreed standard processes.
- As all the members in the air cargo supply chain are operating with different IT systems, the C2 K process achieves transparency and visibility of the actual freight movement for the customer by applying C2 K measurement of milestones and alert setting procedures during transportation. Main benefits are:
    - Improving processes towards paperless shipping management
    - Reducing claims through improved visibility, control and quality
    - Ensuring reliable and timely delivery of freight through harmonized processes and standards of airlines and forwarders
    - Training of operational staff on identical standardized processes
- Freight was originally carried loosely in the cargo hold of the aircraft. But with the introduction of bigger aircraft and specific all freight aircraft, a more standardized

transport device was needed, the so called “Unit Load Devices (ULD)” or standard container.

3.8.7 Fuel and Energy Needs

- Fuel supply is one of the major requests from airlines at the airport. Jet engine aircraft are using kerosene Type Jet A1. The smaller aircraft, which are pushed by piston engines, are using AV-gas, which is similar in it's consistency like super fuel for cars.
- A certain, safe and reliable storage of fuel is mandatory at the airport. There is normally a specific area needed where the fuel stores can be located. They should neither be too close to the runways nor to close to the terminal areas for safety reasons.
- Depending on the number of movements and the main destinations, served from this airport, the storage capacity of fuel has to be elaborated.
- The fuel is stored in big boilers. The boilers have to be refilled either by pipelines, railway tanks, tank trucks, or by a ship supply. Specific pumps will be needed to facilitate the transfer from the oil reservoir to the central tank boilers.
- Often there are several supply systems installed to have redundant systems operating.
- For the service of the aircraft, mainly two possibilities exist:
    - Several tank trucks are delivering the fuel to each individual aircraft
    - An underground fuel distribution system is installed and at all major gate positions, a specific pump truck is pumping the fuel from the fuel valve connector in the ground to the aircraft wing tank
- Other sorts of energy are required at the airport for the aircraft service and all the buildings (terminals, park houses, etc.) and runway and taxiway lights, etc. So specific power stations are needed at each airport, mainly electricity generators but also pressurized air and hydraulic energy may be required.
- Each aircraft being parked at the terminal will need electrical energy, hot or cold air for the cabin and hydraulic power for the systems operation. Each aircraft has an APU system (Auxiliary power Unit), a specific turbine in the aircraft, which can provide different sort of energies on ground.

- Most of the bigger airports are not allowed to use APU's on the aircraft and are providing ground power, either via a ground power vehicle or via fixed cables close to each aircraft gate!

3.8.9 Business Aspects

- Each airport has to cover its expenses by applying service charges/fees to all operating customers like airlines, business jet and private aircraft operators, helicopter operators, etc.
- There is no unique fee system for all airports. But as airports are very different in size, attractiveness and national importance, the charges can vary quite largely. Specific info can be found in the airport economic report, issued yearly by ACI.
- Charges are fees, paid by airlines for services and facilities provided by airports such as:
    - Use of the runway (landing charges)
    - Use of the airport infrastructure (parking and boarding bridge charges)
    - Use of the terminal building (passenger charges)
    - Airport security (security charges)
    - Protection of the environment (noise and emission charges)
    - Other air navigation services (meteorological and aeronautical information services)
- IATA's role is to drive cost reductions and continuous improvements in cost efficiency. Some key facts regarding charges are provided below:
    - External campaigns with major airports involving direct consultation and negotiation
    - Leading the industry's position on charges issues
    - Closer collaboration with local and regional airline associations
    - An industry-wide approach with Member airlines
    - Incorporating charging principles of non-discrimination, transparency, cost-relationship and consultation with users
    - New approaches and strategies for airlines, airports and ANSPs to achieve greater cost efficiency and performance
    - Protecting airline interests in cases of commercialization of airports and ANSPs efficiency and performance
- There are several other opportunities for the airport to generate additional income.

- Most airports are amongst the biggest car park owners and are generating a lot of income via the renting of car space.
- In the terminal area, more and more space is found today to be rented to travel agencies, holiday agencies, magazines, shops, restaurants, car rental services, bank counters and cash machines, etc. …
- All the airlines need space to welcome the passengers, to have the Check-in counters, differentiated by class booking, and also have some space for ticketing and rebooking counters.
- Hotels and conference centres are also a new domain, requested by a lot of companies and business travellers
- The airport is becoming more and more a specific attraction for families, friends to visit the dynamic atmosphere of international travelling flair. The airports are more often therefore to arrange some specific family events and also shopping events.

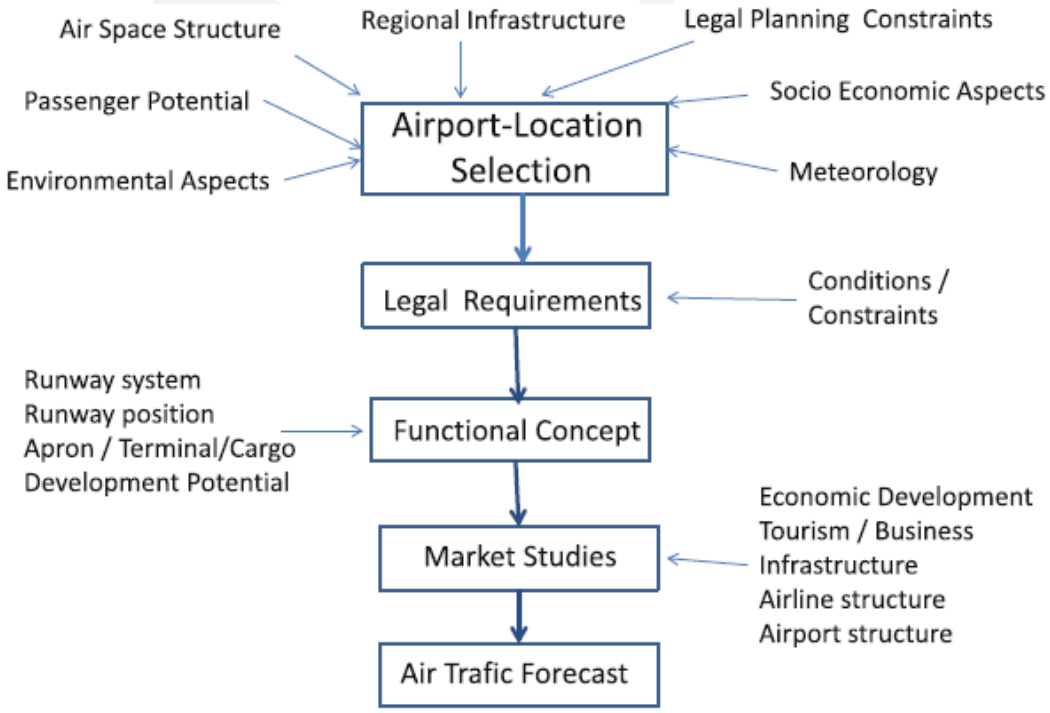
3.9 Airport Planning—Infrastructure

- The airport planning process is very complex and has several constraints to follow, and an ideal planning is rarely happening due to too many restrictions which will have to be considered.
- On the other hand, all the big cities have already an airport and it is their tendency to enlarge and develop the existing airport then to start with a complete new planning process. Here are only some general remarks to be given.

3.9.1 Airport Planning Process

- The first important decision is the selection of the airport location. As the airport should be on one hand close to a major city, the noise and environmental aspects pushes the airport a bit more remote from the city centre and to install a fast link (metro, railway, etc.) between the city centre and the airport.
- As there may be several possibilities, all relevant regional infrastructure aspects have to be analyzed, meteorological and environmental aspects have to be investigated, legal national/regional planning constraints have to be considered, the air space structure (take-off, landing, holding patterns, approach procedures) have to be defined, socio-economic aspects have to be evaluated and also the potential development has to be considered and integrated.

- A final decision has to be done, before the detailed master plan can be developed. The master plan will then have to look at the legal requirements and procedures, to develop the functional concept, integrate all sorts of market studies and to provide some air traffic forecast.
- Most of the airport master plans (Munich, Kuala Lumpur, Madrid, .) after some years of operation have become obsolete, as the growth potential was under or overestimated. But experience has also shown, so that you cannot start with a big plan based on a 20 year forecast and establish and invest all equipments, you need in the long term.
- Each airport today is under a permanent development plan and you will hardly see an airport which is not under continuous reconstruction. With the still constant increase of air traffic, the airports have to master their expansion plans and integrate them permanently.
- A certain market study is required at the beginning of each airport planning (Fig. 8.7). This market study should include estimations about
    - The amount of passengers,
    - the passenger behavior of how to join the airport,
    - the air travel streams
    - the expected airlines and route structure.



Schematic airport planning process

- In parallel the basic requirements for an efficient airport design have to be listed. Figure 8.9 shows the main parameters for the initial airport layout. But some assumptions about the future expansion are also required.
- It is important to secure the additional land around the airport to avoid land speculations and to allow a future expansion in the most important areas like additional runways, another terminal, increase of apron space for aircraft parking and handling.
- ICAO (International Civil Aviation Organization) has issued international quality and safety standards. There is a differentiation between "Standards", which are mandatory for all member countries and their airports and "Recommended practices", which are only recommendations.

Fig. 8.9 Basic airport requirements

3.9.2 Terminal Layout

- The basic arrangement of terminals and gate positions can be very different. This depends a bit on the available space, the general weather conditions in the region, some historical development and the vision of the planning team and the owners.
- The terminal concept is a compromise between aircraft positioning and passenger movements. The finger concept allows the passenger a short way, when changing from one gate to another.
- For example if a passenger arrives at A and has to move during transit to gate B, his physical way is quite reasonable. Whereas in the "Linear Concept, when he arrives in A and has to transit to B, he has quite a long way to walk.

- On the other hand, there are some aircraft in the finger concept are a bit constraint, especially when looking at aircraft position B. When this aircraft is ready for departure but another aircraft is just entering to go to gate position C, it has to wait till this aircraft has moved to his position. There is no independent aircraft movement possible.

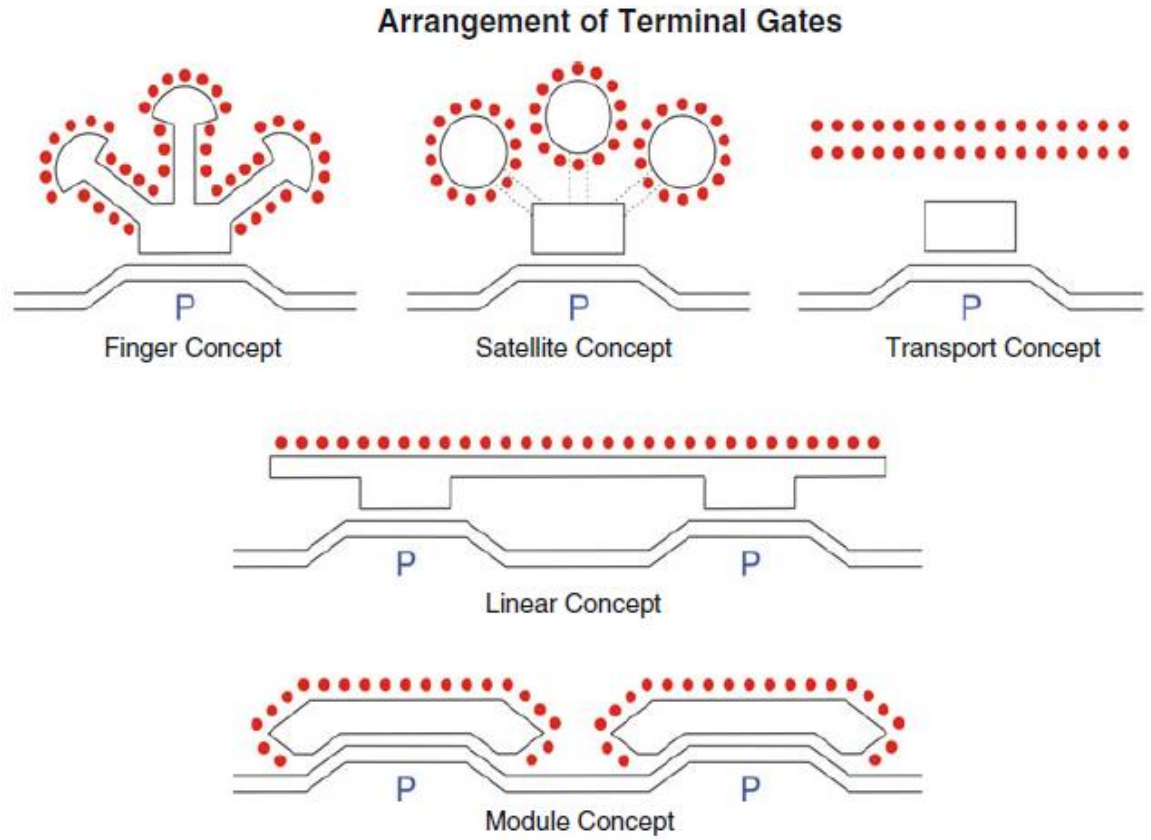


Fig. 8.10 Different concept for the Terminal layout

- This is the advantage of the linear concept, where aircraft have no limitations (or only very little) for departure and arrival. So a reasonable compromise between passenger comfort (reducing walking times during transit and from security check to remote gates) and aircraft movement flexibility has to be found.
- The recent airport terminal designs (Munich Terminal 2, Madrid Terminal 2) seems to favor the linear concept. There is another big argument from the airport side to favor the linear concept. The linear concept is giving ample space for shops, boutiques, restaurants and bars, and people walking to their gate, are offered a variety of opportunities for shopping and relaxing. This side effect is quite interesting for the financial situation of an airport. The long walking distances can be alleviated by the installation of moving belts in the terminal area.

- For large airports with a major part of transit passengers, this offers the opportunity to give the arriving passengers the chance to be guided
    - either to the baggage area and the exit
    - or to the transfer desk or the big boards, where the connecting flight will depart
- A Passenger Boarding Bridge (PBB) is a flexible connection between the terminal building and the aircraft door. There are several names in use for the boarding bridges like jetbridge, loading bridge, airbridge, gatebridge, passenger walkway etc.
- The PBB consists of a fixed part at the terminal and the movable part which can be adapted to all heights of different aircraft doors (sill heights, fuel status, loading status of the aircraft, etc.). PBB provide all-weather dry access to the aircraft and enhance the safety and security of terminal operations.
- They are mostly permanently attached at one end by a pivot to the terminal building and have the ability to swing left or right. The “cab”, located at the end of the loading bridge, may be raised or lowered, extended or retracted, and may pivot, in order to be positioned to all different types of aircraft.
- PBB provides enhanced access to aircraft for passengers with several types of disabilities. They may board and disembark without climbing stairs or using a specialized wheelchair lift.
- The terminals are an important element for the airport planning: The following functions have to be foreseen:
    - Counters for airline ticketing
    - Check-In Counters
    - Security and passport Control zones
    - Waiting rooms and waiting areas in front of each gate
    - Counters at the departure gates
    - Arrival areas with baggage claim zone and customs
    - Baggage handling and distribution system
    - Lounges for airlines
    - Service areas for children, disabled persons, medical service, religious zones, etc.

3.9.3 Runways, Taxiways and Aircraft Geometry Codes

Runways: Major basic principles are

- Parallel runways should be separated by at least 1050 m. This will allow an independent operation on both runways. If the distance is less, the departing and arriving aircraft have to be staggered and this will reduce the capacity of the runway system.
- The runway length depends very much on the different aircraft type and their maximum take-off mass MTOM. If the runway length is 3500–4000 m, nearly all major big long range aircraft can be arriving and departing on this runway.
- The critical design point for the definition of the runway length is normally the aborted take-off case, where the aircraft during take-off with an engine failure close to the point of rotation must still be capable to cancel the take-off and come to a complete stop before reaching the end of the runway. This is a rare case in reality; however the safety considerations are requested in this case as a design and certification point for the aircraft.
- At the end of each runway, there has to be a zone called “stopway and clearway” which is defined in and is needed, if the aircraft has an aborted take-off and has to turn to come back to the terminal and apron area.
- An obstacle free zone at the end of each runway is needed to allow the aircraft, when taking off with an engine failure and a very small climb gradient, not to be obstructed on its climb out phase.

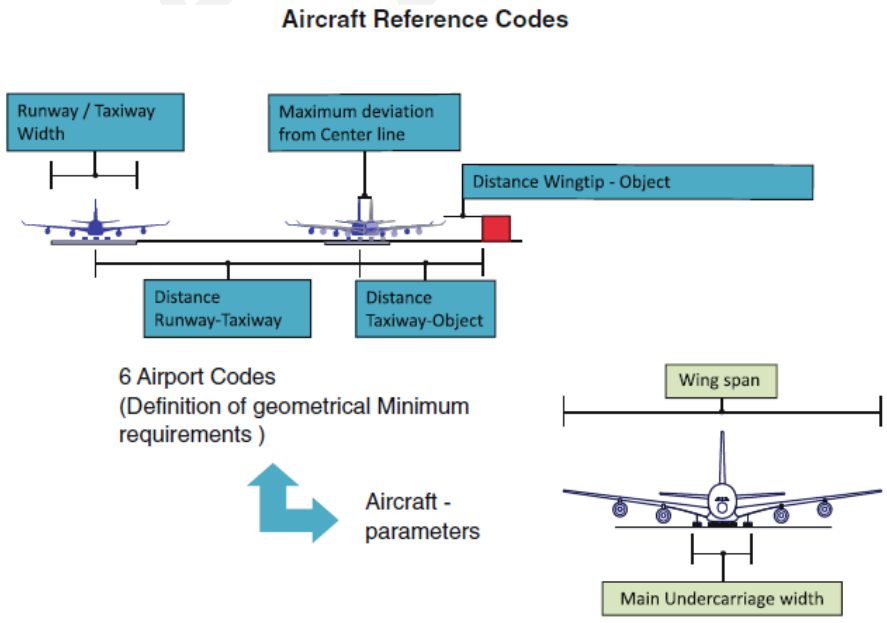


Fig. 8.13 Aircraft characteristics, influencing the airport reference code

- The construction of a runway has to follow strict rules to obtain a certain PCN value which on the other hand allows all aircraft with a smaller ACN value to use the runway without providing a major impact or damage at this runway.
- The width of a runway should have 60 m to allow big four engine aircraft like B747 and A380 to take-off with full thrust and ensuring that the outer engines are still located during the take-off phase above the paved runway. During take-off with full power, the engines are sucking the maximum amount of air and if the outer engines are not over the paved runway, there is a high risk of sucking some unforeseen elements like stones, small animals like rabbits or others through the engine air intake.

Runway Loading—Aircraft and Pavement Classification

- A very important point in the airport design is the choice of the maximal size of aircraft, the airport is prepared in the long term to accommodate. The dimensioning part is the loading of the pavement of the runway.
- ICAO has defined a system, which allows balancing the maximum aircraft weight and the pavement strength of the airport runway. There are two critical figures defined, which allows to compare aircraft mass and pavement strength.
- ACN (Aircraft Classification Number) is calculating the impact of a given aircraft on to the structural pavement of a runway. The necessary aircraft elements, which determine the ACN are:
    - Aircraft Take-off mass MTOM
    - Aircraft mass on main undercarriage legs
    - Wheel geometry
    - Wheel tyre pressure
- PCN (Pavement Code Number) is the figure which describes the quality and loading capability of the runway pavement. The PCN requires the following inputs from the runway pavement construction:
    - Flexible or rigid Pavement surface quality aspect
    - Sublayer construction of runway
- For a safe operation for big aircraft on an airport runway, the PCN number must be higher than the ACN figure PCN > CAN

Taxiways

- The taxiway system is providing the interface from the runway to the apron area. The design should be done in such a way that no conflict or only a minimum of crossings between the departing and the arriving aircraft will take place.
- This leads to two parallel taxiways and to from the runway and also at the apron area, two parallel guiding lines for the arriving and departing traffic will be important for a simple and efficient airport operation.
- The Apron area has to be large enough to accommodate all arriving aircraft.A certain amount of direct passenger bridges (gate bridges) are normally installed directly at the terminal to allow a smooth and easy embarking and disembarking process for the passengers.
- The standard is to board the passengers from the left side of the aircraft (seen in flight direction!). For bigger aircraft, two or three gate-bridges can be installed and can be used to facilitate and accelerate the boarding and deboarding process.
- The gate bridges are normally defined in such a way that alternatively two big aircraft or 3–4 smaller aircraft can be handled at the same terminal space.

Codes for Aircraft Sizes and Limitations

- One important characterization has been issued by ACI, the classification of aircraft sizes and their corresponding aircraft codes.
- These codes are important, as the gates at the terminal have to be installed in such a way to allow a maximum number of aircraft being placed directly at the terminals. But the aircraft codes are also limited to the maximum dimensions of the aircraft to be accepted at the international airports.
- Especially, before the A380 entered the market, the airports have established the new category F (Fig. 8.15), which has defined the 80 m by 80 m box as maximum dimension in wing span and fuselage length.
- Bigger aircraft cannot be handled at the airports without major modifications to taxiways, apron areas and terminal access. This limit was a boundary for the development of the A380, where the engineers from Airbus would like to increase the span by some five additional meters.

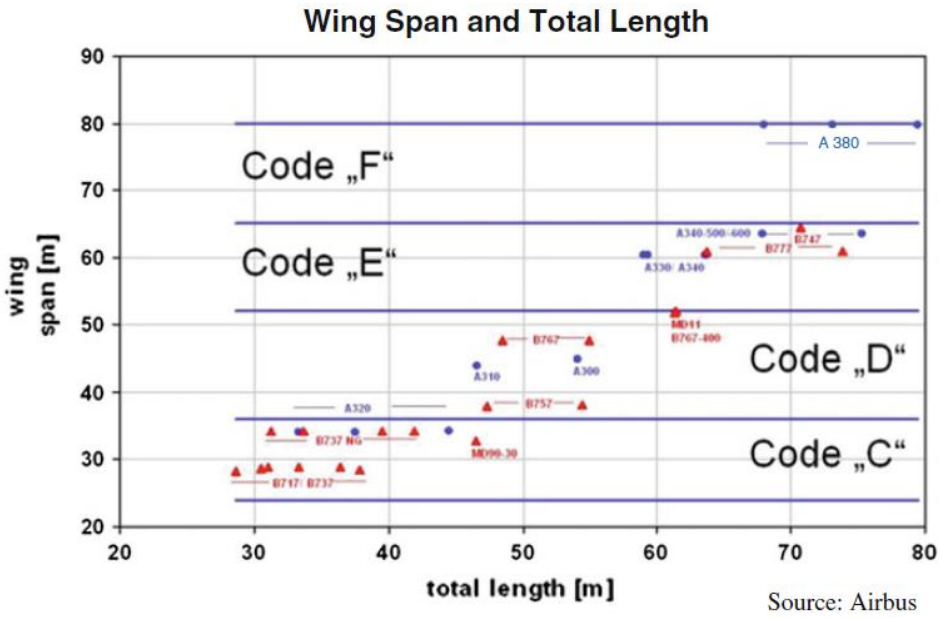


Fig. 8.15 Airport codes for the characterization of aircraft sizes

3.9.4 Planning of Baggage and Cargo Handling

- Passenger's baggage and freight/cargo are normally handled at the airport at different places.
- The baggage of all passengers is normally dropped off at the Check-in counter. It has then to be delivered to the aircraft through an automatic baggage handling system.
- Freight, which is often transported also in the cargo hold of passenger aircraft, is handled at the specific freight centre of the airport. The freight centre needs apron space to load specific freighter aircraft.
- But it needs also a large building, where ULD and pallets can be packed and unpacked and where there is a link to trucks or railway wagons, which will continue to bring the freight to the consignee.
- This is a mode change from air to road, needed in the system to bring the cargo to the places of destination. In addition, the internet and the globalization is also favoring a worldwide transport system, where most high value goods are transported today by aircraft.

Baggage Handling System

- There are several requirements for a modern Baggage Handling System (BHS). There are several constraints to be balanced like: time, high reliability, care, registration and storage of baggage. The following tasks have to be fulfilled:

- Departing baggage has to be delivered in time to the aircraft
- Transit baggage has to be transferred to the corresponding flight by respecting the time constraint
- Arriving baggage has to be delivered to the passenger at the baggage claim carrousel as quickly as possible
- All baggage has to be X-ray controlled before departing
- Correct sorting of baggage per flight (Only 1 out of 10.000 bags to be faulty advised)
- Automatic storage and redistribution of all baggage arriving in advance

- Figure 8.16 shows a schematic view of a baggage handling system. Although the primary function of a BHS is the transportation of bags, a typical BHS will have to make sure that a bag gets to the correct location in the airport.

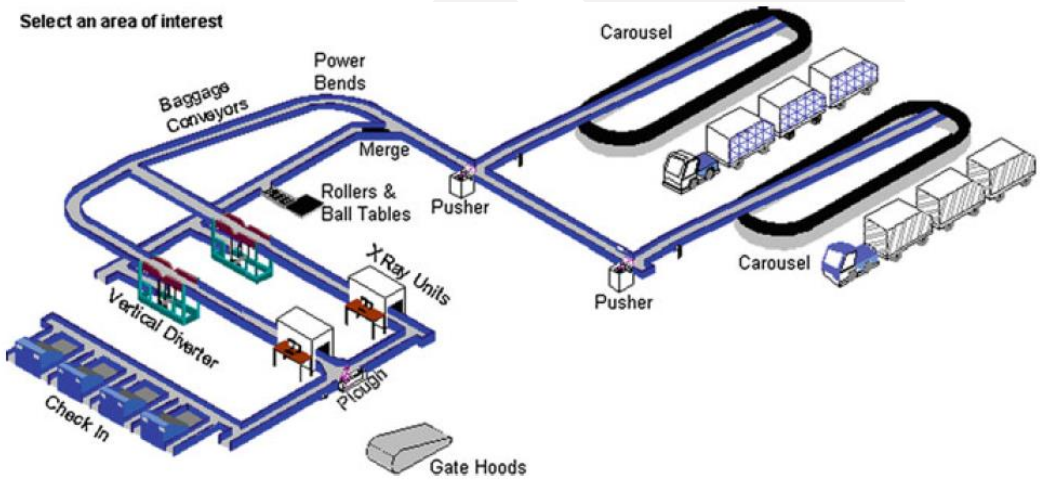


Fig. 8.16 Principle of a baggage handling system BHS

- The sortation of a bag, i.e. the process of identifying a bag, and the information associated with it, to make a decision on where the bag should be directed within the system, is one of the crucial and critical elements and requires a complex IT system of bag ticketing, bag tracking, and bag control. This IT system will help to support and control the BHS by
  - Detection of bag jams
  - Volume regulation (to ensure that input points are controlled to avoid overloading)
  - Load balancing (to evenly distribute bag volume between sub-systems)
  - Bag counting
  - Bag tracking
  - Redirection of bags wrongly directed

Cargo Handling

- The freight (good) is arriving at the airport, will be accepted and all the necessary documentation has to be established, including customs declaration etc.
- The good can either be received as fully consolidated ULD (unit load device, i.e. container or pallet) or as simple parcel. Parcels have then to be consolidated in a ULD within the same destination.
- When finished, they will be brought to the ULD export side and will be loaded to the aircraft as quickly as possible. Normal time from delivery to the airport and boarding on an aircraft lasts from 2 to 24 h.
- The incoming freight (Import) will be offloaded from the aircraft and stored in the import storage house. When it is just transit freight, it will go immediately to the export storage place. When an incoming ULD contains several parcels/goods, it will be broken down and the single goods will go to the landside, where some trucks will take them to their final destination.

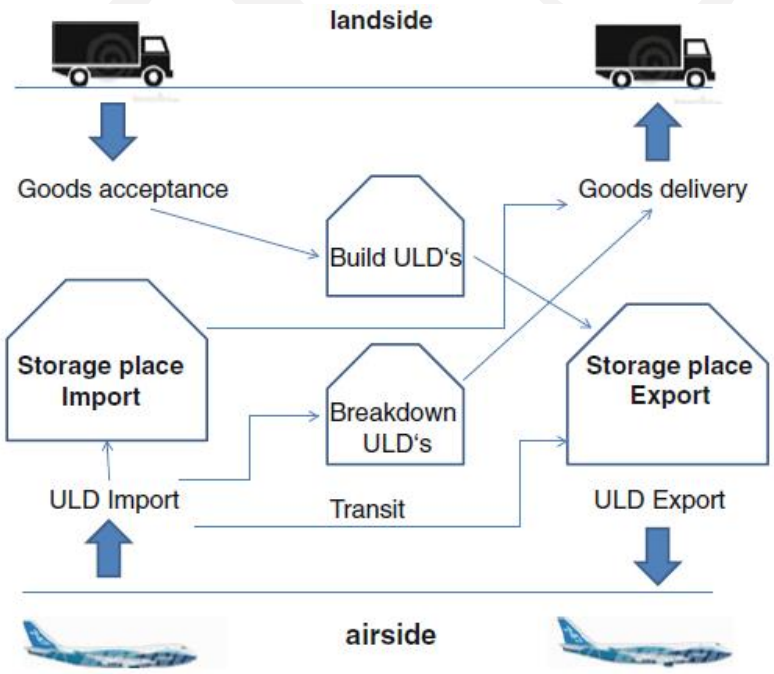


Fig. 8.17 Freight process at airport

- In the freight centre, there should also be space to accommodate the administration (customs, security staff, airline staff, freight agents and freight forwarders).
- There are different classes of cargo goods like:
    - Standard goods
    - Express freight

- Frozen foods
- Perishables
- High Value goods
- Airmail
- Animals
- Hazardous goods

3.9.5 Specific Critical Airport Elements

The airport needs a lot of other elements to ensure a proper operation. Some critical and important elements are shortly described below and also the main aspects, which have to be considered in the planning phase.

Fuel Storage Centre:

- Depending on the size of an airport, a fuel infrastructure for a storage, supply, distribution and provision has to be developed. Also a lot of safety aspects have to be considered.
- Aviation fuel can cause severe environmental damage; all fueling vehicles must carry equipment to control fuel spills.
- Fire extinguishers must be present at every fueling operation.
- Airport firefighting forces are specially trained and equipped to handle aviation fuel fires and spills.
- Aviation fuel must be checked daily and before every flight, for contaminants such as water or dirt.
- In the airport planning process, the fuel storage zone has to be carefully selected. On one side it should be remote to the runways for any aircraft incidents/accidents; on the other hand the fuel area should be connected to the road, rail or a specific pipeline, providing the delivery.
- Normally, the fuel zone is a protected separate area, where only specific authorized and trained personal has access. The authorities are requesting certain skills from the personal, who are handling the fuel distribution.
- The supply of fuel to the airport can be done by
    - Pipeline (Best choice!)
    - Railway system
    - Road with tank lorries

- Ship (if a water system is available in the vicinity)

- The fuel then has to be transported from the fuel storage depot to the aircraft. 2 basic options are available:
  - either by a fuel truck (tank lorry)
  - Or by an underground pipeline system, where the fuel can be directly pumped at the aircraft position into the aircraft via a pump vehicle.

Rescue and Fire Fighting:

- The principle objective of an airport rescue and fire-fighting service (RFFS) is "to save lives in the event of an aircraft accident or incident".
- Rescue and Fire Fighting Services (RFFS) is a special category of fire-fighting that involves the response, hazard mitigation, evacuation and possible rescue of passengers and crew of an aircraft involved in an aerodrome ground emergency (or potentially off aerodrome).
- The International Civil Aviation Organization (ICAO) defines the requirements for aerodrome Rescue and Fire Fighting Service (RFFS) in Annex 14, Volume 1—Aerodrome Design and Operations.
- The Civil Aviation Authority of each State inturn publishes the corresponding regulations and guidance for their operators.
- Modern commercial aircraft can have the capacity to carry several hundred passengers and crew. Therefore, due to the mass casualty potential of an aviation emergency, it is critical that emergency response equipment and personnel arrive at the scene within the minimum possible time.
- The maximum response time from initial notification until the first vehicle is on scene and spraying fire retardant is defined by State regulation and generally ranges from three to four minutes under conditions of good visibility and uncontaminated surfaces.
- At large aerodromes, this often means that more than one fire station will be necessary. The timely arrival and the firefighters' initial mission is to protect the aircraft against all hazards— most critically fire—increase the survivability of the passengers and crew on board.
- Airport firefighters have advanced training in the application of firefighting foams and other agents used to extinguish burning aviation fuel in and around an aircraft. This helps to provide and maintain a path for the evacuating passengers to exit the

fire hazard area. Should fire be present within the cabin or encroach upon the cabin from an external fire, the responders must work to control and extinguish those fires as well.

Winter Operation and Aircraft de-Icing:

- Planning and preparation are two of the key factors involved with successful winter operations, as well as a strong execution of clearing procedures. Due to its operating duties the airport is obliged to remain open during operating hours and he is therefore, responsible for snow removal and de-icing.
- There are two different procedures needed:
    - The de-icing of aircraft surfaces prior to take-off
    - The cleaning(mechanical and partly chemical) of all operational surfaces at the airport

De-icing of Aircraft:

- In critical weather conditions, (when snow or cold rain is falling) all aircraft have to be de-iced prior to take-off. Specific fluids will be sprayed on the wings and tailplanes of each aircraft to avoid freezing of all liquids (water, snow, rain, ice) on the upper wing surface.
- If ice would build up on the upper wing and tailplane side, this could change the aerodynamic flow around the lifting surfaces and degrade the performance of the aircraft during the critical take-off- phase.
- This spraying on the upper lifting surfaces will be done either by a specific crane construction or a spraying vehicle.
- Specific fluids are used for De- and Anti-icing of aircraft on ground. The AEA has defined two fluids:
    - AMS 1424: a Newtonian fluid, SAE Type 1
    - AMS 1428: a Non-Newton fluid, SAE Type 2
    - SAE defines even type 3 and type 4 anti-icing fluids. Details are given in
- Nearly all used de-icing fluids contain some toxic elements (glycol) and are not very good in terms of environmental usage. There is a big interest to recover most of the fluid, which is therefore sprayed at specific stations with some recovery installations.

Cleaning of Operational Surfaces at the Airport:

- The airport takes care of the mechanical clearing of the snow with ploughs and cutter blowers and also the chemical de-icing of operational surfaces. There is a specific ice warning system which checks the constant temperature of the ground and air through specific sensors.
- A fairly precise temperature can be measured in the take-off and landing area of the runway. This information makes it possible to use the ground de-icing chemicals in an extremely environmentally friendly way.

Other Airport Services:

- The airport is normally an independent small city in it's region. A lot of additional service functionalities have to be provided like a medical service station with permanent staff.
- It could happen that a passenger in an aircraft may have a heart attack and the pilot decides to land at the next the next possible airport then a "First medical aid" service is required.
- Most airports provide rooms for religious ceremonies and contemplation. Relaxation areas are also often provided.