EAC 139-15
MASTER PLAN

Forward

As of 3 November 2022, Amendment 15 to Annex 14 – Aerodromes, Volume I – Aerodrome Design and Operations and related amendement of ECAR 139 which requires that a master plan, containing detailed plans for the development of airport infrastructure, should be developed for airports deemed relevant by States. This EAC is intended to provide guidance material to assist States and airports in planning the successful expansion of existing airports and the construction of new airports based on the guidelines established in an airport master plan.

This guidance material is vital in building airport capacity in a timely and phased approach, thus avoiding significant delays in the future due to capacity constraints. Airport capacity will be increased and airport delays will be reduced through more precise and up-to-date airport planning that provides the right facilities at the right time, within the context of overall affordability, operational efficiency and safety.

This EAC takes into account the importance of consultation and cooperative planning among stakeholders, with the objective of reaching consensus on all major decisions and changes to the plan over time. It considers the need to develop a systematic approach in determining future airport requirements and suggests significant features in the airport planning process.

An airport master plan should be established as an effective, continuous programme capable of implementation. It is a long-term guide to development that supports an airport's business development strategy, underpins preliminary assessment of financing and is an indication of required investment levels. Without a master plan, there is a real and significant risk that short-term decision-making will result in capital-intensive capacity enhancement projects that are poorly located and inappropriately sized. This often results in wasted capital on projects that potentially restrict an airport's overall capacity and performance, thereby impeding the airport's ability to fully utilize the runway system's ultimate capacity.

This EAC is divided into the following sections and chapters:

- Section I contains four chapters and introduces the concept of airport planning including traffic forecasting and financial planning;

- Section II contains three chapters and identifies various elements of airside development: runways, taxiways, aprons and other facilities such as air traffic services and visual and radio navigational aids;

- Section III contains three chapters and considers the elements of landside development including the terminal building, ground transportation and airport city (sometimes also known as aerotropolis); and

- Section IV contains three chapters which include guidance related to a broad spectrum of facilities that support airport operations including, but not limited to, operations centre, medical centre, rescue and firefighting, cargo, fuelling and utilities.

The appendices to this EAC contain guidance on emerging issues that should be given consideration in an airport master plan. Experience gained in the commissioning of greenfield airports, particularly in the Asia Pacific Region, revealed the need for an operational readiness and airport transfer (ORAT) programme. This relates to the start-up management of a new airport to accommodate the diverse needs of the airport operator, airlines, passengers, tenants, government organizations, regulatory bodies, surface transportation and other agencies, as well as construction personnel and the surrounding community.

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GLOSSARY

Some of the terms are defined in the ECARs and are used in accordance with the meanings and usages given therein. Additionally, a wide variety of commonly-used terms have been included to describe facilities, procedures and concepts for airport operations and planning which have the widest international use.

Administration area. All the ground space and facilities provided for administration and management purposes of airport management, aircraft operators and airport tenants. It may include control tower, estate maintenance facilities, contractors' depots, vehicle parks, staff and aircraft catering, etc.

Aircraft maintenance area. All the ground space and facilities provided for aircraft maintenance. This includes aprons, hangars, buildings and workshops, vehicle parks and roads associated therewith. Such an area is normally designated as a security restricted area.

Aircraft stand. A designated area on an apron intended to be used for parking an aircraft.

Airside. The movement area of an airport, adjacent terrain and buildings or portions thereof, access to which is controlled.

Airside waiting area. Space between the departures concourse and airside exits from the passenger building.

Apron. A defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance.

Arrivals concourse. Space between baggage claim area or customs inspection and landside exits from the passenger building.

Baggage claim area. Space in which baggage is claimed.

Baggage container. A receptacle in which baggage is loaded for conveyance in an aircraft.

Baggage sorting area. Space in which departure baggage is sorted into flight loads.

Baggage storage area. Space in which checked/hold baggage is stored pending transport to aircraft and space in which mishandled baggage may be held until forwarded, claimed or otherwise disposed of.

Cargo area. All the ground space and facilities provided for cargo handlings. It includes aprons, cargo buildings and warehouses, vehicle parks and roads associated therewith.

Cargo building. A building through which cargo passes between air and ground transport and in which processing facilities are located, or in which cargo is stored pending transfer to air or ground transport.

Cargo warehouse. A building in which cargo is stored pending transfer to air or ground transport.

Check-in. The process of reporting to an aircraft operator for acceptance on a particular flight.

Check-in concourse. The space between the passenger building landside entrance and the check-in positions.

Check-in position. The location of facilities at which check-in is carried out.

Departure concourse. The space between the check-in positions and the airside waiting area.

Expansibility. The ability to be physically extended to the limits of the site to provide additional space and extra capacity using either new or existing operating procedures.

Flexibility. The ability to adapt to new and radically different technical and physical requirements and methods of operation, with consequent changes in the use and population of specific areas, and the ability to be gradually modified in accordance with evolutionary changes. It also means the ability to increase the operating capacity within existing physical limits.

Immigration control. Measures adopted by States to control the entry into, transit through and departure from their territories of persons travelling by air .

Landside. Those parts of an airport, adjacent terrain and buildings or portions thereof that are not airside, as identified by States and relevant entities in their security programmes.

Movement area. That part of an aerodrome to be used for take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron(s.(

Obstacle. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:

a) are located on an area intended for the surface movement of aircraft; or
b) extend above a defined surface intended to protect aircraft in flight; or

c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.

Off-airport processing facilities. A passenger or cargo transport link terminal at an urban population centre at which processing facilities are provided.

Passenger amenities. Facilities provided for passengers which are not essential for passenger processing.

Passenger area. All the ground space and facilities provided for passenger processing, including aprons, passenger buildings, vehicle parks and roads.

Passenger building. A building through which passengers pass between air and ground transport and in which processing facilities and amenities are located.

Passenger boarding bridge. A mechanically operated, adjustable ramp to provide direct passenger access between aircraft and buildings.

Passenger terminal building. A building provided primarily for the processing of arriving, departing and transiting of passengers.

Passenger processing. The reception and control of passengers during their transfer between air and ground transport.

Passport control. The immigration and/or police inspection or departures passengers.

Pier. A corridor at, above or below ground level to connect aircraft stands to a passenger building.

Port health control. The medical inspection of documents and/or passengers, baggage, cargo.

Transfer passengers and baggage. Passengers and baggage making direct connections between two different flights.

Transit passengers. Passengers departing from an airport on the same flight as that on which they arrived.

Transport link. Any form of transport system provided exclusively for operation between an airport and urban population centres.

Transporter. Any vehicle used to convey passengers between aircraft and passenger buildings.

Terms related to airport capacity

Aircraft traffic demand (at an airport) (for a particular hour). The sum of:

a) The number of aircraft desiring to land at the airport during that hour; and

b) The number of aircraft desiring to depart from the airport during that hour.

Busy hour aircraft traffic demand (at an airport). The aircraft traffic demand which is reached, or exceeded, in the forty (or thirty) most active hours of the year, averaged over two consecutive hours.

Current movement rate (for a particular hour). The sum of:

a) the number of aircraft which land during that hour; and

b) the number of aircraft which depart during that hour.

Hourly airport capacity. The maximum number of aircraft operations that can take place in an hour. Once it is estimated that the hourly airport capacity will be reached in the near future, prompt and careful investigation of the terminal area capacity is required to determine whether the delays are due to runway congestion, airspace conflicts, ATC facilities, or a combination of these and other factors, and what remedial action is needed.

Peak aircraft traffic demand (at an airport). The aircraft traffic demand which will be reached in the most active hour, averaged over two consecutive hours.

Saturation of an airport. Reached when the aircraft traffic demand equals, or exceeds, the corresponding airport capacity.

Note.— The terms “demand” and “capacity” refer to a single airport or a complex of airports serving a particular community.

Service rate. The maximum aircraft movement rate which could be reached at an airport with:

a) The mix of aircraft and of take-offs and landings for the conditions being analysed, and

b) The distribution of service times between aircraft movements typical of the aircraft traffic demand at which saturation occurs.

Sustainable capacity (of an airport). The highest movement rate which could be continuously maintained for three hours or more under defined conditions.

Theoretical airport capacity. The maximum movement rate which could be reached with the mix of aircraft and of take-offs and landings under defined conditions for that airport, minimum separation being maintained between all aircraft

ABBREVIATIONS AND ACRONYMS

A-CDM	Airport collaborative decision-making
ADC	Airport data centre
AI	Artificial intelligence
AOCC	Airport operation control centre
APM	Automated people mover
ARFF	Aircraft rescue and firefighting
ASDE	Airport surface detection equipment
ATC	Air traffic control
AVs	Autonomous vehicles
BHS	Baggage handling system
CAA	Civil aviation authority
CCTV	Close-circuit television
CONOPS	Concept of operations
DATS	Digital air traffic services for aerodromes
DME	Distance measuring equipment
EAC	Egyptian avicsory circular
ECAA	Egyptian civil aviation authority
EOCC	Emergency operations control centre
EMS	Energy management system
FaB	Food and beverage
FSCs	Full-service carriers
GBAS	Ground-based augmentation system
GDP	Gross domestic product
GNSS	Global navigation satellite system
GPU	Ground power unit
GRE	Ground run-up enclosure
GSE	Ground support equipment
GTC	Ground transportation centre
ICT	Information and communication technology
IFR	Instrument flight rules
ILS	Instrument landing system
ISA	International standard atmosphere
IT	Information technology
LCCs	Low-cost carriers
LoS	Level of service
m	Metre(s(
MARS	Multiple aircraft ramp system
MCT	Minimum connection time
MLAT	Multilateration
MLS	Microwave landing system
NDB	Non-directional radio beacon
OaD	Origin and destination
OFAs	Object free areas
OLS	Obstacle limitation surface
OMGWS	Outer main gear wheel span
OOG	Out-of-gauge (baggage)
ORAT	Operational readiness and airport transfer
PBB	Passenger boarding bridge
PRM	Passengers with reduced mobility
PTB	Passenger terminal building
RESA	Runway end safety area
RET	Rapid exit taxiway
RFF	Rescue and firefighting
SARPs	Standards and Recommended Practices
SRA	Security restricted area
UAS	Unmanned aircraft system(reserved)
ULD	Unit loading device
VFR	Visual flight rules

VOR	VHF omnidirectional radio ranges
WAM	Wide area multilateration

REFERENCE DOCUMENTS

Ecaa publications contain information related to airport master planning
ECARS
ECAR 139 Aerodromes
RCAR 139 Aerodrome Design and Operations
ECAR 138 Heliports
ECAR 107 Aviation Security – Safeguarding International Civil Aviation against Acts of Unlawful Interference

EAC 139-66 – Procedures for Air Navigation Services – Aerodromes

The procedures in EAC 139-66 “PANS-Aerodromes” are complementary to the SARPs contained in ECAR 139 and specify, in greater detail than the SARPs, operational procedures to be applied by aerodrome operators to ensure aerodrome operational safety. The procedures in PANS-Aerodromes do not substitute nor circumvent the provisions contained in ECAR 139. It is expected that infrastructure on a new aerodrome will fully comply with the requirements in ECAR 139.

EAC 139-18 Rescue and Firefighting : All aspects of rescue and firefighting at airports are covered including equipment requirements, operational and emergency procedures and personnel training.

EAC 139-19 Pavement Surface Conditions : It describes methods for clearing contaminants and debris from the movement area, snow removal techniques and how to measure and report runway braking action on wet and snow or ice-covered surfaces.

EAC 139-20 Wildlife Hazard Management : The primary purpose of this EAC is to provide aerodrome personnel with the information necessary to develop and implement an effective wildlife control group for their aerodrome. It provides a general review of the bird hazard problem at airports giving information on the type of birds, the magnitude of their hazard to aircraft and why birds are at the airport. It also provides the means for modifying the airport environment to make it less attractive to birds are reviewed and techniques outlined for driving off birds that do come to the airport. Information is also given on the use of radar to detect birds.

EAC 139-22 – Removal of Disabled Aircraft : Organizational procedures to remove an aircraft disabled on the airport are reviewed and a list of necessary equipment provided.

EAC139-23 – Control of Obstacles : It provides guidance on the control of obstacles in the vicinity of airports with respect to the specifications contained in Annex 14, Volume I including the application of the shielding principle. A practice for treating temporary hazards on the movement area is presented and techniques for conducting obstacle surveys are included.

EAC139-24 – Airport Emergency Planning : It provides information related principally to matters concerning pre-planning for airport emergencies, as well as coordination between the different airport agencies (or services) and those agencies in the surrounding community that could be of assistance in responding to the emergency.

EAC139-25– Airport Operational Services : It describes all operational services provided by the airport in detail.

Eac139-26 – Airport Maintenance Practices : It provides guidance material required for maintenance practices at an airport to maintain the safety, efficiency and regularity of aircraft operations.

EAC139-9 – Runways : It discusses factors affecting the siting of runways and the use of stopways and clearways. Provides information on runway length requirements of different aircraft.

EAC139-10 – Taxiways, Aprons and Holding Bays : It contains guidance on the design of taxiways, including fillets, aprons and holding bays. Information on procedures to segregate aircraft and ground vehicular traffic is also provided.

EAC139-11 – Pavements : It provides information on the evaluation and reporting of pavement strength and several design techniques used in different countries. Describes methods for constructing pavement surfaces to provide good braking action.

EAC139-12 – Visual Aids : It contains information on the design of airport lights and their maintenance. Detailed material is included on visual approach slope indicator systems, apron flood-lighting and taxiing guidance and control systems.

EAC139-13 – Electrical Systems : It provides guidance on the design and installation of electrical systems for airport lighting and radio navigation aids.

Eac139-30 Surface Movement Guidance and Control Systems (SMGCS): It provides information on the provision of guidance to, and control in question of, all aircraft, ground vehicles and personnel on the movement area of an airport.

ICAO PUBLICATION

Doc 8991 – Manual on Air Traffic Forecasting :The manual provides a survey of techniques currently used for air traffic forecasting, and practical guidance on the application of these techniques.

Doc 9060 – Reference Manual on the ICAO Statistics Programme : The manual provides guidance and standards on the preparation of civil aviation statistics to ICAO. Doc 9082 – ICAO's Policies on Charges for Airports and Air Navigation Services

Doc 9082 contains the recommendations and conclusions of the Council resulting from ICAO's continuing study of charges in relation to the economic situation of airports and air navigation services provided for international civil aviation. The basis for these policies and principles is set out in Article 15 of the Convention on International Civil Aviation.

Doc 9562 – Airport Economics Manual : The manual provides practical guidance to States, airport managing and operating entities and designated charging and regulatory authorities, to assist in the efficient management of airports and in implementing ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082). It is based on international policies and principles on airport cost recovery that States have developed through ICAO.

Doc 9980 – Manual on Privatization in the Provision of Airports and Air Navigation Services

The manual provides definitions and analyses of the ownership and management options in the provision of airports and air navigation services, together with the possible implications of these options. It also discusses major issues to be examined by States when considering a change in ownership and management. Case studies on commercialization, privatization and economic oversight are also available on the ICAO website.

Aviation security publications

Doc 8973 – Restricted – Aviation Security Manual

Doc 8973 was developed to assist States in promoting safety and security in civil aviation. It contains guidance on how States may comply with the SARPs of Annex 17 – Aviation Security to the Convention on International Civil Aviation (Doc 7300). The objective of the manual is to assist States in the prevention of and, whenever necessary, response to, acts of unlawful interference, through the development of, inter alia, airport design, infrastructure and equipment and procedures for, and the implementation of, security measures.

Facilitation publications

Circular 152 – Selection of ICAO Facilitation B-Type Recommendations

The recommendations adopted at the various sessions of the facilitation division fall into two categories: those concerning amendments to Annex 9 and the other type which does not affect the amendment of Annex 9. The former type of recommendations has been designated, in the reports of the last four sessions, as "A" type recommendations, while the latter have come to be referred to as "B" type recommendations. This publication is concerned only with a selection of "B" type recommendations.

Doc 9636 – International Signs to Provide Guidance to Persons at Airports and Marine Terminals

The question of developing an international sign language, without the use of words as far as possible, to facilitate travellers has been considered by several bodies in recent years. In response to a growing need for such signing a set of signs was approved by the Air Transport Committee and the Council and are contained in Section I of this document. Section II of the document contains certain information concerning the use of the signs, their location and colours to be used.

Doc 9957 – The Facilitation Manual

This manual contains explanations of the provisions of Annex 9, from a historical and current perspective. It has been designed with the aim of increasing the level of knowledge of air transport facilitation issues, improving the results of facilitation programmes in States and increasing compliance with Annex 9. It is also meant to serve both as an instructional and reference tool for States and other interested users on the various immigration, customs, health and quarantine civil aviation-related aspects covered by Annex 9.

Other publications

ACRP Report 25: Airport Passenger Terminal Planning and Design, Volume 1: Guidebook, 2010. Airport Capacity and Delay, Federal Aviation Administration, AC 150/50605, 1983.

Airport Cooperative Research Program (ACRP), Report 42, Sustainable Airport Construction Practices

Airport Cooperative Research Program (ACRP), Report 80, Guidebook for Incorporating Sustainability into Traditional Airport Projects

Airport Cooperative Research Program (ACRP), Report 119, Prototype Airport Sustainability Rating System – Characteristics, Viability, and Implementation Options

Airport Cooperative Research Program (ACRP), Synthesis 10, Airport Sustainability Practices Airport Cooperative Research Program (ACRP), Synthesis 77, Airport Sustainability Practices EASA Certification Specifications and Guidance Material for Airports Design (CS-ADR-DSN(

SECTION I – AIRPORT PLANNING PROCESS INTRODUCTORY NOTES

This EAC is intended to assist airport authorities in the complex task of preparing master plans for the development of existing airports and the construction of new airports. This EAC outlines the planning system and the development of long-term forecasts covering aviation operations, economic factors and other considerations involved in master planning. It explains the need for consultation and cooperative planning by all the agencies concerned, including aircraft operators, national and local government planners, government control authorities (customs, immigration, health, security, etc.), national and local transport authorities, environmental protection agencies, aircraft and equipment manufacturers and international aviation organizations.

ICAO requirements for a master plan , As of 3 November 2022, Amendment 15 to Annex 14 – Aerodromes, Volume I and related amended in ECAR 139 , containing detailed plans for the development of airport infrastructure, should be developed for airports deemed relevant by States.

An airport master plan is a comprehensive study that clearly explains the short-, medium- and long-term initiatives needed to realize the ultimate development potential of an airport. Identifying master plan phases is essential to avoid over or under provision of capacity in order to meet demand and is a key element of feasibility. Master plans are prepared to support the modernization of existing airports and the creation of new airports, regardless of size, complexity or role. It represents the development plan of a specific airport and is developed based on economic feasibility, demand-led traffic forecasts, current and future requirements provided by aircraft operators and other stakeholders. The optimum plan balances these various elements to develop the most efficient facilities to meet business needs.

To facilitate an effective master planning process, all airport stakeholders, particularly aircraft operators and airport planning, strategy and operations departments, should be consulted based on a collaborative and transparency approach. This should be planned early on and carried throughout the process. This includes, but is not limited to, the provision of advanced planning data to facilitate the planning process including future aircraft types, characteristics and numbers of aircraft expected to be used, the anticipated growth of aircraft movements, number of passengers and amount of cargo projected to be handled. Annex 9 – Facilitation, Chapter 6 contains provisions on the need for aircraft operators to inform airport operators concerning the former's service, schedule and fleet plans to enable rational planning of facilities and services in relation to the traffic anticipated. In addition, ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082), Section I, contains guidance regarding consultation with users concerning the provision of advance planning data and protection of commercially sensitive data.

ECAR 139 additionally requires that architectural and infrastructure-related requirements for the optimum implementation of international civil aviation security measures shall be integrated into the design and construction of new facilities and alterations to existing facilities at an airport. The design of airports should also take into account land-use planning, environmental control and climate change adaptation measures for which further comprehensive guidance is available in the Airport Planning eac 139-16 – Land Use and Environmental Control as well as security-related measures aimed at mitigating the effects of unlawful acts in the Aviation Security Manual (Doc 8973 – Restricted and national security program

Limitations of a master plan

It is important to note that a master plan does not constitute a confirmed implementation programme. It provides information on the types of improvements to be undertaken in a phased manner. The master plan provides guidance for the development of the implementation programme that follows. It is only in these subsequent phases that specific plans are designed and established. A master plan, therefore, does not develop specific details with respect to improvements; it is only a guide to the types of improvements that should be undertaken. For example, the financial plan developed in the master plan is a presentation of alternatives, not a specifically tailored financial programme. The master plan points to the direction of development. It does not, however, present a detailed programme of how to achieve the actual funding stage of improvement projects.

The completed master plan

To effectively utilize the master plan, the execution of improvements may require parallel planning while the master plan is in process. To make the master plan a useful guideline, it should reflect the local context and identify potential problems as well as opportunities.

In preparing the final master planning document, a principal goal to remember is that it should be developed in such a way that its adoption by appropriate officials and the general public can be assured.

Having completed the master plan, the appropriate authorities must then take the broad guidelines of the master plan and translate them into a programme that recognizes the specific airport constraints and opportunities presented. This programme would typically be translated into a 5-year capital investment programme as part of a larger 10-year rolling capital plan in close consultation with airport users.
ECAR 139 requires that a master plan be reviewed periodically to take into account current and future airport traffic. To ensure a realistic and appropriate fit to continuously evolving aviation industry conditions, the master plan should be reviewed in its entirety every 5 years, or more often if changes in economic, operational, environmental and financial conditions warrant an earlier revision. Adjustments may need to be made to assumptions used during the initial master plan process, including phasing and ongoing airfield and facility development as air transport evolves.
The master plan's assumptions, and in particular its passenger traffic and aircraft movement assumptions, should be checked annually against actual traffic data. This includes reviewing the assumptions and forecasts in the master plan annually at the conclusion of each planning or fiscal year to cross-check the passenger and aircraft movement assumptions and forecast figures against historical data. This enables the airport management team to evaluate master plan phasing assumptions and adjust as necessary. This is also likely to impact capital and operational budget planning.

Chapter 1 Introduction

1.1 ABOUT THIS CHAPTER

1.1.1 Master planning provides a strategy to anticipate the expected safety, capacity and efficiency impacts on infrastructure, which in turn helps to quantify these investments on a medium- and long-term basis so as to address the needs in an efficient, adequately phased and sustainable manner.

1.1.2 This EAC is intended to assist key aviation stakeholders, including civil aviation authorities, airports and users (in particular aircraft operators) to appreciate and understand the complex task of preparing master plans for the expansion of existing airports and the construction of new airports. It is particularly aimed at assisting those organizations which may not have experienced planning departments or staff. It is compiled in a manner intended to be suitable for use by these stakeholders and their representatives in such matters as supporting requests for finance and in advising airport consultants, engineers and planners of the airport's and user's requirements for demand-led, affordable, functional, efficient and resilient infrastructure.

1.1.3 The manual outlines the planning system and the development of long-term forecasts covering aviation operations, economic and environmental factors and other considerations involved in master planning. It explains the need for consultation and cooperative planning by all the agencies concerned, including aircraft operators, national and local government planners, environmental agencies, government control authorities (customs, immigration, health, etc.), national and local transport authorities, aircraft and equipment manufacturers and international aviation agencies.

1.1.4 Throughout this EAC , guidance is given on deciding the type of facilities that may be required to meet the needs of a community or region and on the selection and evaluation of the corresponding sites. Emphasis is placed on the importance of making an economic appraisal and a cost-benefit analysis, when deciding on the provision of a new facility and assessing its worth to the community in comparison with other projects.

1.2 PURPOSE OF A MASTER PLAN

1.2.1 An airport master plan presents the planner's conception of the ultimate development of a specific airport. It effectively presents the research and logic from which the plan was evolved and articulates the plan graphically and in written form. Master plans are applied to the modernization and expansion of existing airports and to the construction of new airports. Additionally, they can be used as a tool to provide airports and stakeholders with strategic guidance for future development.

1.2.2 In the context of this definition, the term "ultimate development" is taken to mean the inclusion of the entire area under direct control of the airport or that can be acquired for both aviation and non-aviation uses. It also includes suggested land-use on land adjacent to the airport.

1.2.3 A master plan balances the respective demands and capacities of the many elements and ensure goals such as efficiency, adaptability, sustainability and expansibility are met in order to meet the changing needs of an airport. Guidance on the following is provided to permit the phased development of the master plan:

a) assessing the capacity of individual facilities;

b) balancing demand and supply to reach the highest level of efficiency; and

c) planning runway, taxiway and apron configurations, passenger buildings, ground transport links and internal roads, car parks and cargo areas.

1.2.4 An airport master plan should be the shared reference framework within which the individual facilities can operate and expand their separate functions at the highest possible levels of efficiency. As previously explained, it is not always possible for the best plans for individual facilities to be fitted together in a total plan for the airports, without some modifications to make them compatible with each other, especially when considering an existing airport. This often requires some compromise in the plans for individual facilities, but good planning strikes an optimum balance. The complete plan will generate the most effective operation and therefore will demonstrate a higher overall capacity and efficiency than would be the case if there were no reconciliation between the plans of the individual facilities. Care must be taken, however, to ensure that compromises do not adversely impact safety and security.

1.2.5 It is important to recognize that an airport master plan is not a detailed capital investment plan and should be used only as a guide for the:

a) development of physical facilities of an airport – aviation and non-aviation use;

b) development of land use for areas surrounding an airport (the "airport city" plus other surrounding areas) to allow coordination with relevant authorities for proper zoning and compatible land use;

c) determination of the environmental impacts of airport construction and operation;

d) establishment of access requirements of the airport; and

e) safeguarding of future land requirements from encroachment or incompatible uses.

1.2.6 An airport master plan is also mainly used to:

a) provide medium- and long-range policy and decision guidance;

b) identify potential problems;

c) assist in securing financial aid;

d) ensure cost envelopes remain within an affordable and financeable level;

e) serve as a basis for negotiations between the airport authority and concessionaire interests; and

f) generate local interest and support.

1.3 AIRPORT MASTER PLANNING – AN OVERVIEW

1.3.1 In this EAC, all aspects of airport planning are considered and the benefits of master planning are outlined. This includes key considerations, methodologies and best practices. The broadest and most general aspects are covered first, followed by more detailed consideration and thereafter general guidance regarding specific areas and facilities. From basic premises, deductions are made and conclusions are drawn by process of analysis. This is continued through all relevant stages. This approach is applicable to both existing and new airports regardless of size or location, and from the initial planning to subsequent developments and expansion of facilities.

1.3.2 The quality of airport master planning relies on the quality of the inputs at all the different stages. A coherent and coordinated data collection system involving the many different stakeholders is an absolute prerequisite for any demand projection, and therefore airport master planning. In recent years, the amount of data available has increased exponentially. It is, therefore, important prior to any master planning effort to identify which data is necessary, where this data resides and what is the process to extract these data in a meaningful way. A good data collection regime, and the associated analysis, requires time and this requirement must be considered in the overall programme. In addition, data analytics and simulation techniques are encouraged to be used as tools for enhanced planning aspects such as landside connectivity, passenger behaviour, climate change-related infrastructure adaptation and emergency response.

1.3.3 Airports exist as parts of larger integrated systems and networks. For these reasons, an airport must not be considered in isolation. Thus, this EAC includes consideration of factors beyond the airport boundary in an urban planning context. In this regard, airports and urban infrastructure should be clearly articulated within integrated urban master plans including master plans for airports. The objective is for airports and cities to play key roles in the interaction among concerned stakeholders with particular interests in planning, financing and legislation, resulting in more productive, safe and prosperous cities.

1.3.4 As a whole, the most efficient plan for the airport is that which provides the required phased capacity for aircraft, passengers, cargo and vehicle movements, in order to maximize passenger, operator and staff convenience at affordable capital and operating costs.

1.3.5 Flexibility and expandability are fundamental to all aspects of planning. In some cases, existing site constraints may mean that future expansion options are limited. In this case, however, it is important to evaluate the ultimate capacity of the existing systems (runways in particular) and develop the master plan to achieve the ultimate capacity through balanced, incremental yet flexible development phases.

1.3.6 Airport master planning is complex due to the broad range of facilities and services which support the day-to-day continuous movement of aircraft, passengers, cargo and ground service vehicles. These movements must be integrated into the planning of the airport's physical elements including runways and taxiways, aircraft aprons, air terminals and support buildings and surface access systems.

1.3.7 The operation of an airport essentially integrates the functions of many of these facilities and, therefore, the facilities and movement systems must not be planned as separate units. For example, aircraft parking aprons must be functionally integrated with runway and taxiway systems as well as the buildings (air terminals, cargo, aircraft maintenance, etc.) with which they are associated. All airport facilities must be planned in the context of functional adjacencies to ensure a comprehensive and efficient master plan with efficient integration.

1.3.8 Airport planning requires rationalization of potentially conflicting requirements for each of the individual systems and facilities. Airport master plans must address strategic options so that the planning of each individual facility or function contributes to and combines with the most efficient overall plan that provides the greatest degree of flexibility and expansibility for future development.

1.3.9 A master planning process must adopt an agreed framework. Within this framework, a number of planning disciplines are involved in the process including:

a) Policy and coordinated planning: this refers to the steering committee of the master planning process. This committee is in charge of defining the project goals and objectives, developing the work programmes, schedules and budgets, establishing governance, defining the stakeholder engagement process, preparing an evaluation and decision format, establishing coordination and communication priorities, monitoring procedures and establishing data management and public information systems.

b) Economic planning: the economic framework is the basis for any development work. The air traffic forecast underpins the economic analysis or plan which in turn impacts all the planning steps that follow. Economic planning is not only required as an input, but it is used throughout the entire master planning process to evaluate the cost benefit and affordability of development alternatives, and to assess the impact of this development beyond the airport boundaries.

c) Physical planning: this includes airfield configuration (i.e. runways, taxiways, and apron areas) and the terminal complex, and also the connected systems (i.e. ground access, airspace, and support facilities). The master planning process does not include the conceptual or detailed design of the various infrastructure elements, but the provision for all these elements must be included in the master planning process.

d) Environmental planning: the question of the environmental impact of an airport development project is a major factor and concern. It includes both the impact on residential areas and on the natural environment surrounding the airport. It encompasses, notably, noise issues, emissions, sustainability, impact on biodiversity, wildlife and natural resources. A consultation process with those involved in the airport development project and the communities in the vicinity of the airport, is an essential step and must be initiated at the outset of the project. Climate change-related impacts are also relevant for consideration, since required adaptation measures may influence all other disciplines of an airport master plan.

e) Financial planning: this includes both the business case and the funding mechanism of the airport development. Determining the airport funding source and constraints is an important step to facilitate the unfolding of the new developments defined within the master planning. Additionally, the timing and availability of these funding sources can have an impact on the airport development implementation schedule.

1.4 USE OF THIS EAC

1.4.1 Although the chapters in this EAC can be read independently, it is preferable to read them sequentially to understand the essential nature of all dependencies between the different airport elements and how the master planning process framework applies across the EAC . Cross references are also provided to avoid duplication and for the benefit of authorities and/or agencies preparing comprehensive master plans with multiple elements. A glossary of aeronautical terms is presented in the beginning of this EAC.

1.4.2 This EAC does not duplicate the large body of information already available on airport design. Rather, it defines ECAA specifications related to airport master planning and assists in the definition of requirements and in the logical analysis and solutions to problems associated with the preparation of a basic overall framework or plan. This, in turn, provides the sound foundation needed to achieve the maximum advantages of good design, prudent investment and efficient operation and management.

1.5 ORGANIZATION OF THIS EAC

This EAC is comprised of the following four principal sections: airport planning process; airside development; landside development; and airport operations and support elements. Chapters are arranged within each of these sections to present related subject matter that follows the master planning process outlined in Chapter 2.

Chapter 2 Method of Preparing An Airport Master Plan

2.1 ABOUT THIS CHAPTER

2.1.1 This chapter presents an overview of the airport master planning process, the basic components and key factors that should be considered before and during the process. It aims to describe the methodological process and steps, as well as decision-making required to develop a coherent and comprehensive master plan, for both existing airports and new airports (“greenfield” developments.(

2.1.2 The starting point in developing a master plan, selecting an airport site or the assessment of the suitability of an existing site for further development is to define the role the airport will play in the greater urban, regional and national context. Defining the role of the airport, in part, requires an understanding of future demands and the quantity and type of air and passenger traffic to be accommodated. These details are derived from the operational and economic forecasts (Chapter 3). The forecasts will help to define the scale and timing of the operational systems necessary to support future passenger and cargo traffic operations.

2.1.3 For new airports, the site selection process encompasses several key steps commencing with an assessment of the shape and size of the area required for the airport, the location of sites with sufficient area and potential for development, followed by an extensive site evaluation process.

2.1.4 Goals and targets for ongoing development are part of the airport's role-definition and these need to be clearly formulated and documented at the outset of any master planning study. The provision of a new airport or the ongoing development of an existing airport involves substantial capital investment and large-scale construction work. To avoid premature obsolescence and wasted resources, it is important that airports have optimal lifespans. To achieve this, sufficient ground area should be available for ongoing phased development related to growth in air traffic demand. Additionally, the realization of maximum benefits from the investment is necessary, to ensure the safety and security of aircraft operations and to avoid hazards or negative environmental impact on the surrounding community without limiting the growth or the efficiency of the airport. Sites should be chosen that have land areas which offer the best potential for long-term development at optimal financial cost and minimal environmental and social impacts.

2.1.5 The design process itself is best explained as meeting a set of requirements derived from the aspirational goals and targets chosen and translated into airport master plan options. It is common during the master plan process to investigate a large number of options. It is only by developing and evaluating these options that individual master plan components can be understood in the context of each other. The performance of each component (airside versus landside; terminal versus runway and taxiway systems and aprons; etc.) depends on its surrounding context.

2.1.6 Paying significant attention to the criteria and process used to evaluate options for the optimum methods for future development of an airport, is crucial. The studies required and the evaluation criteria used will depend on the complexity of the individual project and will likely be unique for each individual case; however, they will all need to account for similar factors to a greater or lesser extent, such as ultimate design capacity, phasing to balance capacity and demand, costs (including capital expenditure and business case), environmental factors and surface access. While each airport is different, a common factor is the need to consult with users on their requirements to shape the criteria, options development and the filtering process.

2.2 PROCESS OVERVIEW

2.2.1 The airport master plan process is a comprehensive analysis of the airport to establish an organized framework for future facility development. The simplified process, as a whole, can be broken into two main components: pre-planning and airport master planning. The pre-planning step in the process works to define the scope of the master plan effort and the team that will conduct the study, while the actual master plan process will synthesize a recommended development plan for the airport.

2.2.2 The major pre-planning and airport master plan process elements are depicted in Figure I-2-1 in the context of the overall project process, which also includes the post-planning implementation phase. The main outcomes of each phase are highlighted with a dark outline. It should be noted that the process described can also be applied to planning individual airport facilities.

2.2.3 The pre-planning and master planning steps are described in the following sections with information on each step as well as key considerations.

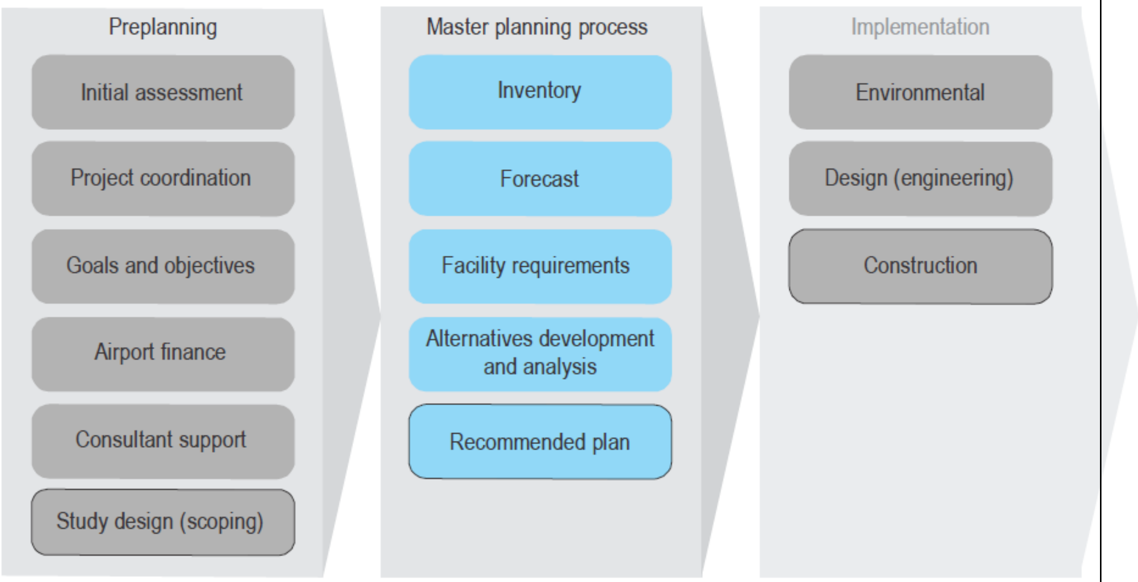


Figure I-2-1. Overall project process

2.2.4 Although all airports can benefit from the implementation of a master planning process, different indicators can be evaluated by the State authorities to prioritize the necessity of such an initiative. Among them, the following can trigger the decision:

a) the level of traffic (aircraft movements and/or passengers and/or cargo;(

b) the growth of traffic (observed or predicted;(

c) changes in the origin and destination (OaD) of flights;

d) changes on the type of flights and aircrafts predicted to operate at the airport;

e) the density of the urban fabric around the airport;

f) the environmental considerations (fragile natural environment, sensitivity to climate change;(

g) strategic importance of the airport (main national gateway, isolation of the territory served); and

h) technological advances that impact and enhance key airport processes (ATC, passenger processing, etc.(.

2.2.5 Other indicators representative of local constraints can also be defined.

2.3 PRE-PLANNING

2.3.1 Before a master plan is conducted, it is essential for the airport owner and/or operator to determine the level of effort and focus required of the master plan study. These critical decisions will ultimately form the scope of work, which is the outcome of the pre-planning step.

2.3.2 Successful redevelopment of existing airports and the development of new airports are the result of recommendations evolving from the airport master plan. Accordingly, if a master plan is to be useful to an airport owner and/or operator, certain pre-planning requirements must be put in place. The following pages describe in more detail the different steps of the pre-planning process outlined in Figure I-2-1.

Initial assessment

2.3.3 At the outset of any planning process, it is essential for the airport owner and/or operator to establish a baseline understanding of the context of the airport and the desired process to follow. The outcome of this baseline understanding will define the scope of the project and assist in establishing the appropriate goals and objectives.

2.3.4 During the initial assessment, the airport owner and/or operator conducting the study and the regulatory body overseeing the process should together focus on informing the scope of the master plan. This step will help to determine whether a new master plan effort is needed, whether the existing plan simply needs to have specific elements updated, whether the plan covers every function in the airport environment or focuses more narrowly on addressing specific issues.

Project coordination

2.3.5 During the pre-planning stage, it is important to assemble the project team that will conduct the study and facilitate stakeholder and community coordination. Establishing a plan at the outset of the study is essential to the success of the master planning project.

Project team

2.3.6 During the pre-planning stage, the airport owner and/or operator assembles a project team that manages and participates in the master planning process from start to finish. Typically, airport master plan efforts are overseen by a regulatory body and are conducted by the airport owner and/or operator who selects a project manager, either in-house or an external subject matter expert, to lead and coordinate the planning effort between the airport owner and/or operator and staff, the aviation consultant team and stakeholders. Given the potential overall complexity of the effort, it is often most effective to acquire a resource familiar with the airport master planning process with a proven track record of efficiently delivering these studies. See Figure I-2-2 below for a graphical depiction of a typical project team.

2.3.7 The process of establishing the airport master planning project team will vary considerably due to the complexity of the airport, focus of the study, local governance, political and jurisdictional makeup, the nature of ownership and control over existing airports, organization and effectiveness of central and local government land planning and transport authorities, and the agency legally responsible for financing the planning project.

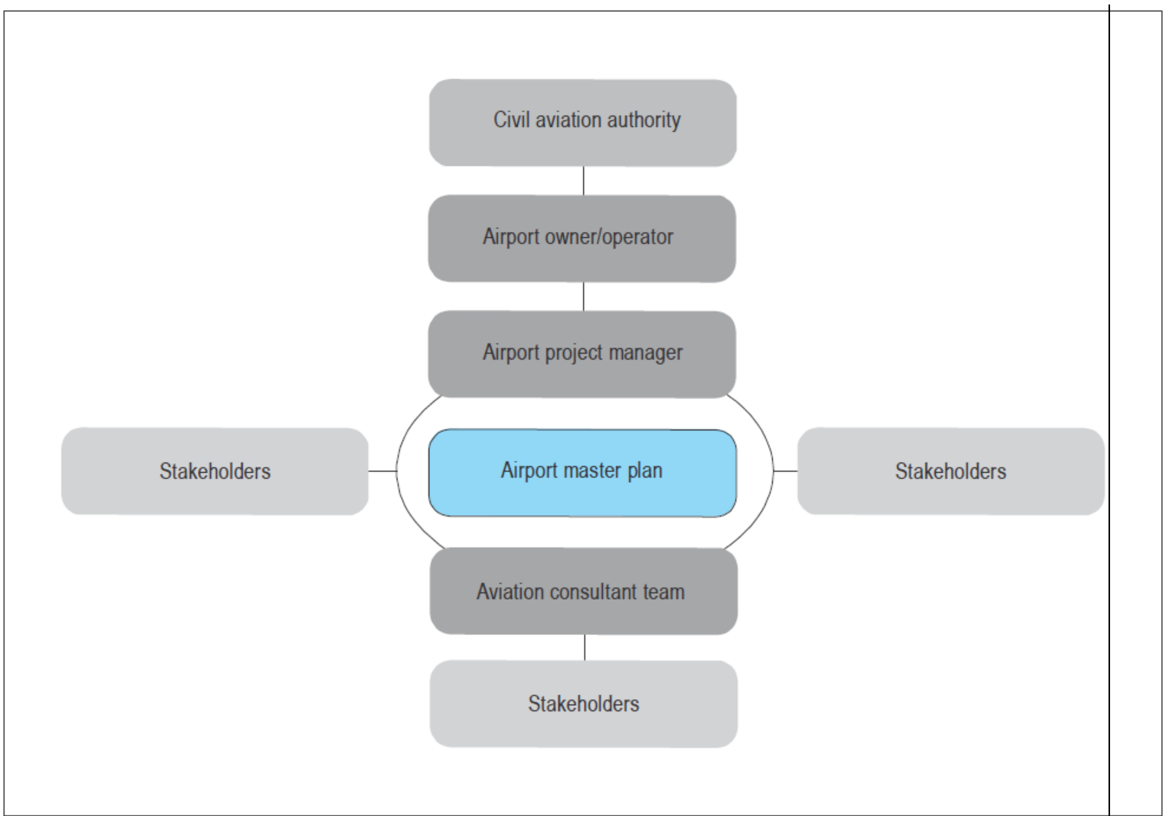


Figure I-2-2. Project team organization

Stakeholder involvement and consultation

2.3.8 The airport master plan, with its recommended development projects, will be of interest to a diverse group of stakeholders and organizations including: private citizens; local and national organizations; airport users; planning agencies; conservation groups; environmental protection agencies; ground transportation officials; concessionaire interests; and airline and other aviation interests including airline and airport trade associations (e.g. IATA and ACI). It is recommended that these groups be consulted prior to and during the master planning process to avoid possible delays to future airport development initiatives (see ICAO requirements for a master plan). It is important to emphasize the different degrees of consultation required with stakeholders. While some of the listed parties should be consulted mainly on the potential external impacts of the master plan, others, such as the airport users, should also be consulted throughout the process in phases such as scope, design brief, concept definition or options development and evaluation. Therefore, it is essential that the master planning team coordinate its efforts and seek the advice of these interested groups prior to and at key milestones during the development of the master plan. This consultation process will help ensure acceptance of the plan and incorporate important input from organized interests, which will lead to a well-integrated and implementable plan.

Goals and objectives

2.3.9 At the outset of the planning process it is recommended that a set of goals and objectives be developed and documented by the airport owner and/or operator that capture stakeholder requirements within those inputs. Using the outcome of the initial assessment, goals and objectives should define the purpose and motivation for developing the airport master plan and the approach required to achieve those goals. Given the unique nature of airports, it is important to tailor goals and objectives to the specific airport in question.

Airport finance

2.3.10 The financial challenges of a major airport expansion plus the cost of conducting a master plan, can be significant. In order to determine the significance of the challenges of financing such a development, determination of airport debt capacity and sources of affordable funding are recommended early on to notify the planners. An initial review of airport finance will provide a basis for discussion with agencies or financial institutions likely to be involved in the financing of airport projects.

Study financing

2.3.11 As part of the pre-planning process, it is essential to assess the approximate cost of conducting an airport master plan and identifying sources of funding. Since airport owners/operators often procure consultant support to conduct an airport master plan, securing funding enables the process to move forward effectively. The preparation of an airport master plan does not need to be overly expensive. The cost can vary significantly depending on the complexity of the airport, level of activity, type of operation, adjacent land uses, ambition, duration of the study and many other factors.

Consultant support

2.3.12 The process of conducting an airport master plan requires a wide range of skill sets and resources that span many disciplines (planning, architecture, engineering, urban planning, financial analysis, economics, programme management, environment, etc.). Some airport owners/operators have the resources to conduct the master planning process internally, but in general, they typically hire a range of specialist consultants to assist in developing an airport master plan. Support is acquired to provide subject matter expertise, additional resources to complete the effort within a specific time frame and to provide independent input and oversight. It is important that the airport acquire support from a qualified and experienced airport master planning practitioner who understands the complexity of the process as a whole and can lead and assemble the appropriate team.

Study design

2.3.13 A key output of the pre-planning step in the process is the scope of work that will define the process to come and the work that the consultant team will perform. The airport operator should develop a scope of work that is appropriate for the circumstances, and available funding that addresses airport goals and objectives. At this point in the process, it is also important to develop a preliminary schedule for project completion. Airport master plans can vary significantly in the time required to conduct and complete the work. In general, it is preferable to limit time frames as much as possible for optimal viability of the study.

Information requirements

2.3.14 At the outset of the planning process, it is important to establish and collect all available data on the airport that will be relevant to the planning process. The nature of the data to be collected should not only cover the physical facilities of the airport, but should also provide measures of utilization, volume and composition of traffic. Typical data relevant to the master planning process will include:

a) airport survey data (photogrammetric base mapping) including property survey;

b) aerial photography;

c) survey of airport and surrounding area;

d) airport base set of airport plans:

(1 airfield;

(2 terminal;

(3 landside; and

(4 other aviation facilities, etc;.

e) as-built drawings;

f) historical airport operations data:

(1 airfield operations;

(2 passenger enplanement data; and

(3 landside operations;

g) photographs;

h) planning documents;

i) existing air traffic approach and departure paths and procedures;

j) environmental documentation;

k) airport financial information;

l) administrative information; and

m) government transportation policies and regulations.

Sources of reliable data

2.3.15 Sources of reliable data are many and varied. They include records kept by: airport management, airlines and other tenants; national and local government agencies; IATA regional offices; Director General Civil Aviation (DGCA) offices; the Federal Aviation Administration (FAA); ACI; aviation trade associations; the United Nations and its affiliated agencies; local and national planning agencies; environmental protection agencies; national banks; international financial institutions; and ICAO publications.

2.4 THE MASTER PLANNING PROCESS

2.4.1 This step should be initiated once the airport owner has completed the pre-planning process and has a complete scope of work, project team and consultant support (if applicable). The purpose of the master planning process is to establish an organized framework for future facility development.

2.4.2 At the outset of every master planning study, to avoid any ambiguities, it is imperative to clearly define the study targets, scope, duration, programme (schedule) and expected outcomes. An effective master plan process creates an auditable decision-making process and enables mutually collaborative and aligned work plans for all involved parties. Roles and responsibilities of the individual participants must be clearly defined as a key part of the overall project governance.

2.4.3 A master plan is made up of five major process components that will ultimately translate to form the master plan document and path forward for the airport. They are:

a) inventory;

b) forecast;

c) facility requirements;

d) alternatives development and analysis; and

e) recommended plan.

2.4.4 In summary, the completion and documentation of each of these steps form the foundation of the master plan as a whole. The outcome of the process is a recommended plan that the airport can move forward with in the form of a report that documents and justifies the recommendations of the plan.

Inventory

2.4.5 The inventory and survey of existing infrastructure is a comprehensive review and documentation of existing airport facilities and operational data that establishes a baseline set of facts that will be built upon in the next design process steps. Developing the inventory is achieved by:

a) reviewing and compiling existing airport documentation;

b) a site visit to survey, review and validate compiled information;

c) photographing facilities, reviewing facility conditions;

d) taking inventory of environmental conditions; and

e) meeting with airport users, airport tenants and other key stakeholders.

2.4.6 The outcome of this step is a chapter in the airport master plan that consolidates and organizes all existing facility information in the form of a narrative, tables, drawings and photographs. While the focus is on documenting facilities, the inventory is also the first step in identifying and documenting issues that will need to be resolved later in the process (e.g. identifying deficiencies in facilities, facility condition.(

2.4.7 When capturing the status of existing facilities and their capacities as part of the inventory, the design capacity, operational limitations and operational capacity should be considered and recorded in detail. The capacity and limitations of the existing air space as well as the existing airfield and airside elements must also be established and documented. In addition, the airport's existing and future concept of operations (CONOPS) should be recorded and captured. It outlines the characteristics of the existing and proposed operational concepts not only from the airport's view, but also considers the perspectives of existing or future airport stakeholders.

Forecast of aviation activity

2.4.8 Traffic forecasts are required as a planning tool to understand the aspired level of aircraft and passenger traffic and intended future mode of airport operations. These need to be created and available at the outset of any master planning study.

2.4.9 A comprehensive forecasting of aviation activity over short-, medium- and long-term time frames, typically involves a 5-, 10- and 20-year planning horizon. The forecast is conducted utilizing the most recent data, as a minimum, the last 5 years of airport operations data. The outcome of this step is a chapter in the airport master plan that documents historic aviation activity at the subject airport, forecasting assumptions, forecasting methodology and forecast results. Aside from forecast activity levels, an extremely important outcome for this step is the identification of the future "design aircraft" for the facility. An equally critical outcome of the traffic forecasting exercise will be the link to the future phasing of infrastructure. The scale and timing of different master plan phases will be defined by the strategic choices related to the forecast demand as well as the different "demand triggers". A detailed discussion of conducting forecasts is presented in Chapter 3.

Facility requirements

2.4.10 The facility requirements step is a comprehensive analysis of an airport's facilities and its ability to accommodate existing aviation demands and forecast future requirements (i.e. climate change adaptation measures). The term "facilities" refers to all infrastructure components of an existing or future airport. The drivers of future facility needs are triggered by changes in activity levels, aircraft type, design requirements, security requirements, climate adaptation

needs, etc. The outcome of this step is a chapter in the airport master plan that documents current and future infrastructure requirements for each airport facility (e.g. runways, taxiways, terminal facilities, landside facilities, cargo, etc.). As part of these, an underlying CONOPS can prove useful to determine the operational assumptions on how to operate the facility requirements. An important part of this process is to ensure the most efficient and sustainable use of existing airport infrastructure is being applied through airport best practices and technologies, while using the identified need for expansion as a catalyst for operational efficiencies and passenger improvements.

2.4.11 The end result is a list of facility needs. The assessment of facility requirements includes all major components of a master plan:

a) airfield improvements (runway, taxiway and apron;(

b) building improvements (terminal, hangar, maintenance, etc;(.

c) support equipment improvement (aircraft rescue firefighting (ARFF), snow removal trucks, etc;(.

d) support facilities improvement (catering, aircraft maintenance, police, security, IT, etc;(.

e) navigational equipment and lighting improvements; and

f) access improvements.

2.4.12 A due diligence review or gap analysis will address the shortcomings of the existing facilities and infrastructure. Airport facility improvement projects will be based on the needs identified in the facility requirements, addressing the capacity needs identified in one of the following ways to:

a) meet the existing as well as phased forecast demands of the facility. The term "demand" can refer to the level of activity (e.g. aircraft type, future passenger activity levels) and type of activity (e.g. general aviation;(

b) meet service levels, design standards or criteria, including new or recently modified standards. These include space availability per occupant, processing equipment numbers, wait times at processing facilities, maximum walking distances, etc;.

c) ensure facilities are well maintained;

d) improve capital and operational efficiency; and

e) meet regulatory requirements (these often include heightened demand on security measures.(

2.4.13 The implementation of new technology and improved processes with concepts such as airport collaborative decision-making (A-CDM) can have a significant impact on improving available capacity in existing or future facilities through detailed coordination between different stakeholders, and can thereby create opportunities to optimize capacity and reduce infrastructure upgrade needs.

Broad determination of the land area required

2.4.14 Before any detailed options development, it is necessary to make a broad assessment of the land area likely to be required. This can be achieved by considering the space necessary for runway development, which generally forms the major proportion of land required for an airport. This requires consideration of the following factors:

a) runway length;

b) runway orientations;

c) number and separation of runways; and

d) a preliminary understanding of the land area needed for airside, landside, passenger and support facilities.

2.4.15 These factors are required to prepare an outline of the runway and airport campus scheme, which will serve as a draft assessment of the order-of-magnitude of land required. Benchmarking other airports can assist in this process, as long as they are viewed as efficient examples. A detailed discussion of the airside requirements is addressed in Section II of this EAC.

Alternative development and analysis

2.4.16 Building on the established facility requirements, the next step in the process develops and analyses possible development concept alternatives for the airport's future operation.

2.4.17 Options development commences with a preliminary study of the limitations and potential of the airport site at an existing airport or potential sites for new greenfield airports.

2.4.18 The analysis criteria and definitions used to evaluate various alternatives must be carefully crafted to accurately reflect the goals, objectives, and other success parameters established earlier in the process. Initial criteria typically include such elements as:

a) environmental impacts;

b) order-of-magnitude costs and/or economic viability and affordability;

c) on/off airport land-use compatibility;

d) sustainability;

e) operational resilience and efficiency;

f) phasing and expansion capability;

g) site and/or land availability;

h) airspace impacts;

i) constructability; and

j) project schedule versus return on investment.

2.4.19 The importance of each criterion is dependent on the focus of the effort and the evaluations may be reflected in this analysis.

2.4.20 The outcome of the alternative development process is a section in the airport master plan that documents the development and analysis of alternative concepts, as well as the rationale behind the analysis criteria used to select or reject various alternative concepts.

Preliminary study of possible airport sites

2.4.21 The location and availability of land has an important bearing on a new airport's growth potential. Not only does sufficient land need to be available, it also has to meet a number of criteria. The process of selecting the right location for an airport starts with the initial understanding of an airport's future land demand, as outlined above.

2.4.22 After the proposed airport's size and initial understanding of its potential operation, type and layout have been approximately determined, possible sites for development of an airport are studied in several steps.

2.4.23 Locational factors are to be tabulated for the purpose of comparison. Once these factors are analysed, additional land requirements for an existing or future airport are plotted on charts and maps. This preliminary study should eliminate undesirable sites or determine the adequacy of an existing site before costly site inspections are undertaken. The preliminary study, typically involves the following steps:

a) preliminary selection of potential sites from maps;

b) survey of individual sites;

c) overlay of approximate determination of the land required over potential site to test implementation;

d) high-level assessment of factors affecting the airport location; and

e) inspection of sites to be considered.

Site inspection

2.4.24 After listing all the potential sites considered worthy of further investigation, a thorough field and aerial inspection is required to provide a basis for assessment of the advantages and disadvantages of each site. At this stage, sufficient information should be available to reduce the number of sites to those meriting detailed consideration, and the planner should review the results of the office study and field investigation. Based on this review, sites that are unsuitable and which do not warrant further examination, should be eliminated and the reasons for rejection fully documented.

Target aspirations for airport siting

2.4.25 Airports should be sited so that aircraft operations can be carried out efficiently, safely and securely, are socially acceptable (i.e. noise contours, etc.) and ensure that the cost of development is kept at an affordable level, taking all factors into account including financing and the impact on users' costs.

Land-use planning

2.4.26 Land-use planning refers to block layout planning exercises where broad determinations regarding airside and landside facilities and their correlation to each other are made. The broader building blocks of the airport's future master plan are discussed at the schematic level in order to inform high-level organization principles of the future sites.

2.4.27 Land-use planning is the first step in an iterative process. The criteria used during this step can include, but are not limited to:

a) efficiency of land use;

b) landside access into airport sites;

c) preferred airside configurations to best suit airport operations/operability; and

d) noise exposure forecasts (i.e. noise contours.(

Layout typologies and configurations

2.4.28 Once initial overall land-use planning options have been developed, they can be compared favourably or otherwise with available sites. The airport "campus" of various facilities can then be further refined to determine how best to correlate airside configurations and aircraft aprons with landside surface access requirements, passenger terminal(s) and other key support facilities.

2.4.29 Each of these components has its own requirements and ideal operational situation. Finding the right balance between the various elements and components, in the context of future demand and operational efficiency, is the core challenge of airport master planning.

2.4.30 With regard to the laying out of individual facilities, it can be useful to consider the relevant adjacencies between them as depicted in Figure I-2-3. This adjacency matrix can help determine the optimum location of each support facility and its adjacency to other existing and future airport facilities based on their functional relationship to each other. This matrix provides guidance based on the following criteria:

a) recommended facility adjacency;

b) access connection to either the taxiway or roadway network, but facility adjacency is not necessary;

c) facility should be located on the airside;

d) facility should be located on the landside; and

e) facility should be located on the airside and/or landside boundary.

2.4.31 In some cases, it might be appropriate to relocate an existing facility to provide space for another facility that can make better use of the area, subject to costs and feasibility.

2.4.32 It is important to provide for a long-term site for each of the support facilities to assure their capital costs and life cycle can be recouped over the useful life of the facility.

Location	Airport Facility	Runways	Taxiways	Gated Aircraft Parking Positions	Inactive Aircraft Stands	General Aviation Hangars	Government/Protocol Terminal	Terminal	On Airport Automated People Mover	Curbfront	Main Access Roadway	Secondary Access Roadway	Passenger Metro Station	Auto Parking Garage/Ground Transportation Center	Economy Auto Parking Lot	Air Traffic Control Tower/TRACON/SENEAM	Crash Fire and Rescue Stations	Crash Fire and Rescue Training	Fuel Storage	Flight Kitchen	Ground Service Equipment Storage	Ground Service Equipment Maintenance	Airline Maintenance	Cargo	Multimodal Cargo Facility	Midfield Cargo Transfer Staging	Cargo Decompression Chamber	Mail Sortation Facility	Warehouses for Hazardous & Non-Hazardous Waste	Central Good Receiving/DutyFree Warehousing	Isolation Pads
AS	Runways		X			O											O														N
AS	Taxiways	X		X	X	X																	X	X				O			
AS	Gated Aircraft Parking Positions		X		O			O												O	X			O				O			N
AS	Inactive Aircraft Stands		X	O				O													X										
AS	General Aviation Hangars	O	X									O																			N
A/L	Government/Protocol Terminal											O																			N
A/L	Terminal			O	O				X	X			X	X			O			O										O	N
AS	On Airport Automated People Mover							X						O																	
LS	Curbfront							X			X			O																	
LS	Main Access Roadway									X				O		O				O											
LS	Secondary Access Roadway														O	X		O	O	X		O		X	X			O	O	X	N
LS	Passenger Metro Station							X																							N
LS	Auto Parking Garage/Ground Transportation Center							X	O	O	O	O																			N
LS	Economy Auto Parking Lot											O																			
A/L	Air Traffic Control Tower/TRACON/SENEAM										O	X																			N
AS	Crash Fire and Rescue Stations	O						O										O													
AS	Crash Fire and Rescue Training											O					O														O
A/L	Fuel Storage											O																			N
AS	Flight Kitchen			O				O			O	X																		O	
AS	Ground Service Equipment Storage			X	X																										
AS	Ground Service Equipment Maintenance											O											O								
AS	Airline Maintenance		X																			O									
A/L	Cargo		X	O								X													X	O	O	O			
A/L	Multimodal Cargo Facility											X												X				O			
AS	Midfield Cargo Transfer Staging																							O				O			
A/L	Cargo Decompression Chamber																							O							
A/L	Mail Sortation Facility		O	O								O												O	O	O					
A/L	Warehouses for Hazardous & Non-Hazardous Waste											O																			
A/L	Central Good Receiving/DutyFree Warehousing							O				X								O											
AS	Isolation Pads	N		N		N	N	N			N	N	N	N		N		O	N												
A/L	Airport Maintenance	O	O									O																			
A/L	Airport Administration							O	O		O	X	O																		
A/L	Employee Processing/SuperGate Access							O				X																			N
A/L	Security Checkpoints							O			O	X																			
A/L	Detention and Deportation							O				X																			
LS	Central Power Plant							O				O																			N
LS	Incinerator							O				O																			
LS	Water Treatment Plant							O				O																			
A/L	Waste Recycling, Compaction, Composting, Disposal							O																						O	
LS	Weather Services							O			O	X	O																		
LS	Rental Car Services/Rental Car Ready-Return							O			O		O	O																	
LS	Rental Car Long Term Storage Lot											O																			
LS	Commercial/Hotel Development								O		O	X	O																		N

Legend:
X = Facility Adjacency is Recommended
O = Access Connection is Recommended, but Facility Adjacency is not Necessary
N = Adjacency is NOT Desired
AS = Airside

Figure I-2-3. Airport Facility Adjacency Matrix
(Image reproduced by kind permission of Strategic Planning Services, Inc.)

2.5 DEVELOPMENT PHASING OF OPTIONS

Outline development phasing

2.5.1 Opportunities for phased development of a preferred master plan play an important role in the options evaluation process. Both the ultimate long-term and the phased medium- and short-term demands need to be considered when evaluating master plan options. Facilities should be provided in line with incrementally increasing demand.

2.5.2 Both ultimate development and phased near-term expansion opportunities and constraints need to be fully aligned to ensure seamless development that is achievable, efficient, pragmatic and deliverable.

Evaluation process

2.5.3 The collection of background material and data begins once the general assessment has been made of the land area required, based on a tentative layout capable of satisfying the airport master plan. This information can be equally useful in evaluating an existing airport site or a potential site for a new airport. Information that should be collected and evaluated can include, but is not limited to:

a) airspace and proximity of other airports;

b) capacity provided by the individual options;

c) deliverability, flexibility and phasing;

d) aviation activity;

e) social and regional considerations;

f) surface access considerations;

g) existing land use and/or potential land-use zoning;

h) engineering assessment;

i) environmental assessment; and

j) financial assessment.

2.5.4 The above criteria are outlined in more detail below, but generally, these criteria should be assessed at a higher level during a preselection phase to narrow down the available options prior to a more detailed assessment.

Airspace and proximity of other airports

2.5.5 Adequate airspace is vitally important for the efficient operation of an airport. Special attention is required to determine the extent and likely effects of any restrictions that might be imposed by airspace limitations. A site close to a demand centre but with some restrictions on airspace, may be preferable to a site with no airspace restrictions but is so remote or difficult to access that it results in limited demand. A balanced evaluation is needed.

2.5.6 When planning for a new airport or the expansion of an existing one, the locations of other airports in the vicinity and ATS routes, together with their associated airspace and any future plans to change them, must be considered. When two airports share overlapping airspace, their combined aircraft movement rates may be restricted. Instead of being able to operate independent of each other to the limit of their individual capacities, it will be necessary to coordinate aircraft movements between airports to maintain the necessary physical separation between aircraft. Therefore, airports and new runways should be located so that any overlapping airspace required for aircraft using other airports, and the resultant limitation of total capacity, is minimized. For the same reason, potential airport and/or runway sites need to be studied in relation to ATS routes so that problems are avoided. Where required, the airspace of surrounding airports, and in particular future airspace demand of those airports, needs to be taken into consideration as part of the evaluation criteria.

2.5.7 In addition to overlapping airspace considerations, the political sensitivities of selecting the site for a greenfield airport in close proximity to national boundaries, will also need to be studied. As part of the ICAO regional air navigation planning process, an amendment proposal for the development, construction and operation of a greenfield airport needs to be circulated to all users and neighbouring States for comment and subsequent approval by the ICAO Council.

Operability of the individual options

2.5.8 The operational impact of each option on the airport and its internal and external stakeholders, particularly airlines, needs to be considered as part of the evaluation process. The efficiency of apron operations, including anticipated taxiing times, needs to be reviewed for each of the recommended options, that is, to minimize fuel burn.

Options capacity

2.5.9 A comprehensive and balanced capacity review of the proposed options across airspace and airfield systems, passenger and support facilities, as well as landside surface access and public transport is required. This is the point in the process where options are sufficiently mature to allow a detailed assessment of overall airport-wide balanced capacity.

Deliverability, flexibility and detailed phasing

2.5.10 The phased increase in additional capacity needs to be considered in the context of deliverability. At existing airports, live operations must always be maintained and protected from disruption. Any disruption to operations should be minimized and how the additional capacity is delivered and the potential impact on the operational integrity of the airport must be considered in each case and consulted with airport users.

2.5.11 Operational business models at airports may change and the flexibility of each option to accommodate different business models or changes in the anticipated traffic patterns should be investigated. How the phased implementation of additional capacity may impact both capital expenditure and overall airport revenues, should be included in the option evaluation process during all master planning exercises.

Social regional considerations

2.5.12 Airports need to be sited or expanded very carefully relative to adjacent populated areas and runways should be aligned so that flight paths that pass over concentrations of population are minimized. However, airports also need to be located adjacent to the towns and commercial areas that they serve. A comprehensive knowledge of the wider catchment area assists in understanding the importance of ground connectivity to the wider region. Generally, a compromise between flight paths over populated areas and ground connectivity is potentially required to ensure the optimal site or option for the development of the airport is chosen.

Surface access (ground access and public transport(

2.5.13 Fast, convenient and reliable access facilities for passengers and freight are essential for an airport to provide efficient services. Locations offering convenient connections to adequate road and rail networks are preferable on the basis that it is cost effective.

2.5.14 The authorities responsible for roads and public transport systems should be involved as stakeholders early on in the development process and presented with any proposals for construction of new airports or major extensions to existing airports. Their participation will ensure alignment on capacity calculations of existing and future systems and their phased development. This will ensure that these authorities are fully informed and involved and will establish an environment for future cooperation.

Land-use assessment

2.5.15 The advantages and disadvantages of different sites will be influenced by the surrounding land use. New airport infrastructure should preferably be located so that existing land uses are not negatively impacted by aircraft operations. Ensuring that adjacent land use remains compatible with ongoing airport operations may require the introduction and administration of land development control measures (e.g. land zoning) in order to avoid future noise or obstruction problems. Sites with approaches over water, but free of bird hazards, and where approach aids can be installed where necessary etc., will generally prove preferable to those locations adjacent to developed commercial and/or residential areas.

2.5.16 In the case where changes to adjacent land use are necessary, there may be obvious social problems and also legal and economic difficulties. Purchase or compulsory acquisition with the attendant legal technicalities and delays may be necessary in certain instances, but arrangements with the appropriate authorities to develop governance strategies (i.e. regional land use and zoning criteria) that support compatible land use, will prove beneficial. EAC 139-16.

Topography, geology and geography

2.5.17 Topography is important because the slope of the terrain, the location and variation of natural features such as trees and water courses, and the existence of structures such as buildings, roads, overhead lines, etc., can affect the requirements and costs for clearing, filling, grading and drainage. Natural slope and drainage of the land are important from a design and construction point of view, as they determine the extent of earthworks and grading needed to produce the desired airfield layout. Generally, level terrain that is well drained, is best.

2.5.18 General soil surveys and sampling are necessary to allow for the mapping of various soil types and to locate extensive areas of rock. The location of on-site water courses and nearby water supplies should also be considered. Expert advice should be sought in these matters.

2.5.19 In areas where tropical diseases are endemic, airport planning should take disease vectors into consideration. The World Health Organization's Guide to Hygiene and Sanitation in Aviation (https://www.who.int/publications/i/item/9789241547772) references these criteria.

Utilities and services

2.5.20 Airports should, if possible, be adjacent to power and water supplies, sewage and gas mains, drainage and telephone lines, etc. Availability of these services may eliminate the need to provide them specifically for the airport and therefore reduce costs. In any case, utilities need to be considered as part of the master planning effort and undergo the same process as other elements of the airport.

2.5.21 As information technology becomes increasingly important in the live operations of airports, information technology master plans will assist in understanding the particular demands regarding the digital infrastructure at airports.

Environmental assessment

2.5.22 The consideration of environmental impacts of airport developments has become increasingly important over recent years. Airports are now expected to address issues ranging from noise, air quality, biodiversity and water management to more global issues – particularly the aviation industry's greenhouse gas emissions. Airport master plans should include an environmental assessment and management plan, as well as a land-use plan that minimizes noise and emissions and protects water resources and habitats.

2.5.23 Any airport master plan project should demonstrate that environmental factors are taken into consideration in the development of a new airport or the expansion of an existing one. All efforts must be taken to minimize environmental impact. Studies of the impact of the construction and operation of a new or expanded existing airport must have minimal negative impact on levels of air and water quality, noise levels, ecological processes, and demographic development of the area.

2.5.24 EAC 139-16.

Noise and other environmental and social aspects

2.5.25 Aircraft noise has historically been one of the critical environmental and social issues to be considered in the development of an airport master plan. Aircraft and aircraft engine manufacturers have done much in recent years to minimize engine noise and modify flight procedures resulting in significant reductions in noise footprints around airports. Another effective means for reducing noise is through proper planning of land use for areas adjacent to the airport.

2.5.26 Factors to be included in airport planning include the measurement and contours of aircraft noise, land-use control, ground run-up and flight noise abatement operating procedures, the availability of ground power, the effect of increased air traffic and the introduction of future aircraft types on the noise impact of an operational airport.

2.5.27 It is not always feasible to site or expand an airport sufficiently far away from population centres to prevent an adverse social reaction. It is important, therefore, to obtain or control sufficient land to overcome or reduce the noise problem for both the airport and the surrounding population. The potential degree of noise disturbance needs to be assessed in terms that indicate the relationship between the level and duration of the noise exposure.

2.5.28 Important factors in forecasting the extent of future noise disturbance at potential sites are aircraft movement rates, timing of phased airport development, aircraft types and hours during which aircraft operations will occur. However, long-term estimates and assessments of noise disturbance can be expected to be somewhat speculative and less reliable than those for a short term. More detailed information on noise evaluation may be found in Annex 16 – Environmental Protection, Volume I – Aircraft Noise.

2.5.29 The noise level produced by aircraft operations at and around the airport is generally considered a primary environmental cost associated with the facility. Most noise exposure lies within the land area immediately beneath and adjacent to the aircraft approach and departure paths. Noise levels are generally measured through some formulation of decibel level, duration and number of occurrences. A large number of noise measuring techniques exist (see Annex 16, Volume I and the Environmental Technical Manual (Doc 9501), Volume I – Procedures for the Noise Certification of Aircraft). Proper site selection and adjacent land-use planning can serve to greatly reduce, if not eliminate, the noise challenges associated with the development and operation of an airport.

2.5.30 The Guidance on the Balanced Approach to Aircraft Noise Management (Doc 9829) provides guidance on alleviating the problem of noise in the vicinity of airports. The balanced approach recommends consideration of four noise management pillars: land-use planning, reduction at source, noise abatement operational procedures and operating restrictions.

2.5.31 Other important environmental factors include air and water pollution, energy usage, industrial wastes and domestic sewage originating at the airport, and the disturbance of natural environment. With regard to air quality, the master plan should consider how to reduce emissions, including the greenhouse gases that contribute to climate change. The Airport Air Quality Manual (Doc 9889), provides more details on airport air quality issues.

2.5.32 The optimal positioning of runways and taxiways, the provision of ground power at aircraft stands, the use of renewable energy, adoption of energy-efficient building designs, and the promotion of sustainable mobility at the airport are just a few examples of strategies to be considered when meeting global climate goals. More guidance on sustainability strategies is provided in Appendix D of this EAC .

2.5.33 An airport can be a major user of water resources and contribute to water pollution if suitable treatment facilities for airport wastes are not provided. The amount of water consumption will have an impact on the local community/environment and the master plan should consider ideas for water reduction and reuse. Strategies for mitigating water run-off and the pollution of local water basins from airport operations are also critically important.

2.5.34 Socio-environmental factors, affecting the health of surrounding populations, in particular due to noise and other airport emissions, shall also be addressed as part of these assessments.

2.5.35 The construction of a new airport or the expansion of an existing one may have a major impact on the natural environment. This is particularly true for large developments where streams and major drainage courses may be changed, the habitats of wildlife disrupted, and wilderness and recreational areas reshaped. The environmental study should indicate how these disruptions might be alleviated.

2.5.36 Sustainability targets can be formulated for the individual project, depending on the ambitions of the individual airport.

2.5.37 Historic sites, protected sites of local or national heritage or importance, as well as areas of special scientific interest also require due consideration during this process. EAC139-16 , Chapter 8, provides more considerations on heritage issues.

2.5.38 Planning constraints and limitations on the land under investigation must also be considered to fully appreciate the availability of investigated land for airport developments.

Climate change adaptation

2.5.39 It is important to identify and assess the risks that changing climate may pose to current and future developments of airport facilities and infrastructures from both airsides and landsides. Coordination is also needed among national and regional climate change adaptation plans, if existing, in order to ensure an airport's master plan adopts a strategic and harmonized approach through all its elements.

2.5.40 Furthermore, airports should re-evaluate the climate projection data every five to 10 years to ensure that adaptation priorities remain in line with projected future climate conditions and airport goals. Additional information on airport climate change adaptation measures is also available from the following ICAO documents:

a) EAC139-16 , Chapter 9 – Climate change resilience and adaptation;(

b) Climate Adaptation Synthesis Report and 2018 Survey Results (refer to https://www.icao.int/environmental-protection/Pages/Climate-Adaptation.aspx;(

c) Climate Resilient Airports (Eco Airport Toolkit e-publication); and

d) Climate Risk Assessment, Adaptation and Resilience Report.

2.6 FINANCIAL ASSESSMENT

Cost considerations

2.6.1 In order to achieve suitable returns from the investment necessary for their construction, airports should be located, planned, built and implemented so that the cost of development is optimized. Thus, topography, soil, geography, construction materials, availability of services and land values are of particular importance.

Land values

2.6.2 Airports require adequate space for future development and the value of land is a factor to be considered. In general, the demand for air transport is related to the population it serves, and, as a result, a large proportion of future airport development work can be expected adjacent to metropolitan areas. With the growth of urban populations, rising standards of living and more extensive road systems, areas occupied by metropolitan districts will continue to expand. Land values generally increase significantly as areas change from rural to urban use so that early reservation of suitable sites will often enable airports to be better located and at lower costs.

2.6.3 Construction of new roads and utilities required for an airport often pass through, or adjacent to, unused land which then becomes attractive to develop. The number of personnel employed at larger airports creates a demand for housing and servicing industries which, if allowed to develop indiscriminately, could adversely affect the efficiency of the airport. Initial acquisition of all land considered necessary for the future ultimate development of the airport, safeguards future expansion and may often prove to be the least expensive option over time.

2.6.4 When a number of alternative sites remain under consideration, cost becomes an important differentiating factor. Economic factors are important because the rate and pattern of growth of an economy is influenced not only by the level of capital investment but by the manner in which capital is used.

2.6.5 Proposals for expenditure on airports need to be considered on their own merits using the cost-benefit analysis. By analysing the estimated stream of benefits and costs over the anticipated useful life of the airport, it is possible to determine cost-benefit ratios which serve as a guide to the value of the project and the choice of site.

2.6.6 Two different types of cost-benefit analysis and comparisons are necessary: An operational cost-benefit analysis and a social cost-benefit analysis. The final evaluation requires an assessment based on the comparison of operational, social and cost efficiencies:

Operational:

a) land availability;

b) airspace availability;

c) effect of any restrictions on operational efficiency; and

d) potential capacity.

Social:

a) proximity to demand centres;

b) adequacy of ground access;

c) potential noise problems; and

d) current land use and need for control measures.

Cost:

a) cost-benefit analysis reflected in a business case including the costs of any surface access, utilities provision and user charges.

2.7 OPTIONS SELECTION AND EVALUATION CRITERIA

2.7.1 Consideration of the relative merits of the remaining options requires:

a) detailed site surveys, including obstacle surveys;

b) preparation of outline airport layouts for each site;

c) preparation of broad cost estimates covering the total capital and operating expenditure required, including all associated off-airport items such as access roads, communications to population centres, planning control of surrounding areas and estimates of annual percentage changes in land values for the probable life of the airport, and the anticipated phasing of expenditure; and

d) when expansion or abandonment of existing sites is in question, the determination of the depreciated and current values of any existing installations together with the value of all other off-airport associated assets, including easements, public utilities, noise zones, etc.

Options evaluation matrix

2.7.2 Evaluation criteria should include operational performance, flexibility and growth, environmental impacts and financial feasibility, including preliminary capital cost estimates and a cost-benefit analysis. Once all options have been evaluated independently, options with limited merits or that are very similar can be eliminated. The performance of the remaining options can be compared using an options evaluation matrix. The criteria used, and the relative importance assigned to each, will need to be determined for each individual project.

The recommended plan

2.7.3 The outcome of an options analysis should be a high-level recommended development plan. The result will be a chapter in the airport master plan report stating the airport’s development strategy for the determined planning horizon. The recommended plan is the precursor to the post-planning processes (the planning implementation phase) where individual elements of the overall master plan undergo a much more detailed review and development towards project implementation.

2.7.4 This chapter in the report typically includes:

a) a supporting narrative that summarizes all the airport master plan recommendations, including the results of site inspections and site evaluations, and the selection of recommended sites;

b) preparation of outline plans for the recommended plan which graphically overlays all proposed development on a single scale graphic of the airport (e.g. typically in the form of computer-aided design and drafting linework overlaid on an aerial or vector base;(

c) a tabular summary of proposed development with development triggers identified (levels of activity, facility condition, phasing, etc;(.

d) a capital improvement plan (estimates of cost and revenue;(

e) an airport layout plan that also depicts preliminary project phasing in alignment with the capital improvement plan; and

f) preliminary engineering and environmental assessment.

2.8 IMPLEMENTATION OF A MASTER PLAN

Limitations of a master plan

2.8.1 A master plan is a guide to ongoing future development, but it must be viewed only as a guide specific to a point in time.

a) A master plan is not a detailed step-by-step implementation programme. The development of an implementation programme follows the guidelines set out in the master plan. Following the development of the airport master plan, specific improvements are then designed and implemented.

b) A master plan is not specific to detailed airport improvements; it is only a guide to the types of improvements which should be undertaken usually in a phased manner. For example, the financial plan developed in the master plan is a presentation of alternatives, not a specifically tailored financial programme. The master plan points the direction of development and it does not present a detailed programme of how to get to the actual funding stage of improvement projects.

2.8.2 A major reason for undertaking airport master planning is to understand the land area that should be safeguarded for future development. However, a master plan in itself is not a safeguarding document, and it merely represents a design or development intent. The airport owner/developer must determine how the master plan should incorporate a land safeguarding strategy and how such safeguards can be developed within the political and legal context of the individual airport.

Transition from study to a guiding document

Ratification of a master plan

2.8.3 Master plans can serve different purposes and the level of detail of different types of master plans may vary.

Internal ratification

2.8.4 Ratification is firstly required within the airport business itself, through which it becomes a guiding document that is adhered to as derivative individual infrastructure projects are developed and implemented.

Stakeholder consultation

2.8.5 Master plan ratification is required from both internal and external stakeholders, in particular the main airport user groups including the airline community. Early communication with such parties will help identify particular requirements early on in the master planning process, as well as enhancing the potential of acceptance of a final master plan by stakeholder groups.

External ratification

2.8.6 In many jurisdictions, ratification processes require public consultation or a passing of other public planning processes. These vary greatly by region and requirements need to be obtained for each individual case. Having completed the master plan, the appropriate authorities must now take the broad guidelines of the master plan and translate them into a programme that recognizes specific constraints and opportunities.

Relationship between an airport master plan and detailed airport infrastructure planning

2.8.7 To effectively utilize the master plan, the execution of improvements may require simultaneous planning while the master plan is in progress. To make the master plan a useful guideline, it should highlight particular local challenges and prospects. The final master planning document should be produced so that the development proposal is acceptable to the appropriate officials and the general public.

2.8.8 A master plan is simply a guide to future development. The future is never completely clear and so the master plan needs to be constantly reviewed as previously stated. Constant championing from the top of the issuing organization, in most cases the airport itself, will ensure that the master plan continues to serve as a constant point of reference for the long-term development of an airport.

Individual infrastructure upgrades derived from the master plan

2.8.9 Development plans are to be created within the context of the master plan. These individual development plans have a certain development horizon, either based on a required capacity increase, or a fixed development time frame.

2.8.10 Development plans focus on individual development steps. Individual projects undergo much more detailed review and development towards project implementation. These include design, engineering and environmental studies.

Business continuity

2.8.11 Master planning precedes development planning and development planning precedes actual infrastructure projects or capacity upgrades. It is important to understand that this hierarchy of decision-making requires time to ensure all planning steps are coherently coordinated. Master and development planning must be undertaken well before the airport's capacity is exhausted to avoid capacity shortfalls and limitations for further development. At all times, an airport should seek to maintain sufficient capacity resilience. Required infrastructure upgrades must be planned, implemented and put into operation before the airport's capacity expires. The master plan phasing strategy should include "throughput capacity triggers" that indicate when development and planning of the next development phase should start. These "throughput capacity triggers" should be planned well in advance of the actual increased capacity needed.

2.8.12 Required implementation timelines, design and delivery programme durations and implementation phasing need to be considered when planning ahead. Upon completion of individual development projects, the inventory and base plan of the airport's site and facilities should be updated to reflect the new facilities and their operational capacities.

Chapter 3 Forecasting For Airport Master Planning

3.1 ABOUT THIS CHAPTER

This chapter describes the vital role of forecasting in airport master planning. It considers why forecasts are necessary and their role in the planning process and how they are developed. This chapter describes the philosophies underlying forecasting processes and of practical application of the forecasts themselves, rather than an exposition of forecasting techniques. Descriptions of some techniques are given in the EAC on Air Traffic Forecasting (Doc 8991). Additional information on air traffic forecasting is also available from documents produced by IATA, ACI, the FAA and the Transportation Research Board, among others.

Note.— Forecasting requires a very specialized skill set and therefore it is recommended that specialist consulting services be considered whenever detailed air traffic/passenger movement forecasts are required..

3.2 FORECASTING NEEDS FOR AIRPORT MASTER PLANNING

3.2.1 Air traffic forecasting is a critical element of the airport planning process. Forecasts are necessary to define the facilities that will be required, the scale of such facilities, and the likely timing when they will be required. The configuration and sizing of an airport are often determined on the basis of detailed forecasts of future long-term airport activity. This can include:

a) the number and length of runways, associated taxiways and aprons needed to accommodate future air services (aircraft types, etc;(.

b) the overall size and configuration of terminal buildings (both passenger and cargo), and the nature of traffic accommodated. The passenger flows, in particular, the need to be analysed using a variety of parameters. These include:

(1 arrival versus departure traffic including peak flow times and projected passenger flow volumes; and

(2 domestic versus international traffic broken down into arrivals, departures and transfer traffic volumes (and flow peaks;(

c) detailed process requirements for security screening checkpoints, customs and immigration, baggage screening handling, airline check-in and other passenger services;

d) commercial planning considerations – retail and food and beverage (FaB) outlets, car rental facilities, business lounges, etc;.

e) landside access – vehicle traffic and ground access requirements – passenger and employee traffic, passenger and employee car parking requirements, public transport including rail, buses, taxis, etc;.

f) staffing levels and other operational requirements and costs;

g) future noise and emissions (from both aviation activity and ground access;(

h) historical climate data and climate projections (local meteorology (MET) office); and

i) support facilities such as hangars, rescue and firefighting, etc.

3.2.2 Forecasts also play a critical role in the financial planning of the airport – often being used to project future cash flows (both revenues and operating costs) as well as capital spending requirements and the impact on user charges.

3.2.3 Forecasting does not predict the future with precision. Instead, the forecasting exercise provides information that can be used to evaluate the possible impact and effects of future uncertainties. As with any forecast of future commercial or operational activity, airport traffic forecasts are subject to considerable variations, due to unforeseen changes in the political, regulatory, economic, industrial or technological environment. It is therefore prudent to examine a range of forecast scenarios, and study how future airport development strategies and plans can accommodate the variances between these various scenarios. The evaluation must also take into account the physical, political, social, environmental and financial constraints under which the airport operates.

3.2.4 Typically, “top-down” air traffic forecasts are based on overall market conditions (global and national economic trends, currency exchange rate, trade, airfare, etc.) and represent “unconstrained” projections of future airport activity. Unconstrained forecasts are developed to show the potential of a region’s aviation market to grow. This approach is appropriate when forecasts are used to determine the development upside and unconstrained potential of the future airport.

3.2.5 The top-down forecast that is driven by macro-economic considerations is often complemented by the bottom-up forecast that is based on airline specific assumptions. Such assumptions may include the size and composition of the fleet, the routes to be serviced and the anticipated capacity growth. Bottom-up forecasts usually address the short- and medium-terms. They are used to confirm the top-down forecast is sensible.

3.2.6 However, it is also important to consider airport capacity constraints. For example, if the airport is unable to extend its runway or build another runway due to land constraints or infringement of adjacent development, this constraint must be reflected in the actual development forecasts. Similarly, there may be regulatory constraints on the airport operations – for example, restrictions applied to the surrounding airspace to address noise or environmental concerns. The identification and acceptance of these constraints on forecast outcomes should be agreed early in the forecasting and master planning process and documented as an extremely important component of the assumptions underlying the forecast output.

3.2.7 In order to ensure consistency in relation to the assumptions underlying the master plan, the development of forecasts should ideally be fully integrated into the planning process. Once both short- and long-term objectives of the airport overall development strategy have been determined, agreed on and documented, a broad provisional plan can be drawn up and evaluated in relation to traffic forecasts. Subsequently, as the balance between accommodating demand and resource availability (finances, land, etc.) is taken into account, the planning process becomes iterative, with initial forecasts being adapted to better reflect modified aspects of the plan and the plan being adjusted to better accommodate revised forecasts. It is important to continue to document the revised assumptions as this iterative process continues.

3.2.8 Once facilitation requirements have been established, capital costs as well as recurring operating costs can be determined. The traffic forecasts are also used in determining annual income from both aeronautical and non-aeronautical sources. The information on facilities to be provided, the cost of providing the facilities and services and the income from their provision may now be compared with the objectives of the airport and the provisional plan, and a cost-benefit affordability analysis should be carried out.

3.3 FORECAST DATA AND OUTPUTS

3.3.1 To a great extent, the outputs from air traffic forecasts will be a function of the historical traffic data available for the airport. Typically, airports or government agencies collect a range of traffic data for the airport, which can include:

a) Air passenger volumes. Typically reported on an annual, quarterly or monthly basis, and in some cases split by market segment (domestic, international or by individual region or destination) or by carrier. The data can also capture the number of transfer and transit passengers.

b) Total aircraft movements. Again, these can be reported on an annual, quarterly or monthly basis, and can be split by market segment, carrier, aircraft type, model or size and category (scheduled passenger, charter passenger, scheduled cargo, charter cargo, general aviation, military, etc.(.

c) Air cargo tonnage, annual, quarterly or monthly, and can be split by market segment, commodity, carrier, passenger belly hold versus dedicated freighter, exports and imports.

d) Airport tower log data, recording details of each aircraft operation at the airport, which can be a useful input to peak period analysis, as described below.

3.3.2 The number of years of historical data and the level of detail available can vary considerably between airports and jurisdictions. As analysis of historical traffic patterns plays an important role in many air traffic forecasts, therefore, the availability of detailed data can greatly enhance the forecasting process. Where data is available for specific traffic segments, then it is possible to model the traffic development of each segment based on a specific set of factors or set of assumptions, which can vary from segment to segment, improving the flexibility of the forecasting model and potentially enhancing the accuracy of the results, particularly in the short-term.

3.3.3 Where necessary, the airport data can be augmented by data from other sources, such as airline schedule data, commercially available air ticket booking data, air cargo waybill data and related government data (for example, the United States Department of Transportation collects detailed passenger, cargo and fares statistics from United States and foreign carriers.(

3.3.4 The air traffic forecasts developed for airport master plans are typically developed for a 20- to 25-year time horizon reflecting the long-life cycle and capital-intensive nature of airport development. Forecasts of annual traffic (e.g. passengers, aircraft movements, and cargo) are typically provided at five-year increments, sometimes with forecasts provided for each of the first five years of the forecast period, to provide more detail which can guide the initial planned developments within the master plan.

3.4 CONVERTING FORECAST DATA INTO PLANNING CRITERIA

3.4.1 Airport facilities are designed to accommodate peak levels of demand, resulting in the need for peak hour or peak day traffic forecasts, rather than just annual forecasts. Therefore, most master plan forecast data will need to be converted into peak period forecasts for both aircraft movements, which define runway, taxiway, air traffic control (ATC) and apron requirements, as well as for passenger, cargo and mail throughput, which define terminal and access system requirements.

3.4.2 Planning for the absolute peak demand (i.e. the greatest demand anticipated; the busiest hour of the busiest day of the year) is inappropriate, as it will result in facilities that are impractically oversized and under-utilized. Airport planners and designers have therefore adopted various planning peak concepts, which are used to determine the airport capacity needed to handle current and future peak traffic levels that meet agreed level of service (LoS) criteria. These concepts aim to ensure that the airports have adequate capacity to meet high throughput demand levels throughout the year with the understanding that an agreed small proportion of users will not be provided with the agreed LoS at extreme annual peaks.

3.4.3 A number of peak hour metrics have been developed for this purpose:

a) The 20th, 30th or 40th busiest hour in the year.

b) The peak hour of the average day (or average weekday) of the peak month (or peak two months) in the year.

c) The peak hour of the second busiest day in the average week of the peak month.

d) The peak hour of the 90th or 95th percentile busy period of the year.

e) The 5 per cent busy hour, i.e. an hour selected so that all the hours of the years that are busier handle a cumulative total of 5 per cent of annual traffic.

3.4.4 Various airports and organizations have adopted different metrics. For example, the United States FAA uses the second metric while IATA recommends the third metric. Other measures also exist but the purpose is the same, which is to select an hour (or period) with a high traffic demand; one which is exceeded on only a few occasions during the year. The selection of a metric may be imposed by the State's civil aviation authority. It is also data driven; some metrics require detailed traffic data, which may not be available at some airports and thus may need to be extrapolated from the data that is available.

3.4.5 Separate peak passenger and aircraft movement peaks (and cargo volumes where data is available) are normally identified, which may not necessarily occur at the same time (e.g. peak passenger volumes may be generated by a small number of large aircraft). Furthermore, separate arrival and departure passenger peaks are normally identified, as these have different facility requirements (e.g. security checkpoints, check-in and baggage drop-off for departures; security screening checkpoints, immigration and customs control, and baggage reclaim for arrivals). The peaks are sometimes further split into domestic, international, transfer and transit, due to the differing facility requirements of these passenger segments. At large airports, the peak traffic may need to be estimated for each alliance and specific group of airlines to identify terminal capacity requirements.

3.4.6 Having identified the historical and current peak traffic volumes, the future peak traffic is typically forecast as a function of annual traffic. In some cases, the profile over the entire day might be as important a feature as the peak hour itself, as this profile would determine policy and requirements if congestion occurs in the peak hour; this may necessitate assumptions of future traffic spreading to off-peak periods.

3.4.7 In summary, the air traffic forecast needs to be converted into the following types of planning criteria:

a) Annual volumes of passengers and cargo (and mail), separated into domestic, international and possibly by market. Further segmentation can define air carrier, whether scheduled or charter service, arrivals, departures or transfers (or trans-shipments.(

b) Annual aircraft movements, segmented by airline, aircraft type and weight category. Forecasts of aircraft landed weight may also be required for revenue projection purposes.

c) Peak hour aircraft movements and throughput of passengers, cargo and mail, further segmented into arrivals, departures or combined (each may occur at different times) with further segmentation by traffic type and airline group, if required (domestic, international, transfer or transit.(

d) Peak day aircraft movements and throughput of passengers, cargo and mail, if required and available.

e) Number of aircraft to be based at the airport by carrier and by general aviation (to determine aircraft parking and maintenance requirements.(

f) The peak period forecasts can be replaced or supplemented by design day schedules (or nominal schedules). These are projections of future schedules on a selected busy day, which incorporate the peak forecasts but also provide planners with information on activity during the rest of the day.

g) Number of airport workers by category (for use in facilities planning, possibly including back-office requirements.(

h) Ground access traffic volumes by mode (private car, drop-off, taxi, public transport, etc.(.

3.4.8 Specific categorization may need to be made for cargo. Arrival and departure characteristics of cargo often differ appreciably in volume, in timing and in facility requirements. Where cargo is expected to arrive or depart on all-cargo aircraft as well as in the belly hold of passenger aircraft, categorization may be necessary to plan cargo terminal and handling requirements and the transfer of cargo from passenger aircraft to the cargo terminal. Cargo handling areas are generally planned on the basis of a square metre per ton handled per unit of time, but this ratio can vary with the traffic mix, degree of containerization, etc., and further categorization may be necessary (usually based on analyses of air way-bills). Special cargo (e.g. perishable, live animals, temperature controlled pharmaceutical shipments) will also trigger specific handling and facility needs. The availability of off-airport consolidation depots can affect the type and duration of throughput. All-cargo aircraft movements themselves should be forecast separately, as such aircraft can often be directed away from peak hours by use of suitable policies, although such efforts may be limited by night curfews.

3.4.9 Specific attention may also need to be given to general aviation, business aviation and charter flights. General aviation activities do not necessarily reflect socioeconomic characteristics of the region or show smooth trends, and the forecasts may need to rely on information provided by stakeholders at the airport within the context of global trends in general aviation. In terms of peak traffic, it may be possible to redistribute general aviation and charter flights away from the peak.

3.5 FACTORS AFFECTING AIRPORT TRAFFIC DEVELOPMENT

3.5.1 Demand for air travel is referred to by economists as a derived demand – passengers fly for a purpose – to conduct business, visit friends and family, undertake leisure activities, etc. Therefore, it is important to identify the factors, both on the demand and supply sides that continue to impact traffic development in a specific aviation market. These can differ considerably between airports and even between segments at any given airport and should therefore be evaluated on a case-by-case basis. The Manual on Air Traffic Forecasting (Doc 8991) covers these factors in detail, but six broad categories of factors are outlined below:

a) Socioeconomic. There is a well-established correlation between economic growth and passenger and cargo traffic growth, which has been observed at the global, national and individual airport levels. Therefore, the forecaster may choose to examine the relationship between traffic and appropriate measure of the economy (national gross domestic product, regional gross value added, household income, etc.). In doing so, it is important that the relationship is well defined and understood. Ideally, the analysis can be conducted for individual market segments and inbound and outbound traffic separately, allowing selection of the most appropriate economic factors for each one. The same would apply to cargo traffic – inbound cargo (imports) may be impacted by the local economy while outbound cargo (exports) may be impacted by the economies of the destination countries or regions. Airport traffic may also be strongly tied to a specific sector of the local economy, such as tourism for passenger traffic or manufacturing or production sectors for air cargo.

b) Air carriers (supply side). The decisions and strategies of air carriers have a significant impact on airport traffic. For example, the growth of low-cost carriers over the last two decades has had a major impact on traffic development at many airports. Consideration needs to be given to the development of incumbent and potential new carriers at the airport, including fleet plans, network strategy and future pricing. Forecasts for airports that handle significant volumes of transfer traffic (or tran-shipment in the case of cargo), will need to take into consideration how the carriers will manage this traffic as demand grows and new aircraft technology emerges. The evolution of various airline business models (growth in certain market segments, airline consolidation, etc.), may also impact traffic development and facility requirements.

c) Market share strategy. Some airports exist within a shared local market from other nearby airports. Many large cities are served by multiple airports. In such cases, it may be necessary to incorporate market segmentation dynamics into the forecast. This may involve forecasting the total demand across a group of regional airports and then modelling the market share captured by each airport. Such traffic can easily shift from one airport to another if more affordable, faster and/or more convenient air services become available. Equally, cargo traffic is highly price-sensitive and can easily shift to alternative routings. In some cases, airports may need to consider the impact of other modes of transportation, such as high-speed rail or super highways on specific markets.

3.5.2 Most airports now actively pursue new and incremental air services through marketing and incentive initiatives. Such incentives may assist an airport to expand its route network and accelerate or stimulate traffic growth. Such strategies may need to be taken into consideration in the forecasts, particularly in the short and medium terms. It is important to document these strategic assumptions when they are being taken into consideration.

a) Technological. Enhancements in aircraft technology have the potential to impact traffic development. For example, more efficient aircraft (e.g. new generation narrow-body aircraft) may make new and longer routes economically viable hence potentially impacting on the need for transfer traffic (hub bypass). Similarly, the retirement of older aircraft models could impact on the level of capacity and frequency operated on some routes and the requirement for airports to provide facilities and equipment for these aircraft (e.g. A380.(

b) Government and regulatory. Government policies and regulations will need to be considered as factors in the traffic forecasts. Although bilateral air service agreements may provide for tailored arrangements that are beneficial and bring about efficiency for both parties, it may also become outdated and therefore potentially limit the growth of international services, if not reassessed while a move towards deregulation (open skies) could lead to more rapid growth in some international markets. Local restrictions on air services due to noise or environmental concerns (e.g. night curfews) will also impact traffic development. Similarly, a country entry regulation usually has a significant impact on the origin and volume of the inbound traffic.

c) Airport constraints. As well as the regulatory requirements mentioned above, the airport may be restricted by physical or operational constraints which need to be reflected in the forecasts. For example, the runway length may be restricted, meaning that it cannot support services from larger aircraft, impacting long-haul traffic growth. Additionally, airspace constraints may restrict the number of aircraft operations at the airport, limiting the growth of aircraft movements. In such a scenario, passenger growth may be accommodated using larger aircraft. In some instances, it may be appropriate to generate unconstrained and constrained forecasts to evaluate the impact of the constraint and the value in its removal it (e.g. traffic forecasts with and without a runway extension.(

3.6 FORECASTING PRINCIPLES

3.6.1 Forecasting requires the coordination of a number of inputs including historical traffic data, historical and anticipated influencing factors, and carrying out analyses to measure their relative impact on future air traffic flows.

3.6.2 The method(s) of forecasting will depend on the available data, on the time and resources available to carry out the forecast, and on the purpose for which the forecast is being developed. A large hub airport handling intricate traffic flows and a multitude of carriers may require a complex and resource-intensive forecasting process, whereas a small airport with steady traffic flows may require a more simplified and less resource-intensive approach.

3.6.3 The forecaster should endeavour to consider all significant data and other information available to ensure that the forecasts are developed with a full and complete understanding of each airport's unique traffic systems and patterns. In order to obtain a reliable background of economic, demographic, trade and technical forecasts to support the demand forecasts, a close liaison with planning bodies in other fields is highly desirable. When additional reliable sources of data are available, such sources can be supplemented for forecasting purposes by market analyses of existing data from carriers and/or by setting up market surveys. Multiple forecasts may need to be generated, reflecting differing scenarios in terms of economic growth, air carrier developments and other factors affecting airport traffic.

3.6.4 A specific distinction can be drawn between forecasting for an existing airport and for an entirely new greenfield airport. An existing airport has generally been operating for many years in a region whose aviation patterns are understood and where the aircraft operators' networks are well developed. Air traffic, passenger and cargo throughput forecasts can largely be based on historical data from the region's air transport system and the airport itself. This data can be used as the baseline from which to project past trends forward, in consultation with key stakeholders such as airline operators, to provide fairly reliable preliminary planning forecasts. Refined forecasts are developed analysing and consulting on factors that may impact future development.

3.6.5 New airports present a different forecasting challenge, particularly if the transport environment is unstable and the region is in a stage of rapid economic development. In such cases, the methods and approaches will also have to differ. The role of market analyses, market surveys and benchmarking against comparable markets and airports is likely to be significant. In some situations, the new airport may be replacing or augmenting an existing airport, in which case analysis of data from that airport can inform the forecasts for the new airport.

3.7 FORECAST APPROACHES AND METHODOLOGIES

3.7.1 There are two broad categories of forecasting techniques that are relevant to airport master planning:1

a) Quantitative methods. These typically involve analysis of historical traffic trends and projecting them forward.

b) Qualitative methods. These are typically based on the expert judgment of informed individuals and can be used when historical data is not available or significant changes are expected that are not captured in the historical data.

.1 Doc 8991 also documents "Decision Analysis" techniques, which can be used for the development of traffic forecasts, although these are not as common.

3.7.2 In practice, a combination of the two approaches is often used – the projections from the quantitative analysis may be adjusted based on expert judgment to capture expected new future trends or step changes in the airport business environment. Equally, qualitative methods may be used to develop short-term scenarios of traffic development (route-by-route bottom-up forecasts) to capture the impact of a new carrier(s) entering the market, which is then combined with the top-down quantitative forecasts to generate long-term traffic projections.

Quantitative methods

3.7.3 The quantitative methods can be broken down into two major subcategories: time series (trend) analysis and casual methods (econometric analysis.(

3.7.4 Time series analysis is based on identifying some long-term underlying growth patterns that fit the behaviour of air traffic in the past. These are single variable forecast models, as only historical traffic data are required to conduct the analysis. The growth pattern considered over time can be a straight line (implying a constant absolute change between successive time periods), asymptotic (implying that development proceeds towards some limiting level at a gradually decreasing rate) or exponential (constant or increasing percentage growth rates). The time series of historical data may need to be smoothed to account for unusual effects, such as terrorism, labour strikes, extraordinary events, etc. The chosen growth pattern is then fitted to the smoothed data and projected forward.

3.7.5 Trend analysis generally uses statistical techniques but can also be carried out roughly visually on graphical plots of historical traffic data. More complex approaches can be applied (i.e. Box-Jenkins method, moving average, exponential smoothing, etc.) to allow for seasonality and other cyclical factors.

3.7.6 Time series extrapolation assumes that all factors influencing air traffic in the past, except for the unusual effects mentioned previously, will continue to influence air traffic in the same way in the future. Even though this is often strictly not the case, trend extrapolation is a useful tool, in that it introduces a degree of objectivity into forecasting. It is a straightforward process that imposes a discipline on presenting the situation in a simple form, which can aid further analysis and/or provide a basis from which to check the validity of forecasts developed independently by other techniques.

3.7.7 One of the major limitations of a time series forecast, is that there may be factors that can reasonably be expected to affect aviation activity at the studied airport in the future that are not reflected in the historical time series, such as slowing down economic growth, changes in traffic mix or airline developments. This limitation can be addressed using casual or econometric methods. Econometric analysis relates a dependent variable (passenger or cargo traffic) to one or more explanatory (or independent) variables. The explanatory variables are those variables which can influence the demand for air travel and can include variables representing such factors as gross domestic product (GDP), population, etc. There are many ways in which the regression can be specified (linear, log-linear, log-log, etc.), with different pros and cons, which the forecaster will need to document and evaluate. Some of the explanatory variables can be specified as dummy variables, which can control one-off factors such as terrorism, labour strikes, air carrier failures, extraordinary events, etc. Separate models can be estimated for individual traffic segments (domestic versus international, inbound visitors versus outbound residents, etc.) with different sets of explanatory variables.

3.7.8 The wide availability of statistical software makes this form of analysis fairly accessible, however, care should be taken to ensure that the formulation is consistent with underlying economic theory. Historical traffic is the outcome of market supply and demand – the amount of air travel consumed at the price at which airlines were willing to provide the service.

3.7.9 There may be an iterative process to determine the final specification of the model (or models). The selection of the final forecasting model should be based on the statistical fit of the model (how well it explains historical traffic) and other statistical measures of the estimation, as well as the plausibility of the model parameters. Traffic forecasts can then be developed by inputting forecast explanatory variables, for example, future projections of GDP or population. These can often be obtained from published sources (government, international intuitions, or private sector) or assumed by the forecaster. Adjustments may be made to the forecasts to reflect anticipated changes or events external to the model (open-skies liberalization, entry of a major new carrier, etc.). These adjustments need to be plausible, documented and fully explained.

Qualitative methods

3.7.10 Qualitative methods can be used when there is a lack of historical data or where the historical data did not generate a plausible model. Qualitative methods can also be used in situations where the future is not expected to adhere to historical patterns due to changes in government policy or the market environment, or for the development of forecasts for a new airport.

3.7.11 One of the most well-established qualitative techniques is the Delphi technique. The Delphi technique is an elicitation technique defined by four key features: anonymity, iteration, controlled feedback and the statistical aggregation of group responses. Typically, a selected group of qualified stakeholders are first presented with a questionnaire in which they are requested to indicate a most probable course of development in future aviation activity. The initial returns are then consolidated and the composite response returned to all contributors giving them the opportunity to revise their original assessments in light of prevailing opinions among others. The Delphi technique is a practical means of bringing together information from many stakeholders and moving towards a consensus outcome.

3.7.12 While these approaches are characterized as qualitative, this does not mean that there is no analytical work involved. Traffic data, airline schedules and market research surveys may be used to inform the decision-making process and ensure that the projections are plausible. In some cases, detailed bottom-up scenarios may be developed to quantify future traffic levels, drawing on the opinion of the surveyed experts.

3.8 DERIVING AIR MOVEMENT AND PEAK PERIOD FORECASTS

3.8.1 The forecasts of aircraft movements and peak periods are typically derived from the forecasts of annual passenger and cargo activities (they are sometime referred to as “derivative forecasts.(”

3.8.2 For passenger aircraft, the forecasts are often derived from passenger numbers and assumptions about the future trends in load factors and average seats per aircraft:

$$\text{Passenger aircraft movements} = \frac{\text{Forecast passenger numbers}}{\text{Average aircraft size} \times \text{average load factor}}$$

3.8.3 This approach can be applied to individual market segments (e.g. domestic mainline, domestic regional, international short-haul, international long-haul). Judgments have to be made about the airline’s ability to achieve higher load factors in the future and the trends in aircraft sizing. Over the 20+ year forecasting period, there are likely to be major airline fleet renewals and restructuring, as well as technological advancements and the aircraft movements forecast needs to reflect all of these factors. Qualitative methods (Delphi, etc.) can be used to illicit stakeholder opinion on future aircraft development, and there may be a need to consider several different scenarios for how airline fleet development and aircraft technology may impact forecast aircraft movements. A similar approach can be used for dedicated cargo aircraft, with the added complication that some cargo may travel in the belly hold of passenger aircraft, and so reasoned assumptions will have to be made about the future proportion of cargo volume carried in this manner.

3.8.4 The peak period forecasts are similarly derived from the annual forecasts, with the exact methodology as a function of data availability, and the peak period metric selected. The peak hour passengers can be derived is by applying the ratios to the forecast of annual passengers. The ratios may be modified over the forecast period to reflect expected changes in traffic development. For example, the busy month ratio may be lowered if more air service is expected in the less busy parts of the year, while the peak hour ratio may be lowered to reflect peak spreading as incremental services are added. The extent to which this occurs needs to reflect the characteristics of the airport and the air service it receives or will receive. An airport with a fairly flat profile over a busy day may experience less peak spreading than one with very pronounced peaks. The capacity to spread the peak depends very much on the demand requirements of passengers, as well as time zone and slot availability at other origin and destination airports. If historical peak hour data is available, correlations between peak hour traffic and annual traffic may provide a fair basis for the future projection.

3.8.5 At smaller airports, a more basic methodology may be more appropriate – a single additional movement in the peak could radically change the peak profile. The method used could lead to different results from a given set of data. Data availability is a major factor in determining the method used.

3.8.6 Further analyses may be needed to examine variations in the peak due to delays, weather restrictions, etc. As long as the limitations of the method chosen are recognized, documented and agreed, they need not pose a problem in that alternatives and cross-checking procedures can be developed. In specific cases, the distribution of traffic categories may differ between the peak and other periods; and that particularly sharp peaking appears to be endemic to long-haul operations, as a consequence of time zones and the advantages of maintaining high aircraft utilization. Sharp peaking often occurs also where local operations are carried out predominantly by "home-based" carriers (e.g. morning departure and evening arrival peaks.(

3.9 ADDRESSING UNCERTAINTY IN TRAFFIC FORECASTS

3.9.1 A viable forecast incorporating different scenarios creates significant value for the airport and its users. The viability of forecasts is subject to many factors, and the timing and size of future requirements needs to be addressed as a variable based on reaching throughput triggers. The longer the period of the forecast, the more scope there is for variations that affect the results and the financial risk involved for error is greater. For example, a consistent annual two per cent traffic growth below forecast becomes a 49 per cent error after 20 years. For this reason, airport master plans and their underlying air traffic forecasts should be updated frequently, every five years being the commonly agreed best practice.

3.9.2 There are a large number of factors that can contribute to the variability of forecasts:

a) Poor forecast methodology or models (specifications and variables that do not capture the factors which actually impact traffic growth.(

b) Use of inaccurate input data, including forecasts of the socioeconomic factors (e.g. gross domestic product (GDP)) expected to affect traffic development.

c) Unexpected changes in socioeconomic conditions (e.g. rapid economic growth, collapse of local industry.(

d) Unexpected changes in market conditions (e.g. bankruptcy or acquisition of a home-based carrier; entry of new model carriers; conversion of a military airfield to civilian use.(

e) Other factors that are difficult to quantify or anticipate (terrorist attacks; pandemics; technological changes; government policy changes; travel restrictions; etc.(.

3.9.3 While it is possible for the forecaster to address the first two points above, it is not possible to fully address the uncertainty associated with the remaining points. Inevitably, a forecast is based on a set of assumptions about what will happen in the future and in what manner and at what time. As there will always be unanticipated events and changed circumstances that will cause traffic to deviate from the expected trend forecast, variability will increase over time. Therefore, the forecasts should explore the range of possible outcomes, and not focus solely on a single outcome.

3.9.4 The traditional approach to addressing uncertainty in air traffic forecasting is to supplement the base "most likely" case forecast with high and low forecasts as indicated in Figure I-3-1. These convey that there is uncertainty in the forecast and provides a range of likely outcomes, but they do not convey any information on the likelihood of such outcomes. Other standard approaches include the use of a "what if" analysis, which generally looks at the impact of a single event, and a sensitivity analysis, which examines the impact of varying key assumptions or model parameters.

3.9.5 These approaches provide airport planners with an understanding of the risk profile facing the airport, but offer little information on the various risk factors that might influence traffic development. Other methodologies have been developed that can provide a greater understanding of the risk and uncertainty associated with the development of air traffic at an airport. Techniques such as the Delphi approach help to identify and assess potential risks, both upside and downside, which the airport may face.

3.9.6 The forecast modelling itself can incorporate the identified risk and uncertainty into the forecasts:

a) Scenario analysis. A large number of separate scenarios can be developed and "played out" to assess the impact of different sets of events occurring together. This can be similar to the high and low forecasts, but developed with a more comprehensive understanding of the risk factors and can explore extreme outcomes to test the robustness of the airport plans.

b) Monte Carlo simulation. A statistical simulation technique that makes use of randomization and probability statistics to generate an often wide range of possible traffic outcomes and provide estimates of the probabilities of such outcomes (e.g. what is the probability, in any given year, of being above or below a specific traffic level). The Monte Carlo analysis has become much more accessible to general users thanks to the availability of specialized statistical software packages.

3.9.7 These forecasting approaches are designed to provide a greater understanding and awareness of future uncertainty. For a particular airport, they can provide a sense of whether the traffic outcome is highly predictable, which might be the case for an established hub undergoing capacity expansion, or highly variable as may be the case for secondary hubs, regional airports and new airports. This understanding can then be used in the airport planning process.

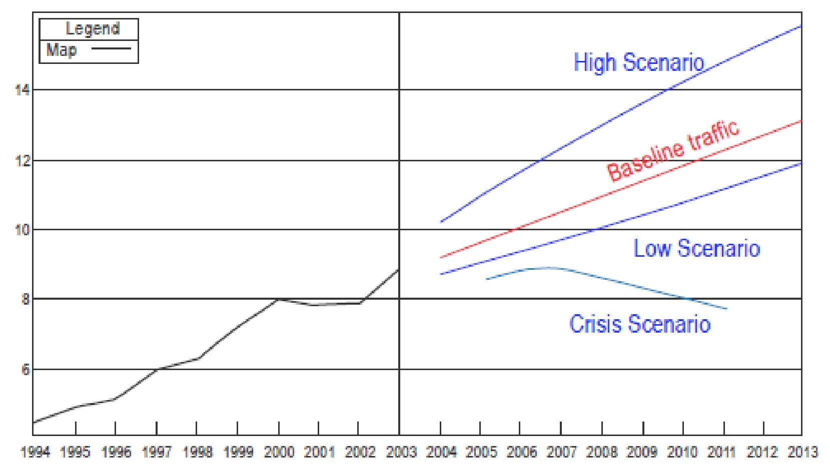


Figure I-3-1. Scenarios in forecasting

3.9.8 The master plan can address this uncertainty directly through more flexible, phased approaches to airport development, such as:

a) basing the phasing of airport development on traffic trigger points rather than specific calendar dates. (e.g. a terminal expansion linked to traffic reaching 20 million passengers per annum rather than a specific year). This can allow airport development to be accelerated or decelerated based on actual traffic growth. Triggers may be based on annual traffic and also peak period traffic;

b) land banking to ensure that land is available for future development as traffic grows. Similarly, protecting terminal space for future uses (e.g. security processes). The space can be designed in such a way that it is productive in the short term (e.g. using the space for commercial activities;(

c) modular or incremental building design that allows building in stages as traffic develops, avoiding the need to commit to a one-time large capacity expansion when it is uncertain when and how it will be needed; and

d) use of swing gates and movable partitions so different traffic types can be accommodated at different times in the same area of a facility (i.e. a swing gate for domestic and international.(

3.10 PRESENTATION OF FORECASTS

3.10.1 Within the limits of available resources, it can be helpful to use more than one method to produce traffic forecasts. Forecasts should address and reflect the uncertainty regarding traffic development at the airport. It is essential that all assumptions, data, and techniques used to generate the forecasts are recorded explicitly. Any adjustments made based on the forecaster's recommendations should be clearly stated and justified.

3.10.2 The forecasts should be presented in a consistent form which allows for periodical updating. The forecasts should be reviewed on a regular basis (every five years or more often if a significant event affected the airport business environment) and revised as necessary. This is likely to also lead to revision of general or specific aspects of the master plan. Significant deviations of the forecasts from actual data, or anticipated changes in the assumptions relating to influencing factors, may well suggest reviews and revision of the forecasts as well as the forecasting methodology used previously.

3.11 SUMMARY

3.11.1 Air traffic forecasting is critical to the airport planning process. The structure, size and nature of the airport are often determined by projections of long-term traffic development. It is therefore important to recognize the need for a sound, documented understanding of the relevant factors affecting traffic and an appropriate methodology for projecting future activity. It is also important that the forecast process is manageable and considers the level of available resources and detail required.

3.11.2 To better inform the planning process, the forecast should consider the uncertainty associated with any projection of future activity. Whether through a scenario analysis, Monte Carlo simulation or other analytical approaches, forecasts can be developed that guide the development of flexible airport master plans that accommodate uncertainty.

Chapter 4 Financial Planning

4.1 ABOUT THIS CHAPTER

4.1.1 This chapter addresses the significance of financing arrangements and financial control in airport master planning and provides guidance for developing practical approaches in these matters. It considers the financing of projects in terms of capital and operational costs, the requirements for domestic and foreign funds to finance the capital investment, the various channels and arrangements through which such financing may be secured, and the sources of income available to an airport for defraying its costs once it becomes operational. It also considers the need for a robust cost-benefit analysis including capital and operational costs, the impact on user charges and the return on investment for all parties to ensure economically sustainable outcomes are delivered.

4.1.2 The policies and key principles for airport charges are set forth in ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082), while the guidance on economic and financial management of airports and establishing airport charges is provided in the Airport Economics Manual (Doc 9562). Chapter 6 of Doc 9562 on "Financing airport infrastructure" specifically addresses various aspects of financing that need to be considered when embarking on an airport infrastructure project.

4.2 PRELIMINARY ECONOMIC FEASIBILITY

4.2.1 The financial challenges of major airport expansion or development of a new airport should not be underestimated. In order to identify the significance of this challenge and the means available to finance such development, very early determination of economic feasibility is a must. Since this is a preliminary consideration, broad order-of-magnitude estimates of the costs can be used. Such estimates will form the basis of the ongoing affordability dialogue with project sponsors, government agencies, financial institutions and ultimately airport users.

4.2.2 Economic feasibility should be determined for each element (land acquisition, airfield, terminals, support facilities, utility supplies, surface access, etc.) of the master plan, over an agreed time period. A thorough business case and cost-benefit analysis must be undertaken from an early stage in the master plan development process, and thereafter at key project development stages, recognizing all master plans should have a clear phasing strategy and considering the iterative nature of airport planning. The most appropriate local, regional and national economic information available at the time should be used to produce forward financial projections, which forms a vital part of the overall analysis. Airport stakeholders should be consulted throughout the business case and cost-benefit analysis process to ensure their requirements are taken into account, and there is a solid return on investment for all parties. As a guide to efficient development, the master plan is not a pre-approval for investment, which requires programme and project development planning along with detailed reviews.

4.2.3 Capital costs to be considered at this stage are broad order-of-magnitude estimates, over a period of years. These include, inter alia, land acquisition (if required), construction, equipment, parts and maintenance, administration and operating costs, and financing fees. Benefits can include the efficient use of existing infrastructure, the cost-efficient development of new capacity to meet demand, improved safety and reliability (i.e. operational resilience), operational efficiency improvements and service quality enhancements. An estimate should be made of the monetary value of the costs and benefits accruing for airport users, passengers, cargo and aircraft as a result of the proposed investment. Major

risks and mitigation plans should also be included in the business case, which will have financial implications. Additionally, the likely impact of the master plan recommendations on the overall economy of the State should be indicated, including effects on the balance of payments and employment, among others.

4.2.4 All of the broad estimates of feasibility made at this early stage of the master planning process will guide the implementation of the various phases of the master plan. High-level inputs typically include traffic forecast demand projections, such as passenger traffic (i.e. number of annual passengers), cargo traffic (i.e. cargo tons per annum) and air traffic movements (i.e. movements in thousands per annum). The development strategies set forth in the master plan must be affordable (both capital and operating costs) immediately and over the entire course of the master plan development term, taking into consideration the availability of funds to finance recommended development phases. For existing brownfield sites, a detailed capacity and demand analysis to ensure existing infrastructure is being used efficiently is important, in advance of new infrastructure being triggered.

4.3 THE ROLE OF FINANCING IN AIRPORT PLANNING

4.3.1 It is vital to determine the sources and extent of the financing means available for the initial provision and continuing operation and maintenance of the prospective airport facilities and services during various phases of the airport master plan. Government grants or loans (sometimes available in turn from international financial institutions), as well as commercially negotiated loans, will be likely to constitute key sources for financing capital costs. In the case of major extensions to existing airport infrastructure, accumulated reserve funds should be used to finance ongoing development phases. Once the availability of adequate capital has been established, a realistic assessment of the annual financial provision is needed to enable the airport to discharge its debt obligations (i.e. capital repayment and interest charges) and build up replacement reserves. For these calculations, the useful economic life (life cycle costing) of the various planned facilities must be calculated taking into account the differing rates of their physical depreciation and obsolescence.

4.3.2 The continuing affordability of the development throughout the construction and development phases and into the operating and maintenance phases must be addressed as an integral part of the airport management's overall financial model. Continuing funding sources include, but are not limited to:

a) shareholder contributions (government and private;(

b) user charges, the establishment of which should comply with the key charging principles set forth in
ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082;(

c) concessions, terms of which should have sufficient flexibility to accommodate changes in the market over time; and

d) rentals.

4.3.3 The traffic forecasts generated to guide the planning and development of airport facilities and services also provide data that support financial projections of the income the airport may derive from user charges. The extent of the contribution to costs realizable from the various means available to airport management, are fundamental elements in the stakeholder engagement process and should be subject to ongoing consultation with strategic planning representatives of the aviation community.

4.4 FINANCING ARRANGEMENTS

4.4.1 The pre-planning consideration questions of economic feasibility, affordability and financing, should produce order-of-magnitude estimates of the costs that will be incurred over time by the proposed airport development project and should broadly identify possible sources of the funds required to defray those costs. As the master planning process proceeds, the magnitude of such costs and when they will be incurred becomes clearer. Forecasts of expected traffic volumes and the definition of potential revenue sources also become more detailed, making meaningful revenue projections possible. This data, in turn, become essential inputs into the preparation of the project's business plan. The financing plan is an important element of the business plan and is, in essence, a blueprint indicating how the costs associated with the project are to be defrayed, and in its preparation, consideration has to be given to both capital costs and operational costs.

4.4.2 The capital costs constitute the investment that the project represents up to its completion, and the operational costs are those which are incurred on a continuing basis once the project, or any part of it (e.g. the first of two planned runways), becomes operational. These two types of costs involve different financing considerations and hence need to be dealt with separately but seen together as part of the overall business plan.

Capital costs

4.4.3 As far as capital costs are concerned, the financing plan needs to provide such basic information as:

a) estimates of the component costs (i.e. labour, materials, equipment) of each distinct part and phase of the overall project;

b) the amount of funds needed for distribution at various stages in the project's progress;

c) the currencies in which payments are to be made; and

d) the sources from which the funds are to be forthcoming, and the applicable conditions (i.e. interest rate and repayment period.(

4.4.4 While high-level cost estimates are typically applied to business cases at a master planning level, there will be significant variations that should be taken into account from project to project. These include, for example, land-use acquisition and development costs, regional variations in labour, materials and logistics. Capital costs should always be independently assessed based on industry benchmarks by qualified experts.

Currency requirements

4.4.5 Where project costs call for payment in foreign funds and the national currency is not freely convertible, it is essential to establish early on how the foreign currency required will be obtained. The provision of the required currency exchange will need to be examined with the appropriate fiscal authorities of the government. For this purpose, a statement should be prepared fully detailing both the foreign currency payments involved, and the extent to which prospective sources of financing for the project can be expected to accommodate foreign exchange challenges. While arrangements securing the loan of foreign funds, or even the provision of foreign goods and services on extended credit terms, serve initially to reduce exchange issues, all such arrangements will continue to be of a legitimate concern to the fiscal authorities of government, since repayment of the debt involved ultimately constitutes a demand on foreign exchange reserves.

4.4.6 The extent to which payment of project costs can be made in domestic currency or will involve foreign exchange, depends on the many and varied factors presented in each situation, and it is therefore only possible to give the following general guide as to the types of costs that might typically be expected to fall into either domestic or foreign currency.

4.4.7 Costs typically payable in domestic currency include:

a) construction work and other services performed by domestic contractors and firms;

b) land acquisition, including associated costs of any easements (e.g. rights-of-way over another's property;(

c) salaries, wages and other related costs of national employees;

d) domestic materials supply and equipment of which the country is not a net importer;

e) interest on domestic credit; and

f) taxes.

4.4.8 Costs typically payable (wholly or partially) in foreign currency include:

a) construction work and other services performed by foreign contractors and firms;

b) imported equipment, materials and supplies;

c) domestic materials of which the country is a net importer;

d) wages, salaries, allowances and other related costs of expatriate personnel; and

e) interest on foreign credit.

Note.— Policy directives and contractual arrangements seeking maximum use of domestic labour and materials can be effective restraints on foreign currency requirements.

Sources of financing

4.4.9 A survey of potential sources of funds to finance the project and the selection of the most appropriate approach, should be undertaken as early as possible in the planning process. This provides an indication of the probability of financing being available from the outset. This also ensures there is adequate time for to complete the preliminaries preceding the conclusion of specific financial arrangements. Early consideration also allows the project governance parties to become versed in the procedural and other requirements of such arrangements, in time to incorporate those requirements directly into the planning process itself.

4.4.10 Potential sources of funds will vary considerably from State to State. Which sources will be approached requires individual study for each project with particular reference to the domestic and foreign currency requirements in each case.

4.4.11 The Airport Economics Manual (Doc 9562), Chapter 6, Part E, provides further guidance on sources of financing.

Domestic sources

4.4.12 Costs to be met in domestic currency may be financed by various means available within the country itself, and include loans and grants from government sources, commercial loans negotiated through banks and other domestic financial institutions, and the extension of credit by contractors and other firms engaged in the project. The higher rates of interest related to commercial loans will usually make this the most expensive form of financing. Government assistance in the form of interest-free loans or grants can appropriately be sought in recognition of the local, regional and national benefits derived from the airports' existence and development. Where revenues are insufficient to cover total operational costs, including depreciation and interest, the execution of any new development project will inevitably depend on government assistance in some measure, and in securing such assistance, the benefits play a particularly important role. As a result of such benefits, financial assistance may be sought from government at both national and local levels (e.g. State, provincial, municipal), but in so doing, the airport should be prepared to demonstrate that the particular communities falling within such jurisdictions derive distinct benefits in addition to those realized nationally.

4.4.13 Where an airport seeks commercial loans directly from banks or other domestic financial institutions, it can expect that forecasts of future operating costs and revenues will be required as a basis for assessing its ability to repay such loans. Where that ability is judged adequate, such commercial financing will probably be obtainable against an appropriate pledge of future airport revenues. However, to the extent that it is found lacking, it is likely that the loan will only be forthcoming if repayment is backed by government or some other acceptable guarantor.

Foreign sources

4.4.14 Project costs payable in foreign funds constitute a demand on the State's reserves of foreign exchange and, as such, their financing will usually have to be arranged through, or with the approval of, the appropriate fiscal authorities of government.

4.4.15 Depending on the magnitude of the costs involved and the state of exchange reserves, it may prove possible to obtain the required financing through domestic institutions. However, where this is not the case, foreign sources will need to be found. In any event, such sources should always be explored as a matter of course, since more favourable financing may be available than that procurable from domestic institutions (lower interest rate, repayment over a longer period, etc.(.

4.4.16 One of the simplest ways of dealing with costs payable in foreign funds is to place the responsibility for financing arrangements on foreign contractors and suppliers who stand to benefit directly from the project. In foreign commercial dealings, it is often the practice for suppliers to be required to state, as part of their bid, the financing arrangements that they are prepared to extend, and for contractors to be given the responsibility for securing the most favourable terms. When applied, such practices will not only help to reduce the financing challenges encountered in airport projects, but will also enable the acceptability of bids to be evaluated from all aspects, including financing. Bidders should be required to quote supply prices separate from the financing charges involved, in order that such charges may be compared with the cost of financing through any alternative source.

4.4.17 Banks, investment houses and other traditional commercial credit institutions operating in the private sector of the country of the contractor providing goods and services for the airport project, may of course themselves be approached directly for financing assistance. However, the cost and other terms of such credit as may be obtainable in this manner are in general likely to be more onerous than those procured from various public sources. Commercial institutions exist in a variety of forms in different countries, and for any particular circumstance those most likely to assist with an airport project are probably best ascertained directly from the government concerned.

4.4.18 Foreign financing may also be available from foreign governments in the form of loans negotiated directly with the government of the recipient country, or may otherwise be facilitated by particular agencies of government that have been established for the primary purpose of promoting the nation's export trade. The development of transport

facilities and the consequential benefits to the national economy as a whole, which are envisaged as resulting from any given project, may evoke the provision of such assistance for various reasons, among them being the desire to promote trade and cultural relations between the two countries. Additionally, as mentioned, the wish to facilitate the export of technology and equipment required for the project and available in the assisting State, may be a further reason for interest. Usually the availability of such assistance, as well as any negotiations subsequently involved, will need to be pursued through the appropriate governmental authorities of the State in which the project is being undertaken.

4.4.19 In the case of developing countries, such assistance may be forthcoming through specific aid programmes, which some governments have established to promote economic and social development. These programmes extend assistance in such forms as loans on preferential terms and the direct provision of supplies, equipment and technology. For projects not qualifying for aid from such sources as these, assistance in meeting the requirements for foreign financing may otherwise be available through the special export-promoting agencies created by certain governments: assistance from these sources takes various forms, including direct loans by the agency itself, guarantees covering private loans, and insurance of the risk assumed by national enterprises in providing goods and services on credit terms.

4.4.20 International institutions that have been established to assist in the financing and execution of projects seeking to promote national economic development are the most important source of foreign financing available to developing States. Prominent among these are the International Bank for Reconstruction and Development (IBRD) and its affiliates – the International Development Association (IDA) and the International Finance Corporation (IFC); the various regional development banks; and the Commission of the European Communities (EC) for the European Regional Development Fund (ERDF.(

4.4.21 As in the case of financing by a foreign government, the possibilities of financial assistance being forthcoming from institutions for any particular airport development project, and the procedures to be followed in applying for such assistance, will need to be ascertained through the government of the country in which the project is being undertaken. There are two main reasons for this:

a) Any loan or grant that may be extended will be made either to a government or government agency, or to a private entity with the support and guarantee of the government.

b) The first test of suitability of a project is whether the sector of the economy in which it falls, and the project itself, are of high priority for development and are so recognized in the government's development plans and whether the project is "affordable" and sustainable, as set out in the overall airport business plan.

4.4.22 The IFC, for its part, has a quite distinct role, which supplements that of the IBRD, its purpose being to further economic development by encouraging the growth of productive private enterprise in member countries, particularly in the less developed areas. Briefly, the means selected for achieving this aim are: to assist, in association with private investors, with the financing of such private enterprises by making investments, with guarantee of repayment by the member government concerned, in cases where sufficient private capital is not available on reasonable terms; to seek to bring together investment opportunities, domestic and foreign capital, and experienced management; and to seek to stimulate the flow of domestic and foreign private capital into productive investments in member countries. The corporation's role is clearly such that airport projects cannot be expected to attract any direct financing assistance, but conceivably there could be situations where domestic financial institutions, endeavouring to find foreign capital for projects of this nature, might find themselves able to benefit from its services.

4.4.23 Another source of financing assistance is the United Nations Development Programme (UNDP). The various kinds of expertise required for the consideration, planning and execution of airport development projects, may be requested from the country's programme of UNDP-funded technical assistance. As well as expertise, funding for necessary airport equipment may also be obtained through the UNDP. Where such technical assistance is sought for any airport development project, the specific requirements will need to be formulated and submitted to the national government for approval.

4.4.24 Recent new sources are financial instruments that provide environmental benefits in order to achieve the United Nations Sustainable Development Goals and avoid the worst climate change effects, such as green bonds, carbon market instruments, green funds, etc., collectively known as "green finance". Airports that plan for sustainable infrastructure projects are often enabled access to these green finance sources that lead to multiple benefits.

4.5 OPERATIONAL COSTS

4.5.1 Brief mention has already been made of the need for careful consideration to be given in the planning process to the future ability of the airport to meet the recurring costs, which have to be defrayed once the airport project, or any part of it, becomes operational. Broadly, such costs comprise operating, maintenance and administrative costs; interest and depreciation or amortization chargeable in respect of capital assets; interest on investment; and any taxes that may be payable on income or property. For convenience, these may be collectively termed operational costs.

4.5.2 Consideration of how such operational costs are to be financed needs to be undertaken based on an estimation of their expected magnitude, year by year, as close as can be made in the planning process. Indispensable to such an estimation will, of course, be the traffic forecasts prepared for the project and the adjustment of operational costs otherwise needing to be made on account of anticipated changes in future price levels. With the magnitude of costs established, the sources of revenue available to the airport for defraying them have then to be identified and, this done, the yields expected from such sources will need also to be estimated as closely as possible, with the traffic forecasts again being used for this purpose.

4.5.3 Operational cost efficiencies should be targeted where capital investments are being made as reflected in the business case process. Capital investments should result in operating cost reductions for all stakeholders.

4.6 SOURCES OF INCOME

4.6.1 The sources of earned income vary. These income sources fall into two broad categories:

a) aeronautical revenues; and

b) non-aeronautical revenues.

4.6.2 Revenues from air traffic operations (a source of aeronautical revenues) are generated from charges for the use of airport facilities and services to meet the basic operational needs of aircraft operators. User charges usually constitute the main source of earned income which is available to an airport for financing its costs. Some examples of charges include:

a) Landing charges (including lighting and approach and aerodrome control charges). Charges and fees collected for the use of runways, taxiways and apron areas, including associated lighting.

b) Passenger service charges. Passenger service charges and other charges and fees collected for the use of the passenger terminal(s) and other passenger-processing facilities (e.g. for passengers embarking or disembarking.(

c) Cargo charges. Cargo charges and any other charges or fees collected in respect of cargo for the use of the airport’s freight-processing facilities and areas.

d) Parking charges. Charges collected from aircraft operators for the parking of aircraft (where not included in the landing charge). Towing charges, if imposed, should also be included under this heading.

4.6.3 Detailed policies and guidance on establishing airport charges have been developed by ICAO, which are available in Doc 9082 and Doc 9562. These documents provide useful advice about which costs may be addressed with aeronautical revenues and which particular kinds of charges they should establish.

4.6.4 Non-aeronautical revenues, as defined in Doc 9562, refers to revenues received by an airport in consideration for the various commercial arrangements it makes in relation to the granting of concessions, the rental or leasing of premises and land, and free-zone operations, even though such arrangements may in fact apply to activities that may themselves be considered to be of an aeronautical character (for example, concessions granted to oil companies to supply aviation fuel and lubricants and the rental of terminal building space or premises to aircraft operators). Also intended to be included are the gross revenues, less any sales tax or other taxes, earned by shops or services operated by the airport itself.

4.6.5 Commercially oriented non-aeronautical activities cover a wide range. The most commonly found activities include, for example, aviation fuel suppliers, Fuels Advisory Body (FaB) concessions, duty-free shops, banks and foreign exchange facilities, airline catering services, transport services (taxis, buses, limousines, ride hailing, etc.) and car parking. Opportunities with the most potential must be determined by each airport in light of its own operational circumstances.

4.6.6 In their overall planning of financing arrangements, airports should bear in mind that user charges and revenues from non-aeronautical sources constitute means not only for defraying operational costs but also for earning foreign exchange. Thus, to the extent that costs, as well as payments falling due in respect of capital loans, have to be met in foreign currency but the country is experiencing a scarcity of foreign exchange, the condition may be imposed that user charges collectible in respect of international operations1, as well as rental or other fees due from concessionaires of foreign ownership, shall be paid in other than national currency. Where payments made in this form come from such foreign enterprises as are accumulating earnings in national funds from their business activities in the country, the net effect of such a condition will be an increase of foreign exchange resources available to the State.

.1 To avoid conflict with Article 15 of the Chicago Convention, such a condition would need to apply to international operations in general, not just those performed by foreign operators.

SECTION II – AIRSIDE DEVELOPMENT

INTRODUCTORY NOTES

The principal factors to be considered for airside elements are outlined in this section, noting some aspects of the plan may require more detailed and intensive study with reference to local conditions and other factors. Runways and taxiways are usually the first to be considered. The capacity of the runway system dictates the phased and ultimate capacity of the airport. Once the dimensional criteria for these critical elements are defined, other functional elements of the airside, such as aprons, airside roads, navigation and traffic control aids, are addressed and integrated with terminal areas such as piers.

A business plan and long-term forecasts are a guide to identify the airside facilities necessary to meet the future demands on the airside system. The air traffic and related passenger forecasts will establish the rate of aircraft movements, the nature of the air traffic, type of aircraft, and other factors that have to be taken into account in planning the layout and dimensions of the runways, taxiways, taxi lanes and aprons. Airfield demand is defined in terms of air traffic movements and expressed in various forms depending on the particular element of the airport being studied.

Before detailed plans can be developed for facilities to meet the many functional requirements of an airport and its users, concepts and options for the various operational systems have to be developed, considered and compared. In process terms, some concepts for individual systems may be incompatible; however, among those which are compatible, the optimum combination can only be determined as the individual plans and their components are developed in parallel and integrated within the master plan.

When overall layouts for runway and taxiway systems and aprons have been developed, all the possible primary options should be considered in conjunction with the placement of the passenger and cargo terminals and aircraft maintenance areas to highlight the best functional schemes and to identify where compromises may be necessary to integrate the planning of the individual elements.

Once the ultimate development potential of an airport has been identified, phased development strategies can be established to balance the capacity and demand of all key master plan elements in order to avoid under, and over investment in facilities, taking note of the large capital cost involved for airports and users.

Chapter 1 Runways And Taxiways

1.1 ABOUT THIS CHAPTER

1.1.1 Runways and their associated taxiways serve as a starting point for consideration of airport layouts due to the large areas of land necessary. While the primary components are developed independently, an awareness of external factors such as topography, obstacle limitations, and intra-airport elements such as passenger and cargo terminal buildings, air traffic, and vehicle access should be taken into account. The objective is to keep all elements of the airport system in balance through an iterative process of reviews and refinements to produce an airport configuration that delivers maximum overall efficiency at the lowest cost, while meeting all the required regulatory and safety standards.

1.1.2 A substantial amount of information exists on the subject of planning and design of airport runways and taxiways. The information in this section provides the airport planner with details relating to airfield dimensions, pavement strength, runway capacity and airport capacity, highlighting the importance of the interdependencies of these elements to the overall airport master planning process. Additional information is available in ECAR 139 –and the EAC139-9– Runways and EAC139-10 – Taxiways, Aprons and Holding Bays.

1.2 ASPECTS AND CONSTRAINTS INFLUENCING AIRSIDE CAPACITY

1.2.1 Airside capacity needs to be clearly defined as a key requirement to meet demand, usually defined by the amount of traffic the airside system can handle within a given period with an acceptable level of delays, and agreed upon with airport users during peak hour operations. The airside infrastructure capacity is influenced by runway capacity, taxiway capacity, apron and aircraft stand capacity, which must be viewed in context with the overall airspace capacity. Airside capacity corresponds to the minimum capacity of all these components and is primarily dependent upon the aircraft mix, based aircraft, system layout and weather conditions that is specific to each airport.

1.2.2 Care must be taken when planning runway operations and their capacity. While the airport's airside infrastructure may provide a certain capacity, it may be possible that the airspace is the limiting factor. This may be due to the proximity of other airfields, the surrounding terrain, airspace restrictions or the type of ATC equipment and procedures in use. For instance, simultaneous operations on multiple runways may result in routing conflicts, which in turn may lead to a lower overall capacity than implied by the separate and individual runway operations themselves.

1.2.3 Determining aircraft fleet mix is a key input and refers to the variety of aircraft operated at an airport. Aircraft mix affects airport capacity, as an aircraft's size, approach speed, and braking ability affecting the length of time the aircraft occupies the runway and the manner in which ATC direct and sequence its activity. Larger aircraft require larger separation distances on approach, have higher approach speeds and longer landing distances, thus impacting runway occupancy time and air traffic movements' capacity. Aircraft spacing requirements are referenced in ECAR 139 , as related EACs and the Manual on Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR) (Doc 9643.(

1.2.4 Other factors that may affect the airport's capacity, include operational caps or restrictions imposed by or agreed with local communities for environmental, political or regulatory reasons. In addition, capacity restrictions may be imposed due to financial issues, such as the availability of capital for investment in expansion, or a user's ability or willingness to fund infrastructure, which should be clear in advance of investment. The lack of human resources to meet demand may also restrict an airport's operational capacity.

1.2.5 The absolute peak refers to the highest 60-minute demand of passengers or aircraft on the busiest day of the busiest month. Although acknowledged while planning airport facilities, this peak is not used as a planning parameter in practice, since it only occurs once a year and would result in over-provision for the rest of the time the airport is in operation.

1.2.6 To avoid over-provision and the inefficient use of capital, a commonly accepted approach is to define an hourly or daily peak which is suitable for planning purposes. The approach to define an hourly or daily peak acknowledges there will be occasions when the infrastructure will be constrained for a short period of time. As the peaks can be predicted, operational procedures and planning can assist to mitigate short-term impacts.

1.2.7 There are various terms and definitions of such a peak hour for planning purposes, and it is very important that there is a consensus on the definition of "peak hour" and "peak day" among all stakeholders involved in the airport master planning process and this consensus definition needs to be carefully documented as a key definition within the master plan document itself.

Capacity and demand correlation

1.2.8 Airport traffic generally occurs in waves, with peak and off-peak times during the day, months and seasons. This is due to the inherent nature of demand and the operation of hub airports reliant on transfer traffic. Depending on the airport and the traffic profile, as stated, developments are usually planned based on a reference peak hour or peak day.

1.2.9 Traffic forecasts agreed upon by the relevant stakeholders will specify the demand for the airport and airside infrastructure as a critical planning input. For airside-related infrastructure, this usually encapsulates, as a minimum, the definition of a design aircraft (with specific performance criteria), air traffic movements per hour and fleet mix. The forecast demand must be translated into specific infrastructure requirements, which determine the specifications of the developments to be undertaken, their sequencing and their phasing. The limitations of forecasting and the possibility of unforeseen events requires that flexibility should be built into the infrastructure demand and layouts, with regular reviews undertaken. For the purposes of master planning, this should be a maximum of every five years and potentially more regularly if major events or a demand shock disruption impacts the defined forecasts. An annual check is recommended in addition, to validate the major planning inputs and assumptions.

1.2.10 Over- or under-provision of facilities can have a significant impact on an airport and the region's attractiveness, connectivity and economic viability. An under-provision of facilities can lead to delays, limit route creation, and increase operational costs, which may cause passengers and airlines to choose other airports. Over-provision of facilities leads to a low return on investment, and can also result in high operating costs that could be unaffordable for users. It is important to provide the right amount of infrastructure to balance capacity and demand for each development phase, and to ensure flexibility in both the size and timing of future development phases.

1.2.11 Figure II-1-1 indicates a common approach to provide adequate capacity for each phase of development with initial minimal over-provision while avoiding under-provision. It shows that infrastructure is planned for the last year of each development phase before the next expansion phase commences operation. Reducing the length of each phase would also reduce the period and amount of over-provision; however, the duration of each phase has to be commensurate with sufficient time for adequate planning, design and construction periods, and a sensible capital expenditure profile.

Capacity evaluation

1.2.12 The purpose of the airfield capacity analysis is to assess the capability of the airfield facilities to accommodate existing and forecast aircraft operations. The task of calculating capacity varies in terms of effort, data requirements and costs. Different methods for calculating capacity may also produce different output metrics. There are, therefore, a range of tools that can be utilized in the analysis.

1.2.13 As a first step, a simple, high-level approach is usually sufficient to evaluate an airside system's capacity. Generally accepted methods, benchmarks and basic spreadsheet-based techniques are initially adequate to arrive at a capacity range which often constitutes the required granularity for master planning purposes.

1.2.14 When the capacity range obtained has to be narrowed down for critical peak hour results or for exact phasing limits, a more analytical approach may be necessary. Sophisticated analysis and calculation tools may be employed, which take a more detailed amount of data into account.

1.2.15 The use of simulation as an evaluation method can be an extremely flexible and dynamic way of evaluating and communicating the effectiveness of new and revised airside layouts. Creating models simulating and visualizing flows on the airside and potentially linked to the airport's landside and terminal can be generated. While the level of detail obtained with this method may not be required for master planning purposes, this can be a very useful approach, on the basis that quality data and planning assumptions inform the model. This must be weighed against the significant cost, time and upfront expenditure required to prepare the model and is not always necessary.

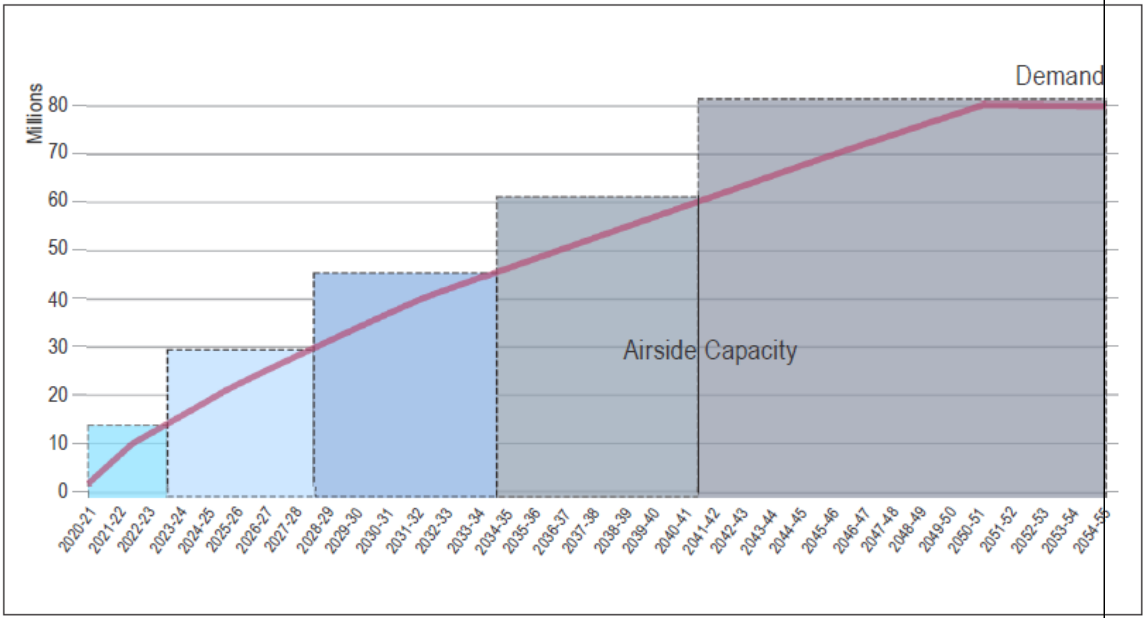


Figure II-1-1. Notional capacity expansion process versus demand

1.2.16 Simulation provides realistic models of airport terminals and other facilities to enable decision support, planning, design, capacity analysis and optimization of airside infrastructure and operational processes. An entire airport system can be analysed as well as individual components, in detail, to:

a) aid the planning of optimal future airport infrastructure developments;

b) identify potential bottlenecks and provide solutions to complex operational problems and planning tasks;

c) improve airside capacity without reducing operational safety and quality;

d) identify the most efficient and cost-effective planning and development options; and

e) support tactical and strategic decision-making for airport operations and management.

1.2.17 If this approach is suitable, applying the modelling tools over a significant period, and using simulation outcomes as a basis for fine-tuning the evolving operational landscape, can promote informed decision-making and performance measurement, particularly in complex and constrained environments.

1.3 AIRCRAFT CHARACTERISTICS AND PERFORMANCE

1.3.1 The airside system design should be based on a critical (or design) aircraft, which is defined in the Procedures for Air Navigation Services (PANS) – Aerodromes (EAC 139-66) as the type of aeroplane that is the most demanding for the relevant elements of the physical characteristics and the facilities for which the airport is intended. This is usually, but not always, the heaviest and largest aircraft that regularly uses the runway. Key inputs to reference are aviation traffic forecasts including consultation with airlines. Consulting with users on their fleet plans and industry trends to inform scenarios is important at this stage.

1.3.2 A general knowledge of aircraft is essential in planning facilities for their use. Aircraft used in airline operations have passenger capacities ranging from 20 to over 500 seats. General aviation aircraft, on the other hand, are normally much smaller in size. In order to present a perspective of the variety of commercial aircraft that make up the airline fleet, Table II-1-1 summarizes their principal characteristics in terms of size, mass, capacity and necessary runway length. The list is by no means complete, but it does include the most common aircraft in use. In a similar manner, some typical general aviation aircraft (including those used for corporate purposes) are shown in Table II-1-2. It is important to recognize that such factors as: operating mass when empty, passenger capacity, cargo load and runway length, can be approximated only in a very general way since there are many variables which can affect these items.

a) Mass. Aircraft mass is important for determining the thickness of runway, taxiway and apron pavements. The aircraft's mass and load factor also affect runway length requirements.

b) Size. The wingspan and the fuselage length influence the size of parking aprons, which in turn influences the configuration of the passenger terminal building(s) (PTB(s)) should they have contact stands available enabling direct passenger access. Size also dictates width of runways and taxiways (through the outer main gear wheel span (OMGWS)) as well as distances between these traffic ways.

c) Capacity. The passenger capacity has an important bearing on facilities within and adjacent to the passenger building, as well as support facilities.

d) Take-off and landing performance. The incorporation of engine performance and appropriate flap settings, combined with payload, fuel and prevailing site factors, during take-off and landing procedures, influence the runway length.

1.3.3 An examination of Tables II-1-1 and II-1-2 reveals the following: maximum take-off mass of principal airline aircraft varies from 33 000 kg to 575 000 kg. For small general aviation aircraft, the range in mass is from 600 kg to 3 600 kg, while corporate aircraft vary from 6 800 kg to 25 800 kg. The maximum number of passengers carried by commercial airline aircraft varies from 20 to over 500. Alternatively, small general aviation aircraft seat from two to six individuals, and corporate aircraft from less than 10 to nearly 30 people depending on the configuration of the interior. Runway lengths for typical passenger or cargo aircraft vary from 2 100 m to 3 600 m at international standard atmosphere (ISA) conditions, but it is important to note that it is not valid to assume that the larger the mass of an aircraft, the longer the runway length required. The trip length has an influence on take-off mass and thereby the required runway length. Therefore, in the analysis of runway length requirements, an estimate of trip length is very important. Runway lengths for small general aviation aircraft seldom exceed 600 m, while for corporate aircraft they are about 1 500 m.

1.3.4 In Tables II-1-1 and II-1-2, aircraft are referred to according to the type of propulsion and thrust-generating medium. The term "piston engine" applies to all propeller-driven aircraft powered by gasoline-fed reciprocating engines. Many small general aviation aircraft are powered by piston engines. The term "turboprop" refers to propeller-driven aircraft powered by turbine engines. Some of the higher performance general aviation aircraft (both singles and twins) as well as some regional airline aircraft use turboprops. The term "turbojet" refers to those aircraft which are not dependent on propellers for thrust, but which obtain the thrust directly from a turbine engine, such as early jet airline aircraft. When a fan is added in the front or rear of a turbojet engine, it is referred to as a "turbofan". Nearly all airline transport aircraft are now powered by turbofan engines, as they are more economical.

Table II-1-1. Characteristics of principal transport aircraft[1]

Aircraft	*Manufacturer*	*Wingspan (m)*	*Length (m)*	*Maximum structural take-off mass (m)*	*Maximum landing mass (kg)*	*Number of seats[2]*	*Runway length required (m)[3]*
A300	Airbus	44.83	54.08	165 000	138 000	267-375	2240
A318	Airbus	34.10	31.45	68 000	57 500	107-132	1400
A319NEO	Airbus	35.80	33.84	75 500	63 900	124-156	1750
A320NEO	Airbus	35.80	37.57	79 000	67 400	150-180	2190
A321NEO	Airbus	35.80	44.51	93 500	79 200	185-220	2210
A330-300	Airbus	60.3	63.67	242 000	182 000	277-440	2300
A330 NEO	Airbus						
A350-900	Airbus	64.75	66.61	275 000	207 000	315-440	
A350-1000	Airbus	64.75	73.59	308 000	233 000	369	
A380	Airbus	79.75	72.73	575 000	394 000	544-853	2970
B737-7MAX	Boeing	35.92	33.63	72 348	61 462	126-140	1800
B737-8MAX	Boeing	35.92	39.47	82 191	69 309	162-175	2300
B737-9MAX	Boeing	35.92	42.11	88 314	74 344	180-204	2300
B747-400	Boeing	64.92	69.85	396 894	285 764	416-500	3300
B747-8	Boeing	68.40	76.25	447 696	312 072	467	3190
B757-200	Boeing	38.06	47.32	115 650	95 250	180-228	1900
B767-200ER	Boeing	47.57	48.51	179 169	136 078	216-290	2700
B767-300ER	Boeing	47.57	54.94	186 880	145 150	204-290	2900
B777-200ER	Boeing	60.93	63.73	286 900	208 700	305-440	2900
B777-300ER	Boeing	64.80	73.86	351 535	251 290	339-550	3000
B777-9	Boeing	64.8-71.8	76.70	351 534	-	400-425	
B787-8	Boeing	60.12	56.72	227 930	172 365	242	2820
B787-9	Boeing	60.12	62.81	254 011	192 777	290	2900
Q200	Bombardier	25.89	20.78	16 466	15 650	37	1000
Q400	Bombardier	28.42	32.83	29 257	28 009	70-78	1300
E175	Embraer	28.65	31.68	40 370	34 100	76-88	1644

Aircraft	*Manufacturer*	*Wingspan (m)*	*Length (m)*	*Maximum structural take-off mass (m)*	*Maximum landing mass (kg)*	*Number of seats*[2]	*Runway length required (m)*[3]
E190	Embraer	28.72	36.24	51 800	44 000	96-114	2056
SSJ100	Sukhoi	27.80	29.94	49 450	41 000	98	2052
CS100	Bombardier	35.10	34.10	60 781	52 390	120	1463
CS300	Bombardier	35.10	38.70	67 585	58 740	130-160	1890
MRJ90	Mitsubishi	29.20	35.80	42 800	38 000	88	1740
ATR42-600	ATR	24.57	22.67	18 600	18 300	48-50	1000
ATR72-600	ATR	27.05	27.17	23 000	22 350	68-74	1500
Saab 340	Saab	21.44	19.73	13 155	12 925	27-34	1300
Saab 2000	Saab	24.76	27.28	23 000	22 000	50	1300
Tu-204	Tupolev	42.00	46.00	108 000	89 500	166-215	1780
MC-21-300	Irkut	35.9	42.3	79 250	69 100	163	

1. See the *Airport Design Manual* (Doc 9157), Part 1 – *Runways, for the latest aeroplane classification by code number.*
2. Number of seats includes the pilot.
3. Under ISA conditions, 0% slope.

Table II-1-2. Characteristics of general aviation and commuter aircraft

Aircraft	*Wingspan (m)*	*Length (m)*	*Maximum take-off mass (kg)*	*Maximum no. of seats[1]*	*Number and type of engine[2]*
Beech 23-Musketeer(s)	9.98	7.62	997.90	4	1P
Beech V35-Bonanza	10.19	8.03	1 542.21	6	1P
Beech 58-Baron	11.53	9.07	3 073.09	6	2P
Beech B80-Queen Air	15.32	10.82	3 991.61	11	2P
Beech B200-Super King Air	16.61	13.34	5 670.00	15	2TP
Beech Model 1 900	16.61	17.63	7 530.00	21	2TP
Bellanca 260C	10.41	6.99	1 360.78	4	1P
Cessna 150	9.96	7.01	725.75	2	1P
Cessna 172 Skyhawk	10.90	8.20	1 043.26	4	1P
Cessna 180 Skylane	10.92	8.53	1 338.10	4	1P
Cessna T310	11.25	8.99	2 494.76	6	2P
Cessna Conquest II	15.04	11.89	4 468.00	11	2TP
Cessna Citation III	16.31	16.90	9 525.00	11	2TF
Dassault-Jet Falcon 20T	16.54	18.29	13 199.54	28	2TF
Gulfstream II	20.98	24.36	26 081.56	22	2TF
Lear Jet 25	10.85	14.50	6 803.89	8	2T
Lockheed Jet Star	16.59	18.42	19 050.88	12	4T
North American Sabreliner-60	13.54	14.73	9 071.85	12	2T
Piper PA-23-250 Aztec	11.33	9.22	2 358.68	6	2P
Piper PA180 Cherokee Archer	9.75	7.32	1 110.00	4	1P
Piper PA-28R-201 Cherokee Arrow III	10.67	7.62	1 247.00	4	1P
Piper Twin Comanche C	10.97	7.67	1 632.93	6	2P
Piper PA-31T2	12.40	11.18	4 297.00	8	2TP
Piper PA-42	14.53	13.23	5 080.00	11	2TP
Piper T 1040	12.52	11.18	4 082.00	11	2TP

1. Number of seats includes the pilot.
2. P = piston engine; T = turbojet; TF = turbofan; TP = turboprop.

1.4 RUNWAY CONFIGURATION AND CHARACTERISTICS

Dimensional criteria

1.4.1 In order to provide a guide for airport planners and a certain amount of uniformity in airport take-off and landing facilities, relevant criteria have been established in Annex 14, This guide outlines any criteria involving widths and gradients of runways and other features of the landing area that must incorporate wide variations in aircraft performance, pilot technique and weather conditions. These are primarily formed to create safety requirements for aircraft, while noting that should these not be achieved, capacity and operating restrictions are likely to be imposed on users, for instance, aircraft take-off weight, aircraft type restrictions. In practice, the objective is to identify options to deliver the optimal business solution considering many factors, including airport and airline needs, capital and operating costs, among many others.

1.4.2 For the purpose of identifying standards for various sizes of airports and the functions they serve, airport reference codes have been developed to inform airfield facility requirements and the amount of land required. The intent of the reference code is to provide a simple method for interrelating the numerous specifications concerning the characteristics of airports, so as to provide a series of airport facilities that are suitable for the aircraft that are intended to operate at the airport. The methodology interrelates the numerous specifications concerning design characteristics leading to groups of airport facilities that are matched to the aircraft types that can operate on the runway. The basis for the code is the aeroplane reference field length and wingspan as shown in Table II-1-3 (Table 1-1 of ECAR 139 .(

Table II-1-3. Airport reference code

Code element 1	
Code number	**Aeroplane reference field length**
1	Less than 800 m
2	800 m up to but not including 1 200 m
3	1 200 m up to but not including 1 800 m
4	1 800 m and over
Code element 2	
Code letter	**Wingspan**
A	Up to but not including 15 m
B	15 m up to but not including 24 m
C	24 m up to but not including 36 m
D	36 m up to but not including 52 m
E	52 m up to but not including 65 m
F	65 m up to but not including 80 m

1.4.3 Determining the critical aircraft type(s) is essential to establishing the principal elements required for a runway as follows:

a) the length, width and structural characteristics of the pavement, which supports the aircraft load and provides surface characteristics for the safe operation of the aircraft;

b) the shoulders adjacent to the structural pavement, which are designed to resist erosion due to jet blast and to accommodate maintenance equipment and patrol vehicles;

c) the runway strip, which includes the structural pavement, shoulders and an area that is cleared, drained, and graded. This area should be capable of supporting fire, crash, rescue and snow removal equipment under normal conditions, as well as providing support for aircraft in case they veer off the pavement;

d) the blast pad, which is an area designed to prevent erosion of surfaces adjacent to the ends of runways, which are subjected to sustained or repeated jet blast. This area is either paved or planted with turf; and

e) a runway turn pad is required to facilitate a 180-degree turn of aircraft where the end of a runway is not served by a taxiway or a taxiway turnaround and where the code letter is D, E or F. Such areas may also be useful if provided along a runway to reduce taxiing time and distance for aircraft, which may not require the full length of the runway. The runway turn pad may be located on either the left (preferred) or right side of the runway and adjoining the runway pavement at both ends of the runway, and at some intermediate locations where deemed necessary. The design of a runway turn pad should correspond with guidance found in the EAC139-9– Runways.

1.4.4 Other runway elements include safety surfaces, such as runway end safety areas (RESAs), stopways, clearways and arresting systems, where applicable.

Runway length contributory factors

1.4.5 The factors that have a bearing on determining the required runway length are fully described in Chapter 3 of EAC139-9 These may be grouped into two general categories:

a) aircraft related factors; and

b) site related factors.

1.4.6 The aircraft related factors are:

a) take-off weight which refers to the weight of the aircraft during take-off. The runway length is determined by the critical design aircraft at its highest weight at which the pilot is allowed to attempt to take-off. The design objective for a primary runway is to provide a runway length for all aircraft that will regularly use it without causing undesirable operational weight restrictions. The take-off weight of an aircraft comprises of:

(1 operational empty weight which refers to the structural weight of the aircraft;

(2 payload refers to the weight which the aircraft is transporting (i.e. passenger weight, baggage and/ or cargo weight); and

(3 fuel refers to the amount of fuel being carried by the aircraft at the point of take-off;

b) performance which refers to the operational characteristics of the engines used by aircraft and the flap settings aiding the lift-off. The engine thrust will have a direct impact on the time taken to reach the desired velocity for take-off.

1.4.7 The site-related factors are:

a) Temperature. The higher the temperature on site, the longer the runway required because high temperatures reflect lower air densities, resulting in lower output of thrust. For a more detailed discussion of temperature effect on aircraft performance and definition of “airport reference temperature” refer to ECAR 139 and EAC 139-9.

b) Surface wind. The greater the headwind component of the prevailing wind the shorter the length required for the take-off run. Conversely, a tailwind increases the length of runway required. For airport planning purposes, the most onerous case usually assumed is no wind.

c) Runway slope. An uphill gradient requires more runway length than a level or downhill gradient. Reference should be made to the average correction factors in Annex 14. For airport planning purposes only, ECAR 139 uses an "average longitudinal slope" computed by dividing the difference between the maximum and minimum elevation along the runway centre line by the runway length, to generate a given slope percentage.

d) Airport elevation. All other things being equal, the higher the altitude of the airport, the longer the runway required. It is always desirable to utilize specific aircraft data from the respective aircraft characteristics for airport planning manuals, as issued by most aircraft manufacturers.

e) Condition of the runway surface. A contaminated (wet, snow-covered, ice-covered) runway surface will increase the length of runway required for take-off or landing. The specific amount depends on the type of contaminant. A study of the climatological condition will indicate whether water, snow, slush, ice, etc., may be expected to be frequently found on a runway.

1.4.8 How much these conditions affect runway length can only be approximated. However, "orders-of-magnitude" can be beneficial for planning and are therefore presented in that context.

1.4.9 Both take-off and landing requirements need to be considered when determining the length of runway to be provided and the need for operations to be conducted in both directions of the runway. With take-off requirements being more stringent in most cases, the runway length is determined by the aircraft requiring the longest take-off run and accelerate-stop distances.

1.4.10 For further details regarding runway length corrections, refer to the EAC139-9– Runways.

Runway safety areas

1.4.11 Specifications on runway safety areas are contained in ECAR 139 and are defined by the following principal elements:

a) The runway end safety area (RESA) is an area symmetrical about the extended runway centre line and adjacent to the end of the runway strip, intended to reduce accidents of aircraft undershooting or overrunning the runway.

b) A stopway is a defined rectangular area on the ground at the end of take-off runway available, prepared as a suitable area in which an aircraft can be stopped in case of an abandoned take-off. The stopway pavement must have adequate strength to support occasional aircraft loadings. The length of the stopway is not included in the published length of the runway; however, the airport authority can specify that the stopway may be used by aircraft operators to determine the allowable take-off mass for an aircraft. The additional take-off pavement length will permit aircraft operators to increase the take-off mass of aircraft by using the length of the runway plus the length of the stopway to calculate the total length of pavement available in the event of an aborted take-off. A detailed description of stopway requirements can be found in EAC139-9 .

c) A clearway is a defined rectangular area on the ground or water selected or prepared as a suitable area over which an aeroplane may make a portion of its initial climb to a specified height. It is an unobstructed, unpaved area also beyond the end of the runway which is controlled and maintained by the airport authority. By designating an area off the end of the runway as a clearway, an aircraft operator can increase the allowable take-off mass of an aircraft because the climb rate requirement of the aircraft can be reduced, as the operator is assured that no obstructions exist in the clearway. A detailed description of clearway requirements can be found in EAC139-9 It should be noted that the use of clearways and stopways in determining allowable take-off mass for an aircraft is not common operating procedure for most aircraft operators; however, they can be effective methods for increasing allowable take-off mass under certain conditions.

d) Clear and graded area is an area whereby the runway strip is cleared of all obstacles except for specified items and is also graded, intended to reduce the risk of damage to an aircraft running off the runway. Further guidance regarding the clear and graded area is given in EAC139-9 .

1.4.12 If the provision of a RESA to its specified dimensions is not possible, the installation of an arresting system should be considered. An arresting system predictably and reliably crushes under the weight of an aircraft, providing deceleration and a safe stop. If an arresting system is installed, the length of a RESA may be reduced, based on the design specification of the system, subject to acceptance by the appropriate authority. It is an acceptable alternative for preventing overrun catastrophes at airports where full RESAs do not exist or are impractical due to environmental or other issues. EAC139-9 has outlined that arresting systems are an effective system in arresting aircraft overruns.

Runway configuration

1.4.13 Guidance for airport planners on the characteristics of each of the runway configurations outlined below are detailed in Figure II-1-2. The runway configuration is determined by the operational requirements of the airport, airspace layout and airport land-use constraints, and environmental considerations such as noise and air quality. For master plans, runway configurations should be planned accounting for the ultimate development potential of the site to safeguard the required land and identify the optimum configuration, in addition to the phasing strategy and nearer term developments. This is essential to maximize overall efficiency and avoid future expansion issues. A number of typical options exist with the following pros and cons.

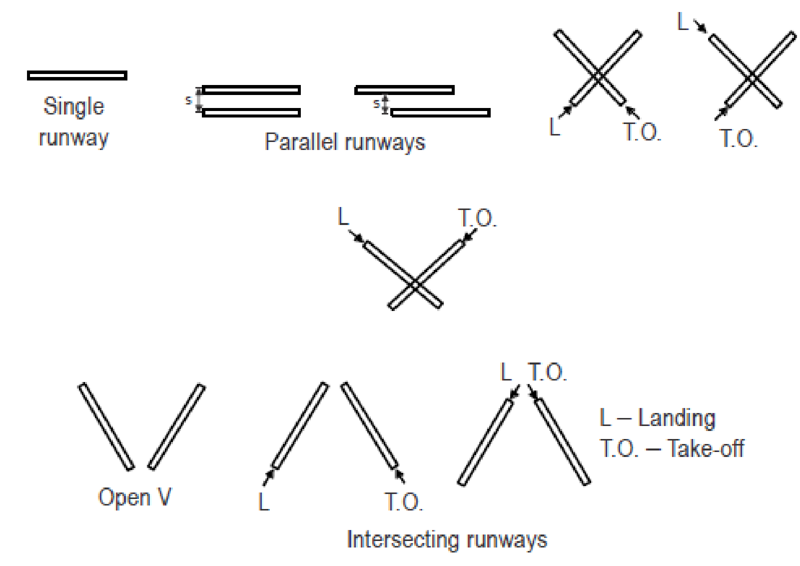


Figure II-1-2. Runway configuration

Parallel runway configuration

1.4.14 The parallel runway configuration is an arrangement in which two or more runways intended for simultaneous use are offset from each other by a recommended minimum distance, as specified in Table II-1-4. This configuration is the one most commonly used at multi-runway commercial airports, as it enables simultaneous operations, high runway capacity and generally simplifies further expansion.

1.4.15 International best practice (refer to IATA's Airport Development Reference Manual (ADRM) at https://www.iata.org/en/publications/store/airport-development-reference-manual) indicates that a separation of approximately 2 000 m delivers optimum space for midfield terminal and apron facilities while keeping the airport site relatively compact; this is recognized as exceeding the minimum separation for safety purposes defined in ECAR 139 .

1.4.16 Site constraints such as operational or topographical factors have to be considered. "Near-parallel" runways are non-intersecting runways whose extended centre lines have an angle of convergence or divergence of 15 degrees or less.

Open V runways

1.4.17 These runways constitute a runway configuration in which two runways diverge from different directions but do not intersect each other. For diverging runways, simultaneous take-offs are permitted subject to favourable wind conditions. Converging runways may also permit simultaneous arrivals subject to missed approach procedures and other factors.

1.4.18 Intersecting runways constitute a runway configuration in which two or more runways cross each other. This configuration may be beneficial when relatively strong prevailing winds from more than one direction occur during the year (or to ensure wind coverage for smaller aircraft). There are inherent risks associated with intersecting runways, most notably runway incursions that should be managed by implementing strict procedures. Intersecting or open V runways are not generally recommended for the purpose of increasing capacity, as simultaneous operations may be severely limited that will reduce capacity compared with alternative configurations.

Runway orientation

1.4.19 Many factors affect the determination of the orientation, siting and number of runways. One important factor is the usability factor, as determined by the wind distribution, which is discussed below. Another important factor is the alignment of the runway to facilitate the provision of approaches conforming to the approach surface specifications. Runways are designated in relation to their magnetic headings or compass alignment, rounded to the nearest 10 degrees. The objective is to ensure safety is not compromised while ensuring the most efficient runway orientation is selected to avoid capacity constraints and to meet the defined business needs.

1.4.20 When a new instrument runway is being located, particular attention needs to be given to areas over which aircraft will be required to fly when following instrument approach and missed approach procedures, so as to ensure that obstacles in these areas or other factors will not restrict the operation of the aircraft that the airport is intended to serve. In practice, the number and orientation of runways at an airport should be such that the usability factor of the airport would normally not be less than 95 per cent for the range of aircraft that the airport is intended to serve.

1.4.21 The number and orientation of runways at an airport should be such that the usability factor of the airport is optimized considering that safety is not compromised. The length of the runway should provide declared distances adequate to meet the operational requirements for the aircraft which the runway is intended to serve.

1.4.22 The following distances should be calculated for each runway:

a) take-off run available;

b) take-off distance available;

c) accelerate-stop distance available; and

d) landing distance available.

1.4.23 The length of the runway is measured from the start of the runway pavement or where a transverse stripe marking is provided to indicate threshold displacement, at the inner edge of the transverse stripe across the runway.

1.4.24 While many factors are relevant in the determination of the siting, orientation and the number of runways, it is useful to list those which most frequently require study. These factors may be classified under the following four headings:

Type of operation. Attention should be paid to whether the airport is to be used in all meteorological conditions or only in visual meteorological conditions, and also whether it is intended for use by day and night, or only by day.

Climatological conditions. A study of the wind distribution (wind rose) should be made to determine the usability factor. In this regard, the following comments should be considered:

a) wind statistics used for the calculation of the usability factor are normally available in ranges of speed and direction, and the accuracy of the results obtained depends, to a large extent, on the assumed distribution of observations within these ranges. In the absence of any data as to the true distribution, it is usual to assume a uniform distribution since, in relation to the most favourable runway orientations, this generally results in a slightly conservative usability factor;

b) the maximum mean crosswind components given in ECAR 139 , SUBPART f, refer to normal circumstances. There are some factors which may require that a reduction of those maximum values be taken into account at a particular airport. These include:

(1 the wide variations that may exist, in handling characteristics and maximum permissible crosswind components, among diverse types of aircraft (including future types;(

(2 prevalence and nature of wind gusts;

(3 prevalence and nature of turbulence, down drafts, etc;.

(4 the availability of a secondary runway;

(5 the width of runways;

(6 the runway surface conditions – water, snow and ice on the runway materially reduce the allowable crosswind component; and

(7 the strength of the wind associated with the limiting crosswind component. A study should also be made of the occurrence of poor visibility and/or low cloud base. Account should be taken of their frequency as well as the accompanying wind direction and speed.

Topography of the airport site, its approaches, and surroundings, particularly:

a) compliance with the obstacle limitation surfaces (OLSs;(

b) current and future land-use. The orientation and layout should be selected so as to protect as far as possible the particularly sensitive areas, such as residential, school and hospital zones from the discomfort caused by aircraft noise;

c) current and future runway lengths to be provided;

d) construction costs; and

e) possibility of installing suitable non-visual and visual aids for approach-to-land.

Air traffic in the vicinity of the airport, particularly:

a) proximity of other airports or ATS routes;

b) traffic density; and

c) ATC and missed approach procedures.

Pavement strength

1.4.25 Aircraft cannot be operated safely on the ground without full knowledge of the loading characteristics of the aircraft and the load bearing properties of the airport pavement on which it is to operate. The evaluation of pavements is a very complex process, with several possible analytical approaches; these are described in the EAC139-11 – Pavements.

1.4.26 The surface of a paved runway should be constructed to provide good friction characteristics when the runway is wet. The average surface texture depth of a new surface should be not less than 1.0 mm as stated in the EAC139-19– Pavement Surface Conditions.

Defining runway capacity

1.4.27 Runway capacity, also referred to as runway-taxiway system capacity, is dependent on the efficiency of the runway entry and exit taxiway system, use of parallel taxiways and holding bay locations. Expected fleet mix, airline operational requirements, arrivals and departures mix, runway configuration and acceptable delays will also have a critical role in the achievable runway capacity. Various options should be considered to identify the optimum balance between these elements to meet the defined facility requirements in a cost-efficient manner.

1.4.28 For example, the Federal Aviation Administration (FAA) has a procedure to compute runway capacity and aircraft delay for airport planning and design. It defines “capacity” as the throughput rate, that is, the maximum number of operations that can take place in an hour, and “delay” as the difference in time between a constrained and an unconstrained aircraft operation. These definitions take into account that delays occur because of simultaneous demands on the facility. The acceptable level of delay will vary from airport to airport or may be defined by the appropriate national regulator (civil aviation authority, etc.(.

1.4.29 The throughput method for calculating runway capacity and average delay per aircraft, is derived from computer models used by the FAA to analyse airport capacity and reduce aircraft delay. Calculations of hourly capacity are needed to determine the average delay. Since airport and airport component hourly capacities vary throughout the day due to variations in runway use, aircraft mix, ATC rules, etc., a number of calculations may be needed. Further details are available in the FAA Advisory Circular “Airport Capacity and Delay” (l50/5060-5) and ARCP Report 79 Evaluating Airfield Capacity.

1.4.30 Based on the FAA methodology, the annual capacity of a single runway airport configuration, for example, could exceed 270 000 operations depending on the traffic mix, suitable airspace availability and ATC facilities. However, the development of an additional runway based on capacity requirements may be considered for airports with a current demand level below 150 000, if traffic is increasing and it is expected to exceed those levels by the time a new runway is operational. Besides the capacity requirements, some airports may warrant an additional runway to avoid total airport closure in case of an aircraft incident, runway maintenance or repair, snow removal, partial unlawful seizure of an airport, or unplanned runway occupancy by an inoperable aircraft, subject to a review of costs, benefits and a business case consulted upon with airport users.

1.4.31 The following criteria may be used to determine the need for an additional option to increase capacity:

a) a parallel runway may be planned when the demand is forecast to reach the existing runway capacity during the ensuing five years; and

b) although intersecting or open V runways are not generally recommended for the purpose of increasing capacity, consideration of terrain, noise, obstacles may make these layouts more practical. It should be demonstrated that the configuration chosen will provide sufficient runway capacity to accommodate demand into the foreseeable future or will provide a substantial increase in runway capacity at a considerably lower cost compared to provision of a parallel runway. A comparison of capacities with a parallel runway configuration should be made.

1.4.32 For parallel non-instrument runways, the minimum distance between their centre lines relative to their intended operational nature, should be as stated in Table II-1-4. For parallel instrument runways, subject to conditions specified in the Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM, Doc 4444) and the Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS, Doc 8168), Volume I – Flight Procedures, the minimum distance between their centre lines relative to the intended operational nature, should be as stated in Table II-1-4, except for segregated parallel operations whereby the specified minimum distance:

a) may be decreased by 30 m for each 150 m that the arrival runway is staggered towards the arriving aircraft, to a minimum of 300 m; and

b) should be increased by 30 m for each 150 m that the arrival runway is staggered away from the arriving aircraft.

1.4.33 Mixed mode operations on parallel runways tend to deliver the highest capacity. Mixed mode can be operated as terminal-based (i.e. certain terminals use a specific runway only) or compass-based (where the runway use is determined by the direction of the route flown.(

1.4.34 Segregated mode operations are also common, with arrivals and departures taking place on separate runways. This mode reduces airspace constraints, congestion on the taxiway system and noise impacts.

1.4.35 Further guidance on determination of minimum distances between parallel runways for simultaneous use under instrument flight rules (IFR) is available in the Manual on Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR) (Doc 9643.(

Table II-1-4. Runway separations

Minimum separation distance (m) (between centre lines)	Simultaneous use of parallel instrument runways
1 035	Independent parallel approaches
915	Dependent parallel approaches
760	Independent parallel departures
760	Segregated parallel operations

Minimum separation distance (m) (between centre lines)	Simultaneous use of parallel non-instrument runways
210	Where the higher code number is 3 or 4
150	Where the higher code number is 2
120	Where the higher code number is 1

Displaced thresholds considerations

1.4.36 A displaced threshold is a threshold not located at the extremity of a runway. While it is unlikely to be desirable to maximize efficiency in airport planning, in some cases due to local conditions, it may be desirable to displace the threshold permanently. When studying the location of a threshold, consideration should also be given to the height of the instrument landing system (ILS) reference datum and/or microwave landing system (MLS) approach reference datum and the determination of the obstacle clearance limits of which are detailed in Annex 10 – Aeronautical Telecommunications, Volume I – Radio Navigation Aids and the EAC139-23– Control of Obstacles.

1.4.37 For master planning purposes, the significance of a threshold displacement lies in the reduction of the effect the approach surface has on the airport's surrounding, thereby mitigating noise disturbance as aircraft overfly a certain location at a higher altitude than without threshold displacement. Buildings and other structures are less likely to infringe the approach surface. In addition, as the approach lights would be relocated towards the runway end by the same distance as the threshold displacement, land-use impacts of such lights are less severe, thus aiding a more compact airport area.

1.4.38 Displacement of the threshold from the runway extremity will inevitably cause reduction of the landing distance available, and this may be of greater operational significance than penetration of the approach surface by marked and lighted obstacles. A decision to displace the threshold, and the extent of such displacement, should therefore respect an optimum balance between the considerations of clear approach surfaces and adequate landing distance.

1.4.39 When not used for aircraft landing operations, the displacement distance between runway end and threshold is still available for take-off operations, thereby not reducing the take-off run available in the same runway direction.

1.5 OBSTACLE LIMITATION SURFACES

Note.— Specifications related to obstacle restriction and removal are currently available in ECAR 139 , subpart G. At the time of publication of this EAC , these specifications are currently under comprehensive review based on extensive work and detailed studies over the past several years and significant changes and improvements are anticipated.

Characteristics of obstacle limitation surfaces

1.5.1 Obstacle limitation surfaces (OLSs) define the airspace around airports to be maintained free from obstacles. This permits the intended aircraft operations at the airports to be conducted safely and to prevent the airports from becoming unusable by the growth of obstacles around the airports. This is achieved by establishing a series of OLSs that define the limits to which objects may project into the airspace. Airport planners should attempt to limit the impact of OLSs to avoid operating capacity constraints, where feasible and practical to do so.

1.5.2 Objects that penetrate the OLSs may, in certain circumstances, cause an increase in the obstacle clearance altitude/height for an instrument approach procedure or any associated visual circling procedure or have other operational impact on flight procedure design. Criteria for flight procedure design are contained in the Procedures for Air Navigation Services – Aircraft Operations (Doc 8168.(

1.5.3 The OLS dimensions, specifications and criteria as detailed in ECAR 139 SUBPART G , provide the relevant information for airport planners.

1.5.4 An aeronautical study may also be applied to examine the impact of obstacles in the vicinity of new airports during the master planning stage.

1.6 TAXIWAYS

General facility requirements

1.6.1 To provide a guide for airport planners and a certain amount of uniformity in airport taxiing facilities, set criteria have been detailed in Tables II-1-5, II-1-6, and in other ECAR 139 specifications. These criteria involve widths, separations, gradients and design specifications of taxiways and other features of taxi movement areas relative to the critical (or design) aircraft primarily for safety purposes.

1.6.2 Since the speeds of aircraft on taxiways are considerably lower than on runways, dimensional criteria are not as stringent as for runways. These lower speeds permit the width of taxiways to be less than that of runways. Taxiway width standards are described in Table II-1-5. Similarly, taxiway separation criteria are also less stringent than for runways. Separation criteria between two taxiway centre lines as well as taxiway and runway centre lines are detailed in Table II-1-6.

1.6.3 For any given airport, the taxiway system should be able to accommodate (without significant delay) the demands of aircraft arrivals and departures on the runway system. The taxiway system must also be able to accommodate operations for the airport’s critical (or design) aircraft. Taxiway systems are relatively easy to expand in a phase manner, therefore at low levels of runway utilization, the taxiway system can accomplish this with a minimum number of components. However, as the number of runway movements increases, the taxiway system capacity must be sufficiently expanded to avoid becoming a factor that limits airport capacity. The phasing of taxiway systems should be considered in the context of the entire airfield expansion and not in isolation. Clear demand-based triggers should be applied to maximize efficiency and minimize runway occupancy time and delays, as part of an airfield system which should always take into account the interdependencies of intersecting elements such as runways, taxiways, rapid exit taxiways (RETs), etc.

1.6.4 The taxiway system should be designed to maximize the efficiency of aircraft movement to and from the runways and apron areas. An efficient taxiway layout can reduce aircraft fuel burn and emissions and these aspects, where appropriate, should be taken into account on taxiway planning as well. A properly designed system should be capable of maintaining a smooth, continuous flow of aircraft ground traffic at the maximum practical speed with a minimum of acceleration or deceleration around the full airside system. When designing an airside system, it is recommended that the taxi flow strategy of the system be taken into consideration, to ensure the design avoids conflicts along individual taxiways, and eliminates airside bottlenecks. One-way taxi operations are preferred, to avoid conflicting flows on any taxiway segment.

1.6.5 An evaluation of alternative taxiway system options must take into account the operating efficiency of each system, in combination with the runway and apron layouts it is designed to serve. The greater the complexity of the airside system, the greater the possibility for reducing operating costs through a comparison of alternative taxiway systems.

1.6.6 Taxiway shoulders are constructed because jet blast from taxiing aircraft cause the areas adjacent to the taxiways to erode, which could lead to the ingress of foreign object debris. The requirement to build taxiway shoulders will depend on the frequency of jet operation, the condition of the soil, and the cost of maintaining the grass areas adjacent to the taxiways. More detailed dimensional criteria of taxiway shoulders can be found in the EAC139-10– Taxiways, Aprons and Holding Bays.

1.6.7 When considering options evaluation, the taxiway layout has a significant impact on the efficiency and safety of airside operations. In particular, attention should be given to access and egress of aprons, potential bottlenecks in the layout and possible dangerous areas (“hot spots”) when planning new or improving existing facilities. Single dead end taxiways (cul-de-sacs) for access to aprons may, for instance, cause congestion and should be avoided as much as possible.

Table II-1-5. Taxiway width

	OMGWS			
	Up to but not including 4.5 m	4.5 m up to but not including 6 m	6 m up to but not including 9 m	9 m up to but not including 15 m
Taxiway width	7.5 m	10.5 m	15 m	23 m

Table II-1-6. Taxiway separation distances

Code letter	Distance between taxiway centre line and runway centre line (metres)								Taxiway centre line to taxiway centre line (metres)	Taxiway, other than aircraft stand taxilane centre line to object (metres)	Aircraft stand taxilane centre line to aircraft stand taxilane centre line (metres)	Aircraft stand taxilane centre line to object (metres)
	Instrument runways Code number				Non-instrument runways Code number							
	1	2	3	4	1	2	3	4				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	77.5	77.5	–	–	37.5	47.5	–	–	23	15.5	19.5	12
B	82	82	152	–	42	52	87	–	32	20	28.5	16.5
C	88	88	158	158	48	58	93	93	44	26	40.5	22.5
D	–	–	166	166	–	–	101	101	63	37	59.5	33.5
E	–	–	172.5	172.5	–	–	107.5	107.5	76	43.5	72.5	40
F	–	–	180	180	–	–	115	115	91	51	87.5	47.5

Note 1.— The separation distances shown in columns (2) to (9) represent ordinary combinations of runways and taxiways. The basis for development of these distances is given in the Airport Design Manual *(Doc 9157), Part 2.*

Note 2.— The distances in columns (2) to (9) do not guarantee sufficient clearance behind a holding aeroplane to permit the passing of another aeroplane on a parallel taxiway. See the Airport Design Manual *(Doc 9157), Part 2.*

Parallel taxiways

1.6.8 Depending on the amount of traffic at the airport, taxiways parallel to the runway may be implemented to allow a safer and more efficient usage of the runway and to enable aircraft taxiing to and from the aprons.

1.6.9 Parallel taxiways may be required from an operational perspective when any one of the criteria is forecast to be reached within five years. Should these thresholds be met as part of the master plan assessment, provision should be made to accommodate these facilities as part of the ultimate master plan and phasing strategy as follows:

a) there are four instrument approaches (those which are counted towards annual instrument approaches) during the normal peak hour;

b) the annual operations total 50 000;

c) the normal peak hour itinerant operations total 20; or

d) the hourly total (itinerant plus local) operations are:

(1 30operations per normal peak hour – for runways serving more than 90 per cent small aircraft and where there are less than 20 per cent touch and go operations; 40 operations per normal peak hour where there are more than 20 per cent touch and go operations (each touch and go is considered two operations;(

(2 30operations per normal peak hour – for runways serving 60 per cent to 90 per cent small aircraft; and

(3 20operations per normal peak hour – for runways serving 40 per cent to 100 per cent large aircraft.

1.6.10 Parallel taxiways provide safety benefits in addition to increased efficiency. However, the criteria given are based on having staged development following the construction of taxiway turnarounds.

1.6.11 A partial parallel taxiway, or equivalent (as can be obtained by intersecting runways), provides satisfactory efficiency as well as safety to aircraft operations. This option is particularly viable where construction costs are high. A partial parallel is generally economically justified at activity levels equal to 60 per cent of the values given for full parallel. If a full or partial taxiway is strongly preferred over taxiway turnarounds, it may be considered if current operations are 20 000 per year, if there are no turnarounds existing, and if a positive business case is developed.

1.6.12 The separation distance between the centre line of a taxiway and the centre line of a runway, the centre line of a parallel taxiway or an object, should not be less than the appropriate dimension specified in Annex 14, except that it may be permissible to operate with lower separation distances at an existing airport if an aeronautical study indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of aircraft. For master planning purposes, this will be a critical factor in developing options, as it will impact the amount of land required to fully develop the airfield.

1.6.13 Further guidance on factors that may be considered in the aeronautical study is given in the EAC139-10.

1.6.14 ILS and MLS installations may also influence the location of taxiways due to interferences to ILS and MLS signals by a taxiing or stopped aircraft. Information on critical and sensitive areas surrounding ILS and MLS installations is contained in Annex 10 – Aeronautical Telecommunications, Volume I – Radio Navigation Aids, Attachments C and G, respectively.

1.6.15 When taxi movements in both directions along a taxiway are required, it is advised to operate dual parallel taxiways to support the runway system. Additional parallel taxiways improve airside flow and reduce congestion on the system. When planning an initial taxiway system, sufficient area must be safeguarded for the number of future parallel taxiways required in later phases. The separation distance required between the centre line of a taxiway and the centre line of a runway, or the centre line of a parallel taxiway or an object, should not be less than the appropriate dimension specified in Table II-1-7.

Exit taxiways

1.6.16 Taxiways for exiting runways only are designed to allow an aircraft to vacate the runway after its landing. The function of locating taxiways for exiting runways only, or turn-offs, is to minimize runway occupancy time by landing aircraft. Taxiways for exiting runways only can be placed at right angles to the runway and also at other angles. When the angle is 25 to 45 degrees, the term rapid exit taxiway (RET) is used to denote that it is designed for higher speeds than other exit taxiway configurations. It is important to provide a straight distance after the turn-off curve on a rapid exit taxiway to allow an exiting aircraft to come to a full stop clear of any intersecting taxiway or runway.

1.6.17 Runway exits should, to the extent possible, intersect the runway at a 90-degree angle or at a 30-degree angle if they are rapid exit taxiways (RETs). Similarly, an RET should not be crossed by other taxiways as far as practicable. RETs are widely used on higher traffic airports to increase runway capacity and should be considered during the development of a new runway or to optimize an existing runway.

1.6.18 The location and type of exit taxiways depend on the mix of aircraft, the identified critical aircraft, the approach and touchdown speeds, the exit speed, the rate of deceleration, which in turn depends on the condition of the pavement surface and the number of exits. The rapidity and the manner in which ATC can process arrivals is an extremely important factor in establishing the location of exit taxiways. The location of exit taxiways is also influenced by the location of the runways relative to the terminal areas for efficient movement of aircraft between these areas.

1.6.19 To improve the efficiency and capacity of the airside system, a greater number of RETs and runway access taxiways should be positioned in the predominant runway direction to reduce runway occupancy time.

1.6.20 Table II-1-7 details the typical exit taxiway usage by distance relative to each aircraft type. Although this is flexible due to factors such as the aircraft and site characteristics outlined above, this table details a range in which the runway exits should be positioned based on the standard conditions and typical airport and aircraft operations in order to capture all aircraft codes intending to use the airport.

1.6.21 A sufficient number of exit taxiways should be planned so that additional exits would not be required within five years following the completion of construction relative to forecasted demand over this time.

Table II-1-7. Accumulated RET usage by distance from threshold

Aircraft category	*50%*	*60%*	*70%*	*80%*	*90%*	*95%*	*100%*
A	1 170	1 320	1 440	1 600	1 950	2 200	2 900
B	1 370	1 480	1 590	1 770	2 070	2 300	3 000
C	1 740	1 850	1 970	2 150	2 340	2 670	3 100
D	2 040	2 190	2 290	2 480	2 750	2 950	4 000

Runway holding bays

1.6.22 Holding bays and bypass taxiways can enhance airport capacity. These facilities seldom constitute restraints on the attainment of full airport capacity within the existing airport property since land areas are normally available to permit their construction. However, the need for these facilities should be determined as part of the master planning process to prevent delays that would occur due to a lack of these facilities. The following criteria should be applied in determining the need for holding bays and bypass taxiways, once a parallel taxiway has been justified.

1.6.23 When activity is forecast to reach around 30 total operations per normal peak hour or 20 000 annual itinerant operations or 75 000 total operations, a holding bay or bypass access taxiways should be considered, giving due consideration to other factors. These factors are:

a) mixture of types of aircraft, such as air carrier or military aircraft operations simultaneously with general aviation aircraft;

b) existing airport layout; and

c) location of navigation aids (including the critical area surrounding a navigational aid – existing or proposed – in relation to possible holding bay locations.(

1.6.24 A runway-holding position or positions shall be established:

a) on the taxiway, at the intersection of a taxiway and a runway; and

b) at an intersection of a runway with another runway when the former runway is part of a standard taxi route.

1.6.25 A runway-holding position shall be established on a taxiway if the location or alignment of the taxiway is such that a taxiing aircraft or vehicle can infringe an OLS or interfere with the operation of radio navigation aids.

1.6.26 The distance between a holding bay, runway-holding position established at a taxiway and runway intersection or road-holding position, and the centre line of a runway, shall be in accordance with Table II-1-8 and, in the case of a precision approach runway, such that a holding aircraft or vehicle will not interfere with the operation of navigation aids.

1.6.27 Usually, there is insufficient economic justification for construction of a holding bay to accommodate one aircraft. Also, provision for more than four aircraft is not usually justified. If the traffic density is such that more than four holding positions appear necessary, an investigation will generally disclose that another solution to the problem is in order.

1.6.28 The location of the runway holding position must acknowledge and factor OLS limitations to ensure that the critical aircraft holding does not infringe the relevant OLS when stationary. The relevant OLS criteria, dimensions and limitations can be found in 1.5.

Table II-1-8. Minimum distance between a runway centre line and a holding bay, runway-holding position or road-holding position

	Code number			
Type of runway	*1*	*2*	*3*	*4*
Non-instrument	30 m	40 m	75 m	75 m
Non-precision approach	40 m	40 m	75 m	75 m
Precision approach category I	60 m[b]	60 m[b]	90 m[a,b]	90 m[a,b]
Precision approach categories II and III	–	–	90 m[a,b]	90 m[a,b]
Take-off runway	30 m	40 m	75 m	75 m

a) If a holding bay, runway-holding position or road-holding position is at a lower elevation compared to the threshold, the distance may be decreased by 5 m for every metre the bay or holding position is lower than the threshold, contingent upon not infringing the inner transitional surface.

b) This distance may need to be increased to avoid interference with radio navigation aids, particularly the glide path and localizer facilities. Information on critical and sensitive areas of ILS and MLS is contained in Annex 10, Volume I, Attachments C and G, respectively.

Note 1.— The distance of 90 m for code numbers 3 or 4 is based on an aircraft with a tail height of 20 m, a distance from the nose to the highest part of the tail of 52.7 m and a nose height of 10 m holding at an angle of 45 degrees or more with respect to the runway centre line, being clear of the obstacle free zone and not accountable for the calculation of obstacle clearance altitude/height.

Note 2.— The distance of 60 m for code number 2 is based on an aircraft with a tail height of 8 m, a distance from the nose to the highest part of the tail of 24.6 m and a nose height of 5.2 m holding at an angle of 45 degrees or more with respect to the runway centre line, being clear of the obstacle free zone.

Note 3.— For code number 4, where the width of the inner edge of the inner approach surface is more than 120 m, a distance greater than 90 m may be necessary to ensure that a holding aircraft is clear of the obstacle free zone. For example, a distance of 100 m is based on an aircraft with a tail height of 24 m, a distance from the nose to the highest part of the tail of 62.2 m and a nose height of 10 m holding at an angle of 45 degrees or more with respect to the runway centre line, being clear of the obstacle free zone.

Around-end taxiways (also known as end-around or wrap-around taxiways(

1.6.29 Taxiway crossings of runways should be avoided whenever possible in the interests of safety and to reduce the potential for significant taxiing delays. If this is required, an “around-end” or “wrap-around” taxiway should be considered at either or both runway ends, allowing aircraft to transition to the other side of the runway without directly impacting current operations. The distance by which the wrap-around is separated from the runway threshold is relative to the gradient drop of the taxiway and the tail height requirements of the airport’s most stringent aircraft to avoid exceeding the OLS criteria.

Other taxiways

1.6.30 Taxiways allowing the aircraft to enter the runway prior to departure are designed as such. Runway access taxiways are to be located to provide sufficient runway distance for departing aircraft relative to the aircraft mix and to allow efficient access to the runway from the terminal apron area. If a full parallel taxiway is present, a runway access taxiway should be located at both ends of the runway, connecting the parallel taxiway with the runway. For runways experiencing a higher amount of traffic, a second or even a third runway access to the taxiway at each runway end may be justified to enable efficient aircraft queuing and sequencing before take-off, thereby increasing runway capacity.

1.6.31 Taxiways allowing the aircraft to enter the runway prior to departure should always intersect the runway at a 90-degree angle enabling the pilot of an aircraft at a taxiway holding position to see an aircraft using or approaching the runway.

1.6.32 For airports with two operational parallel runways or more, to support efficient airside operations and reduce congestion in the central terminal area, it is recommended to operate at least one crossfield taxiway connecting the runways aside from apron taxiways and taxilanes linking the runways. If developing a single crossfield taxiway, a central location near the runway centres is recommended to reduce taxiing distances for aircraft. If developing dual crossfield taxiways, it is recommended to position each in a way that allows efficient flow around the apron area, but not connecting both runways at their ends, as this may increase taxiing distances and cause conflict with the holding areas.

1.6.33 Link taxiways may be used to connect parallel taxiways to the apron or multiple parallel taxiways to each other. Multiple link taxiways are recommended to improve taxiway flow efficiency and to improve movement between the taxiway and apron systems. This also reduces the risk of congestion on the airside system and increases the resilience of the overall taxiway system.

1.6.34 Taxilane requirements and guidance for airport planners and a set criteria have been detailed in Annex 14. This outlines the criteria involving widths, separations, gradients and design specifications of taxilanes.

1.6.35 In overall taxiway system planning, efforts should be made to avoid unnecessary taxiing since this increases taxiing time, fuel consumption and aircraft wear, and extremely long distances may result in dangerously high temperature tire conditions.

1.6.36 An isolated aircraft parking position shall be designated for the parking of an aircraft which is known, or believed, to be the subject of unlawful interference, or which for other reasons, needs isolation from normal airport activities. This is required to be in a dedicated area which is isolated from routine airfield operations. This implies that the isolated aircraft parking position shall be located at the maximum distance practicable, and in any case, never less than 100 m from other parking positions, buildings or public areas.

Runway taxiway system capacity impacts considerations

1.6.37 The capacity of the supporting taxiway system can have a significant influence on the airport's ability to handle traffic with minimal delays. Proper care should be taken to provide an adequate level of capacity in the taxiway design, especially for airports that are expected to handle large volumes of traffic.

1.6.38 Aircraft push-back can cause delays on the taxilanes or taxiways, due to the time required to start engines. Reducing associated delays could include providing bypass taxiways or multiple taxilanes for aircraft to access and egress the stands. Similarly, "dead-end" taxiways (cul-de-sacs) should be avoided where practicable.

1.6.39 As the runway locations are usually fixed, their position tends to drive taxiway layouts which have to support the intended capacity of the airfield. In cases where runway length and location are fixed, several taxiway system layout options should be explored to identify the arrangement and system with the potential of achieving optimum capacity. This process factors in the number and location of access and exit taxiways, number and length of parallel taxiways, number of taxiway links and operational flow strategy of the system.

1.6.40 The terminal and apron areas should be positioned to allow for efficient movement between the airside and terminal areas to improve capacity. If parallel runways are intended, it is recommended to position the terminal complex area central to both runways to support quick and efficient access to both runways (midfield terminal.(

Taxiway design for minimizing runway incursions

1.6.41 Runway incursions have become a leading safety issue in airport operations. Good airport design practices can reduce the potential for runway incursions while maintaining operating efficiency and capacity. In this regard ,ECAR 139 related EAC contains taxiway design guidance that specifically focuses on design methods to mitigate the risk of runway incursions that should be considered during the design phase for new runways and taxiways.

Taxiway nomenclature

1.6.42 A standardized taxiway nomenclature improves ground navigation efficiency by providing consistency for airport users, in particular, for pilots at the various airports to which they operate, as well as for vehicle operators at each airport. At airports with complex layouts accommodating high traffic density, the risk of runway incursions resulting from ground confusion is expected to be reduced with a clear and logical naming convention. Specifications for a standardized naming taxonomy can be found in ECAR 139 and relevant guidance in the EAC139-10.

1.7 AIRFIELD PHASING PLAN

1.7.1 Section I of this EAC provides the overall approach to the phasing of an airport. The airfield phasing plan has to be developed in conjunction and in balance with the terminal phasing.

1.7.2 Figure II-1-3 shows a typically phased development plan for the airfield that may be obtained using the concepts and methodology presented in this section. A cross reference, locating the type of development with the applicable criteria, is also presented on this diagram.

1.7.3 When implementing an airfield phasing strategy, it is advised to safeguard for the ultimate build early on to mitigate impacts to cost, operations, and the environment in the later phases. When planning an airfield system, it is advised to primarily plan for the final phase, or ultimate layout, to identify the land-use area required for the complete system. With the final phase agreed, the initial development phase layout (Phase 1) should be considered, thereby creating a roadmap of how to get to the final phase layout. It also allows planners to identify key areas whereby preparatory work can be completed in the prior phase to mitigate impacts to cost, operations, and the environment in the later phases.

1.7.4 The point at which infrastructure is required to be developed is relative to the capacity of each system and is detailed for each individual facility in the previous chapters.

1.7.5 When planning for greenfield airports, the initial phase tends to be the most expensive stage due to the earthworks and site preparation required prior to developing the airside system. Therefore, all costs and planning associated to earthworks and site preparation must be acknowledged in Phase 1.

1.7.6 The presence and implementation of dual airport operations will impact potential airport demand and airspace characteristics which directly impact airside demand. Prior to developing the infrastructure for an airside system, the intended combined operational nature of the two or more airports and operational phasing of each airport must be factored in.

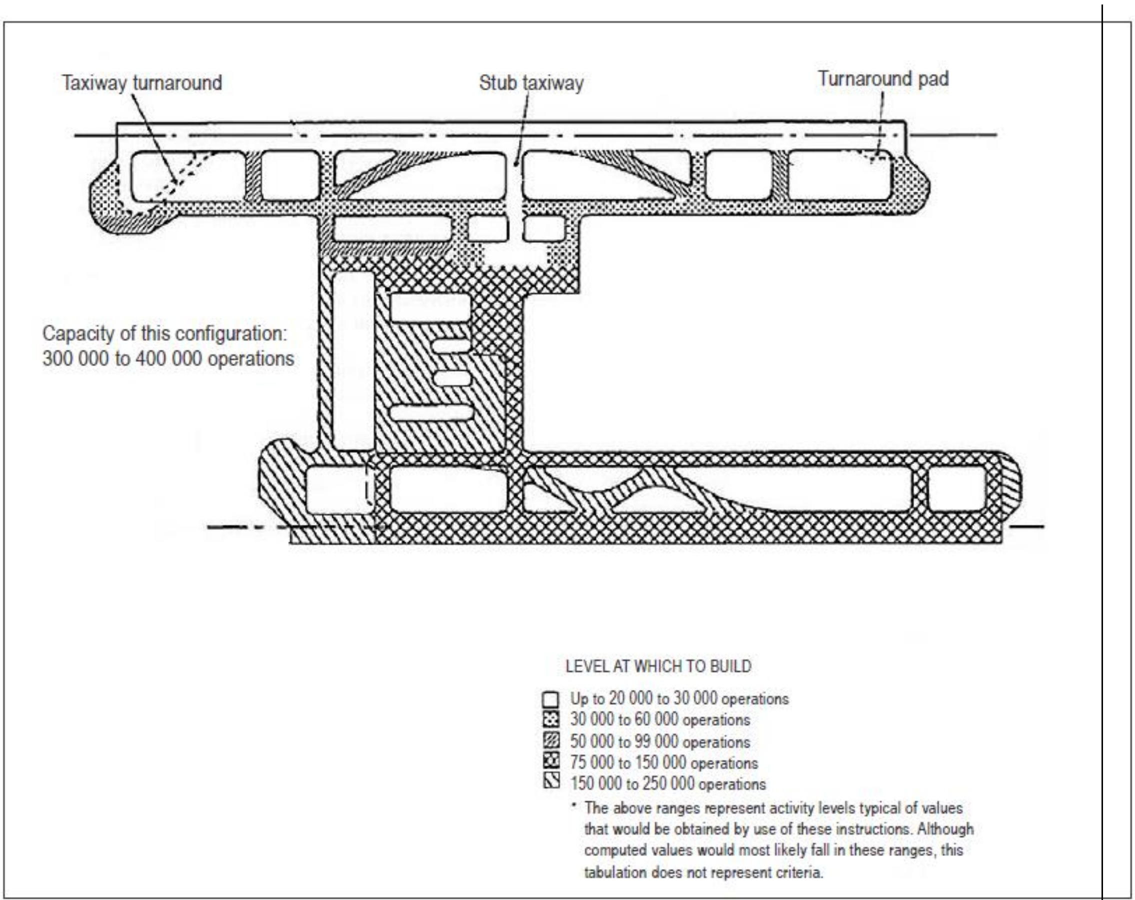


Figure II-1-3. Typical phased development sketch

Chapter 2 Aprons

2.1 ABOUT THIS CHAPTER

An apron is defined as an airside area on an airport intended to accommodate aircraft for the purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance. Aprons can be classified according to their main purpose and function. This chapter describes characteristics of various types of aprons and aspects related to their planning. Not all the apron types presented here are required for every airport, but the need for them and their size should be estimated based on the type and volume of forecast traffic at the airport. Besides aircraft stands, the associated apron taxiways, apron service roads and parking for ground support equipment (GSE) should all be included as a part of an apron system. Other useful references are listed in the beginning of this EAC .

2.2 CONSIDERATIONS FOR APRON PLANNING

Apron siting

2.2.1 Aprons are interrelated with the terminal complex and should be planned in connection with terminal buildings to achieve an optimum solution; the following are general objectives to be considered when siting aprons in the master plan, particularly for commercial passenger operations:

a) minimize taxiing distances between runways and aircraft stands (i.e. savings in fuel, time and maintenance;(

b) allow for freedom of aircraft movement to avoid unnecessary delay (punctuality of scheduled flights;(

c) reserve sufficient area for future expansion and change of technology;

d) maximize efficiency, operational safety and user convenience for each apron complex and the airport as a total system; and

e) minimize adverse effects such as engine blast, noise, air pollution, etc. on the apron and the surrounding environment.

Apron sizing

2.2.2 The planning of a specific apron depends on its purpose and function. However, basic parameters to be considered are as follows:

a) number of aircraft stands required at present and in the future;

b) aircraft mix, both present and future;

II-2-1

c) aircraft dimensions and manoeuvring capabilities;

d) aircraft parking configuration including the shape of the terminal and the surrounding area available for development;

e) clearance requirements between aircrafts, buildings or other fixed objects;

f) method of aircraft guidance onto the aircraft stand;

g) aircraft ground servicing requirements (vehicles versus fixed servicing installations, etc.); and

h) taxiways and service roads.

Aircraft parking configuration

2.2.3 The design of the aircraft parking apron is dependent on how the aircraft will enter and leave the aircraft stand; for example, either under its own power (power-in and power-out) or by taxiing in and then pushed back (tractor-assisted). The different aircraft parking options configurations are shown in Figure II-2-1 and the main advantages and disadvantages of each configuration are provided in Table II-2-1. As a general rule, nose-in parking configurations are common at high traffic airports where the push-back tractor cost is justified by more efficient use of limited apron area; this configuration is used for the contact stands.

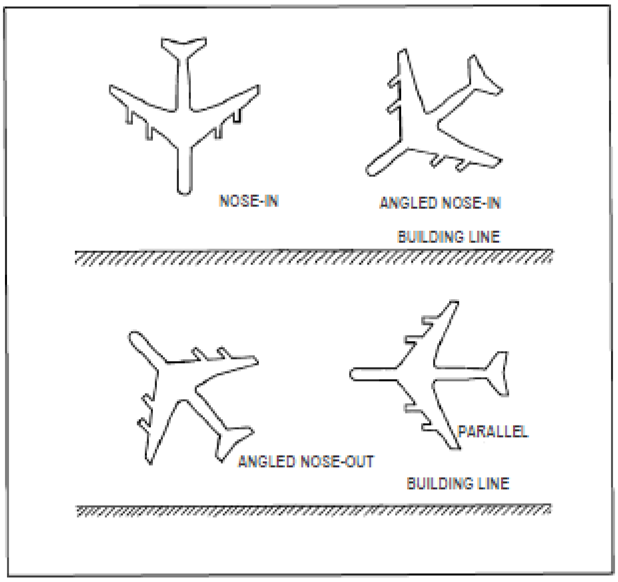


Figure II-2-1 Parking configuration

Table II-2-1. Comparison of different aircraft configuration

	Nose-in (taxi-in and push-out)	*Angled nose-in (in/out by own power)*	*Angled nose-out (in/out by own power)*	*Parallel (in/out by own power*
Advantages	Requires smallest stand area for given aircraft	No requirement for tractor	No requirement for tractor	Easiest manoeuvring for aircraft to taxi in/out
	The effects of jet blast on equipment, personnel and terminal are substantially less Reduces aircraft service time as ground equipment can be positioned prior to aircraft arrival and fewer removal requirements at aircraft departure Easy to employ passenger loading bridge			No requirement for tractor
Disadvantages	Requires tractor for push-out operation	Requires larger apron area than nose-in configuration	Requires larger apron area than angled nose-in in configuration	Requires largest apron area for given aircraft
	Push-out operation requires time and skilled operator	Relatively severe engine blast and noise is directed at terminal	Breakaway engine blast and noise are directed at terminal	Limits aircraft servicing activity at neighbouring stand when aircraft taxi in and out

2.2.4 Other parking configurations are employed at low traffic airports where it is difficult to offset the tractor operation cost by savings in apron size. For a given aircraft, the amount of apron area required varies greatly with the parking configuration. With passenger and cargo handling concepts being interrelated with the aircraft parking configuration, the preferred aircraft parking configuration must be established at an early stage during the phasing strategy in order to safeguard land for the ultimate master plan.

2.2.5 For passenger terminal aprons, a nose-in parking configuration together with passenger loading bridges afford the following advantages:

a) less apron area required;

b) less aircraft ground time due to:

(1 efficient passenger handling;

(2 efficiently positioned ground servicing equipment;

c) a head-of-stand service road can be provided that reduces requirements to drive on an apron and cause potential conflicts with aircraft push-back;

d) better passenger handling in terms of safety, convenience and comfort since there is no need for passengers to walk on the apron, use stairs or encounter adverse weather conditions, such as rain, snow, wind, heat, etc;.

e) substantially less adverse effects on ground equipment, personnel and terminal facilities from jet blast, noise and engine fumes; and

f) greater airside passenger security control.

2.2.6 However, this parking configuration requires a significant upfront capital cost and ongoing operational costs for push-back tractors and passenger loading bridges. These matters should be discussed at the level of pier service required at an airport, as part of a business case process, including airport and airline stakeholders to inform investment choices.

Apron taxiways and aircraft stand taxilanes

2.2.7 A sufficient number of apron taxiways or aircraft stand taxilanes should be provided to prevent aircraft movement conflicts. Wherever possible, terminal configurations should avoid cul-de-sac layouts between terminal piers. As the number of taxiways and taxilanes differs depending on the terminal configuration, the number of total gate positions, and the peak hour traffic, it is worthwhile to simulate the future peak traffic movement to analyse planned apron taxiway and aircraft stand taxilane configurations. Care should also be taken to provide sufficient clearances between aircraft and other aircraft or fixed and moving objects. See the EAC139-10, for details on apron taxiway and aircraft stand taxilanes.

Passenger aircraft stand demand

2.2.8 The number of aircraft stands on a passenger terminal apron depends on passenger aircraft movements by aircraft type during the peak hour and their gate occupancy time. As the number of stands dictates apron size and very often the terminal configuration, it is one of the most important aspects of master planning. The required number of aircraft stands should be estimated for the short-, medium- and long-term and an orderly and timely development scheme prepared. Staged expansion of the apron should be planned when appropriate. However, requirements may vary. For example, in planning medium-term requirements, it may be that, despite an increased volume of passengers, the estimated number of required aircraft stands may remain the same due to the introduction of larger aircraft with greater passenger capacity. In such a case, construction of a larger apron during the initial stage may be the preferred option. Use of the multiple aircraft ramp system (MARS) stand layout configuration should also be considered during the initial design phase, as this type of stand configuration provides greater flexibility and efficiency.

2.2.9 A preliminary definition of the apron layout and configuration can be obtained using the value shown in Table II-2-2, which shows the approximate area required for aircraft apron, both contact and remote, with associated taxiway clearance to object for aircraft with varying wingspans.

Table II-2-2 Sizing for apron stands

ICAO reference code	B	C	D	E	F
Area required (ha) *Contact*	0.22	0.41	0.75	1.14	1.50

ICAO reference code	B	C	D	E	F
Area required (ha) *Remote*	0.19	0.37	0.69	1.07	1.42

2.2.10 Moreover, for medium to large airports, it is important to also use a dynamic tracking model to assure the correct position of the various stands with the taxilanes to avoid congestion on the apron.

Aircraft wing-tip clearance

2.2.11 The dimensional, operational, and servicing needs of aircraft must be accommodated on aprons. Specific aircraft models or categories of aircraft are used for dimensional planning of aprons. For apron planning purposes, wingspan is the main driver and tail height is not usually considered except when determining if an aircraft would penetrate any aeronautical surfaces and assessing potential line-of-sight impacts.

2.2.12 The minimum clearances between aircraft using the stand, as well as between aircraft and adjacent buildings or other fixed objects, are specified in ECAR 139 And Related Ecas During the planning phases, it is also important to evaluate the effect of aircraft jet blast. Aircraft manufacturers provide information on aircraft characteristics, including jet blast, specific to each aircraft type and model for airport planning purposes. Using these characteristics, the potential effects of jet blast can be evaluated for each aircraft type. Planning to minimize the impact of jet blast starts with having a clear understanding of the specific characteristics of aircraft using the apron, as well as the standard operating procedures at each airport (see Figure II-2-2 extracted from the EAC139-10– Taxiways, Aprons and Holding Bays, Figure A2-4. Boeing model 777-300ER.(

Multiple aircraft ramp system

2.2.13 In order to optimize the use of the apron, adopting a multiple centre line configuration for the stand layout (a multiple aircraft ramp system, or MARS) can be a useful option to consider. MARS enables an apron stand to accommodate different aircraft types. An example of a very typical use configuration would be to park two (2) Code C aircraft in the space of one (1) Code E or F aircraft type.

2.2.14 MARS-configured stands enable the airport operator to assign varying aircraft types to a stand position, as wells as address changes in the hourly demand for different types of aircraft parking positions.

Contact stands, active and non-active remote aircraft apron

2.2.15 When planning stands infrastructure, a primary consideration is to determine the total number of stands required for each phase of the master plan in order to meet the traffic forecast demand. This takes into account a number of factors, including peak hour stand demand by aircraft type, the number of based aircraft and overnight parked aircraft that can increase the number of stands required.

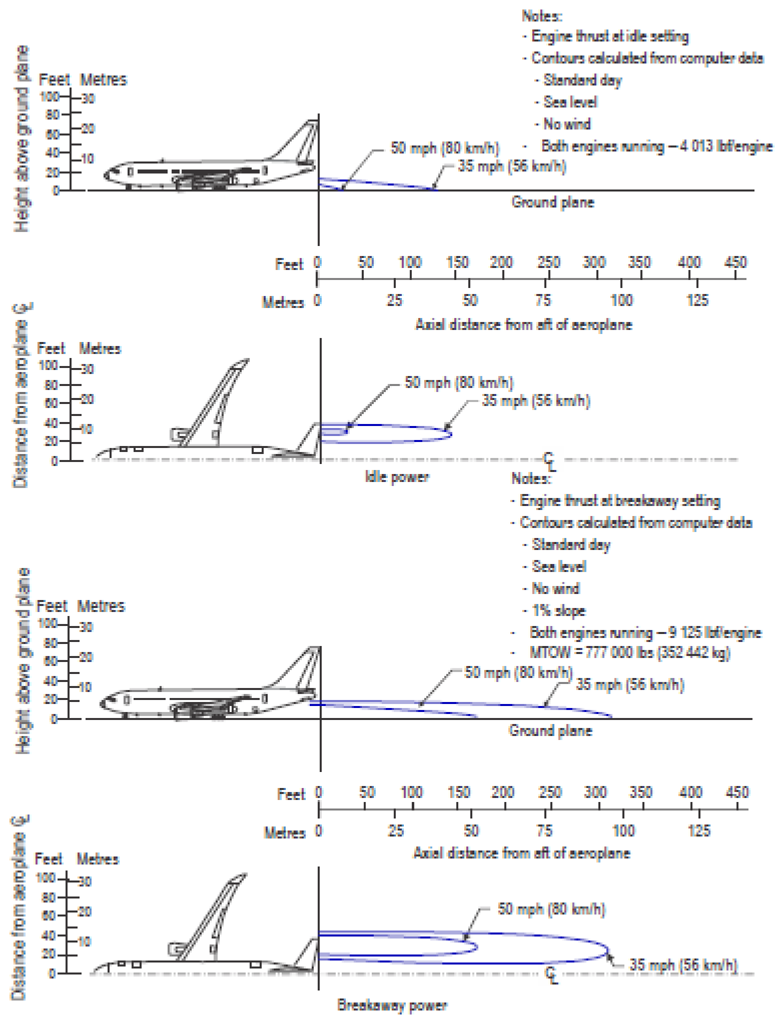


Figure A2-4. Boeing model 777-300ER

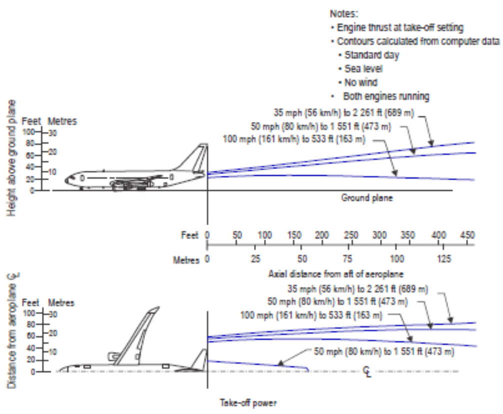


Figure A2-4. Boeing model 777-300ER (cont.)

Figure II-2-2 Boeing model 777-300ER (cont(.

2.2.16 Another important consideration is to determine the number and percentage of contact or “pier served” stands enabling passengers to walk directly to the aircraft on departures and arrivals to the terminal building, whether connected by a jet bridge or a “walk-in walk-out,” compared to remote stands. Although contact stands generally result in a better passenger experience, they come at an infrastructure cost. Operational, passenger and cost requirements should be carefully consulted with users, particularly airlines.

2.2.17 Remote apron parking positions can be classified, in general terms, as either active or non-active. In addition to the main terminal active apron contact stands, airports may also require a separate parking apron where aircraft can park for extended periods and can be used during crew layovers or for light periodic servicing and maintenance of aircraft temporarily on the ground.

2.2.18 Remote aprons may also be designated as active aprons if they are used for active aircraft boarding and deplaning at peak times by choice, or as a buffer when insufficient contact stands are available. In this case, passengers are usually bussed to and from aircraft parked at these remote positions.

2.2.19 The non-active apron is also used to park overnighting aircraft. These aprons are expected in the airports where the number of aircraft parked overnight exceeds the number of terminal parking positions and gates. These aprons can also be used for light aircraft maintenance and servicing during the day.

2.2.20 The need for these facilities should be carefully consulted upon with airport and airline stakeholders to define the master plan requirements and options.

2.2.21 Understanding the apron environment is critical to responsive and effective planning and design. It is important to note that airports, by their inherently unique nature, require diverse apron environments and it is the responsibility of the apron planner and designer to understand the requirements of each of the specific airport apron areas.

Cargo terminal apron

2.2.22 At airports where the amount of air cargo is relatively small and mostly carried by passenger aircraft as “belly cargo”, a specific cargo terminal apron may not be required. However, at airports where dedicated cargo aircraft operate regularly, a specific cargo apron adjacent to the cargo facility may be required. The cargo terminal building should be located with due consideration for its own expansion, while taking into account the expansion of other facilities, such as the passenger terminal buildings (PTBs) so as not to impede their development in future master plan phases.

2.2.23 Many factors influence the efficiency of cargo operators. Airport facilities must be designed to accommodate the aircraft, sorting facilities, and ancillary operations required to move cargo efficiently. Design considerations include the size of the cargo apron facilities, the apron layout, and operational safety are all important factors.

2.2.24 The required size and geometric layout of a cargo apron is a function of the number of aircraft parking positions needed, the category of aircraft parking on the apron and the size of the sort facility required to manage the anticipated cargo volumes. These needs are based on a number of critical elements, including the aircraft fleet mix, number of operations, and cargo tonnage. The number of parking positions also affects the number of interior taxiways that need to be provided to accommodate the necessary aircraft movements. The size of parking positions and taxiway widths are determined based on the design parameters of the critical aircraft using the facility and the space required for GSE operations around the aircraft, including cargo loading and unloading.

2.2.25 While the number of aircraft to be accommodated on the cargo apron and the required taxiways have a significant impact on the size of the apron, planners should also carefully consider the necessary space required for the tenant to operate safely, effectively and efficiently. Requirements include internal access roads for vehicles and tugs, parking locations for GSE, loading positions on the aircraft (nose, belly, side or back), fuelling operations, aircraft servicing, and storage locations for cargo bins upon removal from the aircraft and prior to transfer to the sorting facility.

2.2.26 The planner should examine the need for a cargo apron based on air cargo forecasts and in consultation with cargo operators to ensure their requirements are included in the master plan. The cargo aircraft are normally parked either parallel or nose-in, but parking configurations depend mainly on the forecast volume and type of cargo handling system to be employed.

2.2.27 A further consideration is passenger aircraft with belly-hold cargo rather than dedicated cargo aircraft. Particular consideration should be given to ensure suitable access to the aircraft is provided in order to support efficient turnaround times for operators. For example, the location of security screening checkpoints for vehicles accessing security restricted areas should be planned to facilitate efficient access to cargo (and other vehicles such as catering) in aircraft parked at terminal stands.

General aviation apron

2.2.28 When an airport serves general aviation aircraft (usually small private aircraft and corporate jets), a general aviation terminal including a separate apron and other related facilities may be required. The general aviation terminal and its apron, however, should be located so as to minimize conflict with scheduled aircraft operations and future expansion requirements of the associated aprons and passenger terminals.

2.2.29 General aviation facilities vary in size and configuration, ranging from facilities at airports that accommodate only small piston aircraft to facilities at larger airports that accommodate widebody aircraft.

Helicopter apron

2.2.30 Airports that serve extensive helicopter operations should also consider planning for a helicopter terminal and apron. The location for these facilities may depend on the type of helicopter traffic, such as public passenger service or semi-industrial operations (offshore oil platform services, etc.). See ECAR 138, EAC 139-27 for detailed information on planning a helicopter apron.

2.2.31 The location of the FATO (final approach and take-off) area has to be defined also taking into account the operation of the runway system and OLSs surfaces in order to avoid their penetration.

Military and rescue activity apron

2.2.32 Military aircraft sometime also operate at civil airports. Joint-use airports should also meet the physical characteristics for military aircraft. Hence, during airport facility design, consideration should be given to routine military operations such as medical evacuation, strategic deployment and training missions. All efforts should be made not to limit the capacity of commercial operations resulting from mixed-use airports and facilities.

2.2.33 The military may use additional equipment to assist with the servicing and operation of aircraft. These additional aircraft servicing vehicles include lavatory servicing vehicles and carts, cabin, galley and catering vehicles, air start vehicles and carts, mobile stairs, and aircraft maintenance vehicles.

2.2.34 At the same time, specific to the role of the airport, the apron may also need to be designed to host medical and/or firefighting operations. In this case, during the planning phase, it is important to evaluate the need for segregated facility access points.

Very very important person (VVIP) apron

2.2.35 Some airports that host very very important person (VVIP) and State (or Royal) activity may request a separate apron and terminal in order to guarantee privacy and security protection. The dimensions and layout of this particular kind of apron will be characterized by the size of the aircraft accessing this area and the specified terminal facilities. Usually this terminal or apron complex is located in a remote area of the airport away from the areas designated for commercial activities but also with direct access to the runway.

2.3 PASSENGER TERMINAL APRON

Apron and terminal relationships

2.3.1 As mentioned, apron arrangements are directly interrelated with the passenger terminal concept and configuration. Details of various passenger terminal concepts and configurations are described in later sections. This section presents various concepts pictorially in Figure II-2-3 and briefly describes the characteristics of each concept from the perspective of the associated apron layout.

a) Simple concept. Broadly applied at low traffic volume airports with aircraft normally parked either angled nose-in or nose-out for taxi-in or taxi-out. Consideration should be given to providing adequate clearance between the apron edge and terminal airside frontage to reduce the adverse effects of jet engine blast. Jet engine blast fences may also be appropriate. Apron expansion can be done incrementally in accordance with demands, causing as little disruption as possible to the overall airport operation.

b) Linear concept. This configuration may be regarded as a more advanced development of the Simple concept. Aircraft can be parked at an angled or parallel parking configuration. However, nose-in/push- out parking configuration with minimum clearance between apron edge and terminal are the most common with this terminal configuration, to promote efficient utilization of apron space and safe and convenient handling of aircraft and passengers. Nose-in parking allows relatively easy and simple manoeuvring for aircraft taxiing into the gate position. Push-back operations cause little disruption to apron activities in neighbouring gate positions although push-back tractors and skilled operators are required. At busy airports, double apron taxiways may be needed to eliminate taxiway congestion caused by aircraft push-back operations. The space between the apron edge and terminal frontage can be used for the head-of-stand road which enhances apron traffic circulation. In addition, the space around the nose of the parked aircraft can be used for GSE parking positions.

c) Pier (finger) concept. There are several variations of this configuration, depending on the shape of the pier. Aircraft can be parked at gate positions on both sides of the piers, either angled, parallel or perpendicular (nose-in). Where there is only a single pier, similar advantages to that of the linear concept can be achieved. When there are two or more piers, care must be taken to provide sufficient operational and aircraft manoeuvring space between them. Where each pier serves a significant number of gates, it will be necessary to provide double taxiways between piers to avoid conflicts between aircraft entering and leaving the gate positions and aircraft pushing back from the gate positions.

d) Satellite concept. This configuration provides a satellite unit, surrounded by aircraft gate positions, separate from the terminal. Passenger access to satellites from the main processing terminal is normally via an underground or elevated corridor to maximize the efficiency of the aircraft apron. However, in some cases, depending on the density of aircraft movements, surface access can be provided by buses using the airside road network. Depending on the shape of the satellite, the aircraft are parked in radial, parallel or perpendicular (nose-in) configuration around the satellites. Satellites are used when an increase in the length of the main terminal is impractical. Satellites can also provide the opportunity for incremental airside operational growth which does not impact the operations of the main terminal facility. This configuration may be useful for "power-in, power-out" operations negating the need for push-back tugs; however, this is very uncommon in modern airport terminal design and not generally recommended due to the constraints of expanding or adapting this facility.

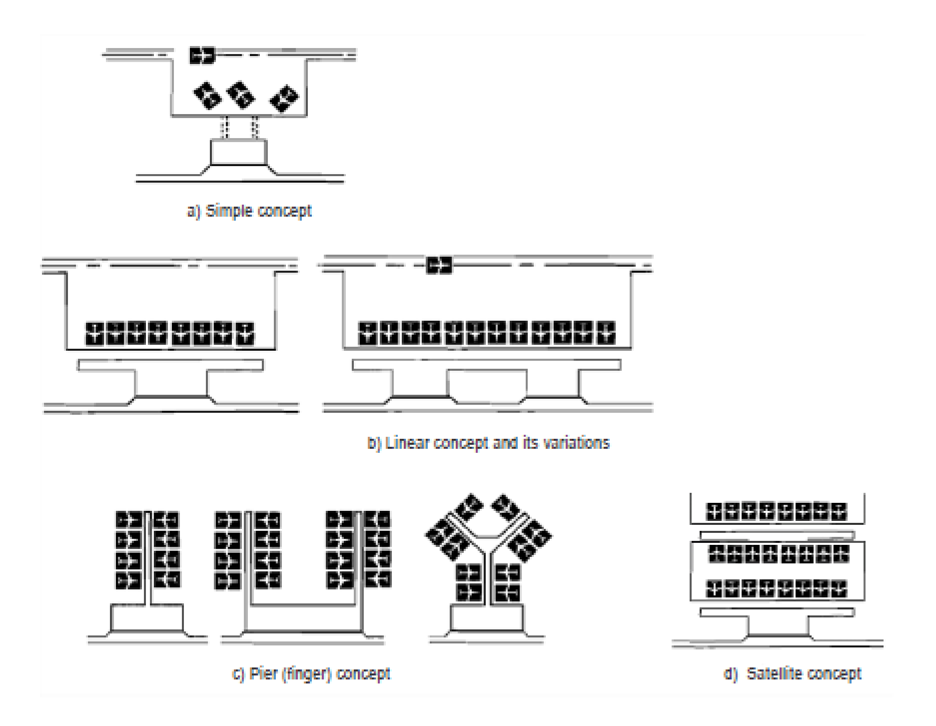


Figure II-2-3 Passenger terminal concept

2.4 AIRCRAFT SERVICING FACILITY

Aircraft de-icing aprons

2.4.1 The size and the position of a de-icing/anti-icing facility adjacent to a terminal or runway is dependent on the meteorological conditions, the size of the aircraft using the airport, the number of aircraft that require de-icing, the type and capacity of the dispensing equipment used, and the method of treatment. The overall capacity and thus size of the facility is estimated using the number of aircraft that require treatment at a given time. The transit time of de-icing/anti-icing vehicles between the refilling and storage area and the de-icing/anti-icing facilities should also be taken into account.

De-icing position:

.1 Near the terminal.

De-icing at the terminal gates has significant operational ramifications. This operation increases gate occupancy time and introduces additional vehicle types to the apron or gate area. In addition, de-icing fluids create traction issues and potentially add an operational and safety risk on the apron pavement, both to ramp personnel and to passengers during ground loading operations. In addition, careful consideration to taxi and holding times to the runway should be given as the de-icing process effectiveness may be compromised if those are extended.

.2 Near runway entry points.

Remote facilities are typically located near the departure end of runways, to reduce the time between treatment and aircraft departure. Due to the potential pollution of the glycolic-liquid used for the de-icing-operation, it is important to consider the potential environmental impact and the necessary related treatment facilities.

On the apron, areas should be provided for staging and parking of GSE. "Staging" means to set ground service equipment in position prior to the aircraft's arrival in order to expedite ground servicing.

Aircraft refuelling operations

2.4.2 The aircraft refuelling mode must be considered during the planning and design of the parking area as there are two modes of refuelling: through the use of aircraft refuelling vehicles (fuel bowsers) or via a "fuel hydrant system" built into the apron pavement.

2.4.3 The advantage of using the hydrant system is that it reduces the number of vehicles on the apron. However, the in-apron hydrant fuel system can restrict flexibility with respect to future reconfiguration of aircraft stand positions. Additional reference information is available in the Manual on Civil Aviation Jet Fuel Supply (Doc 9977.(

Ground support equipment

2.4.4 Various types of apron equipment and systems, such as aircraft towing equipment, preconditioned air units, ground power units (GPUs), potable water systems, aircraft fuelling systems, and baggage service vehicles, are used to service aircraft parked on the apron. The placement, staging and storage of these various pieces of equipment needs to be considered during the planning stage of all types of aprons. It is important to secure such equipment properly in case of adverse weather conditions (storms, strong winds), as this equipment, if not properly secured, can be hazardous to people and aircrafts on an apron.

2.4.5 Examples of equipment and systems required to service the aircraft include but may not be limited to:

a) aircraft towing equipment;

b) preconditioned air units;

c) GPUs;

d) potable water systems;

e) aircraft fuelling system equipment;

f) baggage handling equipment; and

g) cargo handling equipment.

Ground support equipment parking and storage areas

2.4.6 Areas adjacent to aircraft stands may be used for long-term parking (storage) of ground support equipment. However, allocation of these areas is an integral part of the overall apron planning exercise and specific areas dedicated to parking and storage of equipment must be identified during the initial apron planning phase. An area for long-term parking and storage of ground service vehicles, and potentially for the ground vehicle maintenance and repair shop and fuelling station, may be situated at a somewhat isolated location from the passenger terminal apron. All airport facilities should be sited so as to accommodate future growth of the facilities plus future expansion of adjacent facilities. With the increased use of electric GSE vehicles, it will be necessary to locate recharging stations throughout the apron and storage areas. In most cases, these types of vehicles can be recharged during off-peak periods within the remote storage area.

Passenger boarding bridges

2.4.7 When planning terminal aprons, the planners must consider the transfer of passengers between the aircraft and the terminal or concourse. Passengers and baggage can be transferred with minimal use of equipment, or this process may involve a sophisticated system of equipment. Passengers are generally enplaned and deplaned from aircraft using one of three approaches:

a) bridge loading;

b) ground loading; or

c) remote loading.

2.4.8 In particular, a passenger boarding bridge (PBB) is a movable enclosure that facilitates the transfer of passengers between the terminal or concourse and the aircraft in a secure and operationally controlled environment.

2.4.9 The two main categories of PBBs to be considered in planning are:

a) apron drive loading bridges; and

b) fixed loading bridges.

2.4.10 For the purposes of master planning, within the overall number of stands required to facilitate demand during peak hours, the proportion of contact versus remote stands will have a material impact on the size of terminal frontage required. For instance, a higher percentage of contact gates associated with improved passenger convenience and direct access to terminal buildings will result in more terminal, piers and satellite infrastructure provision and space being required, along with higher capital costs. Alternatively, a larger apron for boarding and de-planing will be required if there is a lower level of contact gates being planned. The facility requirements should meet the business plan needs and should be agreed with stakeholders prior to options development and evaluations being considered.

2.5 APRON SERVICE ROADS

2.5.1 Provision and layout of service roads on aprons is of great importance for efficient airport operation and safety. Service roads should provide direct and convenient access between the apron and other service areas of the airport to minimize interference with manoeuvring aircraft and terminal functions. On passenger terminal aprons, service roads may be located at either the rear (tail-of-stand) or in front (head-of-stand) of parked aircraft in nose-in configuration. For aircraft parked in parallel configuration, service roads may be placed along the outside wing-tip. Where service roads pass under passenger loading bridges, sufficient vertical clearances must be provided so that the tallest types of GSE (e.g. catering trucks) are able to pass underneath.

2.5.2 Special attention needs to be paid to the layout and position of the apron emergency roads dedicated to rescue and firefighting (RFF) operations. These roads must be connected with the global airport emergency roads network. Since RFF equipment and vehicles tend to be some of the tallest elements at the airport, overhead clearances need to be considered when laying out this special airside road network.

Head-of-stand service roads

2.5.3 A head-of-stand service road is located between the nose of the parked aircraft and a terminal or cargo building. This configuration allows for uninterrupted access to aircraft, as vehicle movements are not impacted by the movement of aircraft entering or exiting a gate. With this configuration, vehicles and GSE can travel from storage and staging areas around the gate areas directly to aircraft for servicing without accessing taxiways or taxilanes. In this roadway configuration, there is no need to wait for aircraft pushing back or pulling into a gate position or other potential interactions. Head-of-stand service road alignments also tend to increase apron depth and require longer passenger bridge or fixed links.

Tail-of-stand service roads

2.5.4 A tail-of-stand service road is located at the back of the aircraft parking position. The tail-of-stand service road may also be referred to as an “apron edge service road” because the road can delineate the limit of the leased stand areas. Careful consideration needs to be given to the provision of tail-of-stand roads as they can result in potential conflicts between ground support and other airside vehicles and aircraft, since aircraft must cross the tail-of-stand service roads to enter or exit aircraft contact stand positions (e.g. the potential conflict with push-back operation). To avoid operational consequences, tail-of-stand service roads must be located outside all taxiway- and taxilane-object-free areas (OFAs), as penetrations of these areas can result in limitations on the size of aircraft that can use the affected taxiways and taxilanes.

Inter-stand roads

2.5.5 The inter-stand roads pass between parked aircraft positions, linking a tail-stand or other service road with the building pass-through entry or exit point. The number and position of these roads is determined by the method in which the apron will be managed safely.

Chapter 3 Air And Ground Navigation And Traffic Control Aids At Airports

3.1 ABOUT THIS CHAPTER

3.1.1 Planning of airports must include provision for facilities that will support the ATC system, for navigation aids for aircraft approaching the airport and, for control of aircraft and vehicles on the surface of the airport. The purpose of this chapter is to describe the facility requirements for such control aids as they pertain to airport master planning. Specific information on performance of equipment and on siting of navigation, control and visual aids, among others, may be found in Annex 10 – Aeronautical Telecommunications, Volume I – Radio Navigation Aids, ECAR 139 and EAC139-12 – Visual Aids.

3.1.2 Aircraft operations at airports are affected by the time of day and weather conditions termed as visual meteorological conditions (VMC) and instrument meteorological conditions (IMC). In the case of take-off and landing during night-time hours, it is necessary to install approach lighting systems and runway lighting systems. These systems and radio navigation aids are needed under IMC with the lighting systems dependant on the types of approach runway, as defined in ECAR 139. The Manual of All-Weather Operations (Doc 9365) provides guidance concerning the provisions of necessary facilities and services required to support a particular operation.

3.1.3 Radio navaids for precision approach runways require accuracy and certain instrument landing system (ILS)-restricted areas to ensure performance. Operations conducted under limited visual reference should have additional facilities and equipment, services, and procedures available at aerodromes beyond those required for operations in good weather. The runways and taxiways should meet more stringent criteria, an instrument approach aid with associated instrument approach procedures should be required, and visual aids should be provided to assist the flight crew in transitioning from instrument to visual reference.

3.1.4 To ensure safe and efficient flight operations when peak hour aircraft movements increase, it is necessary to define the aircraft separations and to coordinate the landing sequences between arrivals, the take-off sequence between departures, and the separation minima between departing aircraft.

3.2 VISUAL AIDS

3.2.1 The selection of the visual aids at an airport depends primarily on the visibility conditions under which its operations are intended to be conducted (i.e. visual flight rules (VFR) or instrument flight rules (IFR)); on whether night operations are planned and on the type of aircraft to be operated at the airport. ECAR 139 , specifies the operating conditions for which type of visual aids should be provided. In general, approach and runway lighting aids or taxiway markings are related to the type of runway being implemented:

a) non-instrument;

b) instrument approach – flight path information provided by radio navaids such as NDB and VOR; and

c) precision approach – flight path information provided by radio navaids such as ILS and MLS.

3.2.2 This must be confirmed in order to plan for and implement the correct type of aid.

3.2.3 The visual aids requirement should be determined during the initial planning of the airport. The possibility of light pollution on the surrounding area needs to be considered and mitigation measures put in place.

3.2.4 The following visual aids are typical at most commercial airports and need to be incorporated into the airport master plan layouts:

a) Aerodrome beacon (ABN:(

An airport beacon indicates the airport's location during the hours of darkness. Note that the separation from surrounding buildings and the visibility from the arriving aircraft should also be considered including topographical features and future airport development.

b) Approach lighting system (ALS:(

As ALS extend beyond the runway ends, additional land may be required for their installation. It may be necessary to remove obstacles in the approach area in order to ensure the light plane towards approaching aircraft. Length and composition of ALS are different for each precision approach category.

c) Visual approach slope indicator system (VASIS:(

Approach slope indicators, such as precision approach path indicator (PAPI), require OFAs to ensure visibility to the pilot approaching the runway. This must be considered when runway extension or runway holding positions are implemented.

3.3 RADIO NAVIGATION AIDS AND ILS-RESTRICTED AREAS

3.3.1 Depending on the planned operating rate and minimum weather conditions at an airport, some or all of the following navigation aids should be selected and installed:

a) instrument landing system (ILS) and microwave landing system (MLS); for airports requiring precision approach;

b) global navigation satellite system (GNSS); ground-based augmentation system (GBAS) for airports requiring GNSS-based precision approach;

c) very high frequency (VHF) omnidirectional radio ranges (VOR); for airports requiring instrument approach, but not necessarily precision approach;

d) distance measuring equipment (DME); (generally collocated with VOR, ILS or MLS;(

e) collocated tactical air navigation systems with VOR; for airports catering to both commercial and military aircraft operations;

f) surveillance radar systems (primary or secondary radar), airport surface detection equipment (ASDE) and multilateration (MLAT) or Wwde area multilateration (WAM), supporting busy airports by facilitating shorter aircraft separation distances and simultaneous take-off and landings on parallel runways.

3.3.2 When the types of navigation aids needed at the airport have been decided, the site selection should be made with the assistance of the consulting expert. Unless the proposed site is flat with few obstructions, some preliminary site clearing and grading would be necessary. All preliminary grading and site preparation is usually included in the airport construction contract. The best choice of variables to arrive at the most economical configuration of the required navigation aids can be determined by means of a flight check or computer simulation.

3.3.3 It is often difficult to specify exact sizes for the buildings for the sites due to multiple factors, including combinations of the most appropriate navigation aids. The latest information should be obtained from experts in each field to allocate appropriate areas for the required facilities. General guidance is provided in the following paragraphs.

3.3.4 Parts of the ILS, such as the middle-marker and the outer-marker, can be substituted by ILS-DME, and power is provided from the airport to ILS-DME. Non-directional radio beacons (NDBs) that are used as a compass locator are seldom installed because the flight path and waypoints are provided by area navigation (RNAV). If the outer-marker and NDB are installed outside of the airport, the power should be provided from outside of the airport.

3.3.5 The number of instrument landing systems (ILS/MLS) at an airport would depend on the precision approach runways required. Usually the ILS/MLS is planned to serve at least the prevailing wind direction. At busy airports, however, there is a risk that a number of aircraft may result in holding above the destination due to changes of wind direction. Therefore, ILS/MLS should be installed in both runway directions. Since the integrity of the radio signals in airspace depends on the reflecting properties of the terrain surrounding the antennas, minimal roughness and slope with adequate drainage and soil stability is highly desirable. The roughness of localizer course and glide path depends on the number of unwanted signal reflections received by the aircraft. The number and magnitude of unwanted reflections depends on the number, size and material of objects (e.g. buildings, hangars and vehicles) and distance of the objects illuminated by the antennas. Such reflections can potentially cause degradation of the signal-in-space. Therefore, ILS protection areas and associated management procedures need to be identified to prevent such degradation. Particular attention should be paid to these areas, so far as demarcation of boundaries and restriction of other airport activities are concerned. States differ in the way they choose to identify ILS protection areas and to manage vehicle movement restrictions. One method is to identify critical areas and sensitive areas as described in Attachment C to Annex 10 – Aeronautical Telecommunications, Volume I – Radio Navigation Aids. At those sites where the number of significant objects is unavoidably large, the signal quality can be improved with the help of directional antennas. However, these are more costly and larger than the standard type of antennas.

3.3.6 The site grading for navigation aids including radio altimeter (RA), which is required for ILS CAT II/III operations), the construction of access roads and provision of ducts under the runways for the power supply and control of navigation aids should be included in the airport detailed design and construction documentation and contracts.

3.3.7 The areas immediately surrounding the ILS localizer and glide path antennas form the "ILS-restricted areas" within which obstacles or any sort of vehicle movement is prohibited. These areas are designated as "ILS-restricted areas" because the presence of reflecting objects can cause intolerable distortion of the signals. Particular attention should be paid to these areas, so far as demarcation of boundaries and restriction of other airport activities are concerned. In ILS CAT II/III operations, the ILS-restricted areas require a larger area than for ILS CAT I. The ILS categories are described in Attachment C to Part I of Annex 10, Volume I.

3.4 AIR TRAFFIC SERVICES

3.4.1 The requirements for accommodating the air traffic services unit and associated equipment at an airport, will vary according to the plans developed by the appropriate air traffic services authority for the air traffic services organization. At most airports, an aerodrome control tower is required to accommodate a unit providing aerodrome control service and for accommodation of an air traffic services reporting office. This office, however, may not necessarily be a separate unit. At airports planned to be equipped with aids for instrument approach and departure, the equipment and staff are generally located in the control tower room. At some airports, there may also be a need to accommodate an area control centre or a flight information centre. It is important that these requirements be determined at an early stage in consultation with the appropriate air traffic services authorities, and that the planning of buildings on the airport take these requirements fully into account. It is also important that flexibility in the arrangements of air traffic services units and adequate expansion possibilities be reflected in the planning.

Aerodrome control tower

3.4.2 The effective provision of aerodrome control service requires a clear and unobstructed view of the entire movement area of an airport and of air traffic in the vicinity of the airport. The aerodrome control tower should therefore be centrally located and be of such a height that aprons, taxiways, runways and the airspace surrounding the airport, particularly approach and departure areas, are clearly visible from the aerodrome control tower and that future developments (expansion) of the manoeuvring area or future construction of buildings would not restrict this view.

3.4.3 The aerodrome control tower should be located at a site which:

a) enables proper control cab orientation;

b) is as close as practicable to the thresholds of all runways and/or strips. Where certain directions are used more than others and/or where an ILS system exists, the control tower should be located to those thresholds;

c) minimizes the adverse impact on the performance of existing or forecast navigational aids; and

d) enables clear lines-of-sight, unimpaired by direct or indirect external light sources, such as apron lights, car parking lights, surface traffic and street lights, and reflective surfaces (e.g. building facades.(

3.4.4 Siting and cab height at the tower location should take enhancement of visual resolution into consideration by ensuring that the air traffic controllers' line-of-sight is perpendicular or oblique, rather than parallel to the line established by the aircraft and ground vehicle movement, and where the line-of-sight intersects the airport ground surface at a vertical angle equal to or greater than 35 minutes of arc.

3.4.5 The height of the control tower, based on the standard angle of the line-of-sight from the air traffic controller's view at the control desk to the runway-end, should be 0.8 degrees or more. Surveys show that this angle is at least 1.4 degrees at newly built towers. It is also necessary to consider appropriate sight distance.

3.4.6 To ensure the line-of-sight, the height of the control tower may project from the horizontal surface. In this case, it is necessary to verify the operation procedures so as not to affect the approach and the departure.

3.4.7 At large-scale airports, when it is difficult to view the entire airport from only one aerodrome control tower, additional towers may be planned. The cabling requirements associated with the need for remotely controlling and/or monitoring of approach and landing aids, airport lighting and the provision of radar and communication facilities should be taken into account. Another important factor is the security of the control tower.

3.4.8 At some airports "virtual control towers" or "digital air traffic services for aerodromes (DATS)" are being tested. Airports with a virtual control system are monitored using closed-circuit television (CCTV) equipment that is centralized in a remote facility. It is possible to monitor multiple airports from a single facility using this technique. Cameras spread out around an airport eliminate blind spots and give controllers additional detailed views. Infrared cameras can supplement images in rain, fog or snow and other cameras can include thermal sensors to see if animals stray onto the runway.

Apron control unit

3.4.9 The number and complexity of aircraft and vehicle movements on an apron may create a need for an apron management service with clear sight lines to all parts of the apron. The aerodrome control tower may also serve this function, and it may be beneficial to collocate the apron management unit in the same building due to similar requirements, such as special lighting, noise protection, air conditioning and communication equipment.

3.4.10 At larger airports, aprons may be required in varied locations, and additional secondary control towers may be required to ensure the line-of-sight. These towers may be lower than the main control tower as they only need to ensure visibility of a certain target apron area.

3.4.11 Apron control service facilities can also be located on top of other suitable structures, as long as the elevation facilitates suitable visibility of the apron area in question. Suitable locations may include the top of the PTB, the terminal's fixed link structures or above an ARFF station. The office should be large enough to accommodate control desks, associated devices and operating personnel, and provision should be made for equipment rooms, office space and rest facilities nearby. Requirements for special lighting, noise protection, air conditioning and special accommodation of sensitive equipment such as radar should be considered.

3.4.12 Apron control functions can also be facilitated by CCTV cameras. Installed at strategic conditions, with the necessary resolution and zoom functions, CCTV can observe the manoeuvring areas even during challenging weather conditions. The controller can be situated at the main ATC tower or at an off-site or remote location.

Approach control office

3.4.13 The approach control office, where required as a separate entity, should be located conveniently close to the aerodrome control tower.

Area control centre and flight information centre

3.4.14 The area control centre or flight information centre, where required, should preferably be located conveniently close to the aerodrome control tower and the approach control office. The centre should be large enough to accommodate control desks, associated devices and operating personnel, and provision should be made for equipment rooms, office space and rest facilities nearby. Requirements for special lighting, noise protection, air conditioning and special accommodation of sensitive equipment, such as radar and computer equipment, should be considered.

Air traffic services reporting office

3.4.15 If required as a separate unit, rather than as a part of another air traffic services unit or aeronautical information service unit, the air traffic services reporting office should be located in close proximity to other briefing and reporting offices; for example, a meteorological briefing office or an aeronautical information services unit. The office should be easily accessible to flight crews of departing and arriving aircraft and to flight operations airline officers. It should be sufficiently large to accommodate necessary staff and equipment and to enable flight crews and other personnel to prepare flight plans and reports. Additional information relating to briefing offices may be found in the Aeronautical Information Services Manual (Doc 8126.(

3.5 COMMUNICATIONS

Aeronautical mobile services

Air-ground communications for airport traffic control, surface movement (manoeuvring) control and approach control are operated by the corresponding air traffic services, and the associated terminal equipment should be suitably sited in relation to these services. If air-ground communications for en-route ATC or other services are to be provided, the associated terminal equipment should be suitably sited in relation to the corresponding area control centre, flight information centre or other services concerned. Once the equipment is installed, it is necessary to establish the plan in consideration of future expansion because any type of rearrangement is too costly and difficult. The transmitters and receivers for en-route ATC are often placed in a remote building off-site.

SECTION III – LANDSIDE DEVELOPMENT INTRODUCTORY NOTES

In the past, the landside of the airport has included surface access infrastructure, airport support facilities, and all the terminal elements leading up to the exit onto the aircraft parking apron or entrance to the passenger boarding bridge (PBB). The interface between the passenger terminal building (PTB) and the apron or aircraft door has traditionally been considered the boundary of the landside and airside.

Over the years, evolving security requirements and approaches have moved this traditional boundary further back into the building. PTB, therefore, now typically includes both traditional landside components as well as elements that are considered airside. So, although the PTB has historically been considered to fall in the landside category, this section refers to both landside and airside elements within the context of the terminal building.

Therefore, for the purposes of this section, the major elements comprising the landside of an airport may be identified as all areas of the airport and buildings, including parts of the PTB to which the non-travelling public has free access as well as the non-public portions containing airline operations, cargo facilities, airport administration, and government facilities. With respect to airside, the term is generally understood to mean that part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron, to which access is controlled. Within the PTB, its airside components are those that are located beyond passenger and staff security screening checkpoints to which only travelling passengers and authorized personnel have access.

Chapter 1passenger Terminal Building

1.1 ABOUT THIS CHAPTER

This chapter deals with planning for facilities to accommodate those activities associated with the transfer of passengers and their baggage from a surface mode of travel to air. It also covers the transfer of connecting and in-transit passengers and their baggage between flights. Planning principles, factors affecting the type and scale and specific planning details of various passenger building functions are presented in this chapter. It should be noted that this chapter primarily covers typical and/or generally applicable processes and configurations. Many exceptional arrangements and conditions exist around the world that are applicable to specific States, regions or economic blocs. These primarily deal with facilitation of free movement of people and goods, which lead to additional specific passenger categories and often impose specific requirements on facilities and processes. These include, but are not limited to, the following examples:

a) the Schengen travel area between participating European States;

b) the Trans-Tasman Travel Arrangement between Australia and New Zealand;

c) the United States Customs and Border Protection Agency Preclearance facilities in participating States; and

d) the particularities, features and requirements related to the above examples and other such arrangements are not specifically dealt with in this section.

1.2 GENERAL CONSIDERATIONS

1.2.1 As the main building component of an airport, the passenger terminal building (PTB) is the key facility component of an airport master plan. It should have convenient access to ground transport, while also being located as close enough to the runways to facilitate the efficient movement of aircraft to and from the terminal parking positions and aircraft stands. Therefore, the location of passenger facilities is inseparably associated with the planning of the overall runway and taxiway layouts and the total airport plan.

1.2.2 Aircraft operations are more efficient when aircraft taxiing distances, fuel consumption, and time spent by aircraft in ground movement areas are minimized. Care must be exercised, however, to ensure that overall airport expandability and flexibility are not compromised.

Objectives

1.2.3 Airport passenger buildings serve the many needs of different types of users. The primary function of passenger terminal buildings is the facilitation of processes that enable the safe and efficient interchange of passengers and their baggage between public and/or private modes of transport and aircraft. It is critical that passenger buildings meet user needs by providing the necessary facilities and an optimum LoS while being cost-efficient to develop and operate. The design should be flexible enough to adapt to changes in processes or business models and enable economical capacity expansion when required.

Planning principles

1.2.4 An airport master plan maximizes the potential of future infrastructure through logical, cost-efficient and sustainable planning and design solutions. The type, size and components of the passenger building is a product of the master plan's activity forecasts, requirements analysis and options development.

1.2.5 Requirements should include the expected demand and levels of service, concept of operations and what is required in terms of supporting infrastructure. How a facility is operated can drive different levels of utilization within the proposed infrastructure and therefore its ability to accommodate demand. Examples include common use strategy, airline allocation, and technology adoption.

1.2.6 The passenger terminal plans in the master plan document should therefore be limited to conceptual studies and drawings. Such drawings should not be so detailed as to preclude adjustments that evolve later during the detailed planning phase, which follows the adoption of the master plan. Such refinements are frequently made as an airport development project moves beyond the master planning phase to final design and construction.

Greenfield and existing passenger terminal development

1.2.7 Planning for greenfield facilities requires substantial effort on the master planning steps of site evaluation and assessing the environmental impact. The amount of land required to support forecast traffic levels needs to be determined first, prior to undertaking the initial search for suitable airfield locations.

1.2.8 The overall site layout of passenger terminals, whether greenfield or existing, is driven by the orientation and positioning of the runway(s), and the location of the terminal building should be well connected to road and rail surface access links and be positioned to meet the airport's potential landside commercial development aspirations.

1.2.9 For both greenfield and existing passenger terminals, it is important to safeguard future flexibility by ensuring that established facilities can be expanded without extensive modification. Therefore, the location of passenger facilities is closely linked to the planning of the ultimate runway and taxiway layout and the airport-wide master plan. It is important to safeguard sufficient land around the initial or existing terminal development for the future expansion of the facility or for the provision of additional passenger terminal facilities, up to the airport's ultimate development phase with expansion triggers always driven by demand and not by time frames.

1.2.10 In addition to this, a long-term development strategy should be established that sets out high-level development safeguards beyond the planning horizon. The master plan should carefully consider what, if any, airport facilities or functions are established in the vicinity of the terminal building. This type of safeguarding will eliminate any substantial future disruption and/or capital expenditure.

1.3 FACILITY REQUIREMENTS

1.3.1 The purpose of requirements analysis is to determine the required capacity for existing or planned facilities. For passenger terminals, the size and capability of every subsystem is assessed. Current and forecast demand of each element is then compared to the capacity to identify space and processing requirements.

Passenger traffic demand

1.3.2 The forecasting step of the master planning process results in an annual air transport movement and passenger traffic forecast for the planning horizon that are key inputs for the next step in the process which is to establish facility requirements. The forecast will drive the size of the basic passenger terminal facility. However, passenger terminals at airports with similar passenger throughput volumes can vary substantially in size.

1.3.3 This is because the demand for passenger processing facilities is entirely dependent on the specific annual, seasonal, and ultimately the daily and hourly traffic profiles. The more concentrated the demand over a specific period, the more passenger processing capacity will be required. Conversely, airports with more evenly spread passenger demand can accommodate the same total annual demand with fewer processing facilities.

1.3.4 Therefore, secondary forecast data needs to be extracted from the annual air traffic forecast. The required secondary forecast data consists of peak hourly runway movements for both arriving and departing flights. Using primarily the associated aircraft fleet mix and assumed passenger load factor, the corresponding peak hourly passenger volumes can be established. These are typically disaggregated between arriving, departing and transferring passengers. Further disaggregation is often applied depending on the local context, such as by international and domestic passengers or country and region-specific groupings; for example, Schengen and Non-Schengen in Europe or Transborder in Canada.

1.3.5 Defining a planning demand is a key input to establishing facility requirements and should be a part of the master plan's requirements analysis. Although demand will primarily be driven by flight schedules and load factors, the actual concentration of the demand at any process will vary widely inside the terminal facilities, based on such factors as the arrival profile of the passenger, the time of day, passenger segmentation and the location of the processing subsystem with respect to other processes. It is important to note that an airport terminal is made up of a set of interconnected subsystems, therefore a balanced approach must be used to ensure that one component of the terminal system does not create a bottleneck.

1.3.6 Processing facilities should not be planned for the absolute highest passenger demand peak since this level of demand only occurs infrequently. It is more cost effective and sustainable to establish a lower level of throughput as the design flow rate, and accept a slight degradation in passenger processing and comfort levels in limited instances, when the absolute peak throughput is approached or achieved. This is accomplished by establishing a typical "busy hour" which will prevent the overprovision of passenger processing facilities and minimize unnecessary capital expenditure.

1.3.7 The busy hour can be established using a variety of methodologies depending on the local context and/or airport operator/developer preference. With busy hour design flow values established, the sizing of individual processing facilities is undertaken by applying formulae based on metrics covering space per passenger, queue times, agreed levels of service and processing rates. The outcomes of these calculations help determine the number of individual processing facilities and necessary space.

1.3.8 The sum of the individual passenger processing area requirements forms the basis of the overall future passenger terminal net area required and is a key input for the development of the master plan. Various elements are then added to establish the total PTB size, such as vertical and lateral circulation, commercial areas, office space, building structure, plant space, etc. The static calculations typically suffice to establish future terminal space requirements at the master plan level and thus the initial order of the magnitude capital expenditure. For more complex airports or advanced study stages, modelling and dynamic simulation can be applied to refine facility and space requirements.

Terminal development phasing

1.3.9 In planning, the aim should be to ensure that the available processing and holding capacities meet the demand requirements and the desired LoS. These plans must also be affordable and flexible enough to accommodate incremental capacity increases in line with traffic demand growth.

1.3.10 Airport terminal projects involve many stakeholders, long design and construction lead times, and must be scheduled to ensure that the right capacity is delivered at the right time. Development plans and phasing should always be linked to traffic volumes and not specific years. The forecasted traffic growth and lead time required for each individual infrastructure facility are two key factors in defining a “demand trigger”, which will initiate the planning and construction of the next terminal phase. These triggers should be set so there is sufficient time to develop the new facilities prior to reaching the “design day” capacity.

Demand capacity assessment and facilities requirements

1.3.11 In order to establish the overall sizing of a PTB, a high-level estimate of the number of individual processing “units” needs to be made for each of the key processes (e.g. check-in, security screening checkpoints, baggage reclaim) based on anticipated peak passenger demand. The demand relates to the quantity of people (passengers, visitors, or staff, where applicable) that undertake a process (at processing subsystems) or just occupy terminal space (e.g. in holding/ circulation subsystems) over a certain period of time.

1.3.12 Capacity and facility requirements for both new and terminal upgrade projects can be analysed using a formula-based approach, simulation modelling or a combination of both. Formula-based approaches, such as those found in the IATA’s Airport Development Reference Manual (ADRM), are usually employed in the initial stages of planning to ascertain approximate requirements, which are generally expressed in terms of the number of units of processing capacity (e.g. check-in desks, security checkpoint lanes, etc.), and the space required to accommodate the processing units, related queuing areas, and directly related support facilities (e.g. offices, secondary screening areas, etc.(.

1.3.13 Space requirements can then be established for each of the passenger processes by deriving an area requirement from the number of individual facilities in each process, the total of which will form the core of the “net area” space programme for the processing elements of the terminal. Well-recognized industry best practice guidelines on designing service levels such as the IATA’s Level of Service Concept (see Section III, Chapter 1) can be used to integrate desired passenger waiting times into the calculation to determine the amount of queuing space that needs to be provided.

1.3.14 Further area requirements, not directly related to passenger processing but required to support the overall terminal operation, can then be added. These include commercial zones (retail, FaB), passenger toilets and restrooms, back-of-house facilities, such as baggage handling system (BHS) requirements, ground handling equipment storage, ramp support rooms, storage and plant rooms, office accommodations, etc. Usually, a “gross area factor” is then applied to allow for circulation space, building structure, and other building elements. The combined areas then form the total area schedule for the passenger terminal development.

Operational objectives

1.3.15 The needs of airlines and their passengers must be considered and are important inputs to the master plan. Internally, space allocations will be determined by the airport’s context, its airline partners and how the airport operates. For example, a connecting hub with a highly peaked “bank” flight schedule will have different requirements than an airport that serves primarily OaD passengers with a more evenly spaced airline flight schedule. These considerations not only impact the requirements for the passenger terminal but also the entire airport master plan.

1.3.16 Operational requirements are critical for determining the floor area and types of facilities required and the level of efficiency that can be expected. Consultation with users should be conducted to confirm the expected level of service (LoS) and discuss such issues as airline allocation and how the infrastructure will be used. Before any expansion, existing facilities should be assessed to determine whether utilization can be optimized through improved processes or technology.

Key variables influencing capacity and requirements

1.3.17 There are several factors that impact the capacity and requirements of airport terminal facilities. These include:

Demand: The volume of arriving and departing aircraft, passengers, bags, meeters and greeters, well-wishers and vehicles within a defined period. The demand forecast establishes the peak hour volumes by category (e.g. originating, terminating, transfer, transit, split by, for example, international, domestic passenger types), as well as the design day-flight schedule, if required for more detailed modelling or simulation analysis.

Passenger presentation profiles: Not all passengers departing in the peak hour arrive at the airport within that hour. Some passengers may arrive many hours in advance of a flight while others may arrive an hour or less before flight departure. The length of time before a flight that a passenger arrives is influenced by many factors, including: duration of flight, frequency of service to that destination, type of ticket, purpose of trip (i.e. leisure versus business), and knowledge of the process (i.e. a frequent traveller tends to arrive later than a new or infrequent traveller because the frequent traveller understands the time required for the necessary processes prior to going to the gate). If possible, a survey should be conducted on existing traffic arrival patterns to generate a passenger arrival distribution.

Once the planning period demand is determined, the arrival pattern for each facility should be assessed at that location. Typically, presentation profiles will reduce planning demand by extending it over a longer period. For example, peak hour departing passengers typically arrive at the terminal over a 2- or 3-hour period, distributing the volume that is present at check-in or security screening checkpoints over that time. Conversely, peak hour arriving passenger demand is very concentrated, as all passengers on any individual flight arrive at the airport at the same time.

Additionally, the throughput of preceding facilities often distributes the flow of passengers at subsequent or “down-stream” facilities. For example, demand at passenger security screening checkpoints is closely linked to demand at check-in. How passengers spend their discretionary time can also alter the passenger arrival patterns. Thus, a single planning passenger throughput volume may need to be adjusted for each of the various facilities in a terminal, even if the total volume is the same.

Dwell time: How passengers spend time at an airport other than in “processing” or queuing to process, is discretionary. This may be time spent at the airport doing any number of activities including shopping. Variations in dwell time can alter distribution patterns and affect requirements.

Processing rates time: In calculating throughput and queuing at processing facilities, assumptions are made about processing rates times. Within a spreadsheet model, an average amount of time per passenger is used, while in a simulation model, distributions are employed (such as an advanced distribution function with a minimum of 1 minute, a maximum of 5 minutes, and an average of 2 minutes). Regardless of the type of model used to project the required size of a facility, variations in the expected processing rate can result in notable changes in the number of units and space requirements for the specific facility.

Level of service (LoS): The level of comfort a passenger experiences in relation to passenger processing is referred to as level of service. The two key metrics that determine the LoS of an individual processing function are space per passenger and waiting time for a specific process.

There are multiple methods and measures for quantifying LoS performance. An approach that is widely accepted for airport terminal planning is set out in IATA’s Level of Service Concept. This framework identifies various minimum service requirements for each of the individual passenger processing components. It is described in IATA’s Airport Development Reference Manual (ADRM) publication (https://www.iata.org/en/publications/store/airport-development-reference-manual/; IATA ADRM 11.(

The framework sets out ranges of metrics classified as “over-design”, “optimum”, “sub-optimum” and “under-provided”. Provision of an “optimum” level of passenger processing facilities is the recommended objective, aiming for a good level of passenger comfort while avoiding over-provision and under-provision of infrastructure. IATA states frequently within the ADRM that the LoS provisions are to be viewed as guidelines and not design standards.

Concept of operations (ConOps): Consulting with airline users on the concept of operations (ConOps) will help in understanding the operational assumptions which help determine the capacity and requirements. How a facility is operated can drive different levels of utilization and efficiency within the proposed infrastructure and the space and processing units required. This, at best, can mean that additional demand can be accommodated by such key drivers as a common use strategy (e.g. check-in desks, bag drops and gates), airline assignments and technology adoption.

Utilization rates: In a facility where the ConOps provides passengers with a choice about the process they utilize, such as check-in (e.g. self-serve kiosks, full-service counters, hold checked baggage, baggage drop and premium check-in) assumptions are made about the utilization – the percentage of passengers using each of these options. Variations in these utilization rates can have a significant impact on the number and variety of facilities required, localized queuing for the various modes and the total throughput of the facility, which subsequently impacts downstream processes.

Use type: Within an individual facility, user type service differentiation can be implemented. For example, within the check-in area, differentiated check-in facilities are often provided for different users, such as economy class passengers, premium travel class and frequent travellers or passengers travelling in groups. Similarly, in addition to general passenger security screening, many airports and countries operate a known traveller or premium product which may reduce the processing time for passengers using these facilities.

Other users: Many terminal facilities, such as check-in, are used exclusively by passengers. However, in the case of security screening, there are other groups that may be processed through the general security screening checkpoints. While some airports have dedicated non-passenger facilities, in many cases the passenger security screening checkpoints must also provide screening for other users, including airline flight crews, airline ground staff, airport authority staff, and concessionaire staff.

Staff shift changes should typically be planned not to impact passenger peaks. However, airline flight crews, depending on the location of their support facilities, often travel through security screening in the hour preceding their flight departure. This demand may often occur during the passenger peak hour. These other users can have an impact on the capacity and should be accounted for the in the master plan's requirements analysis.

Allocation of airline facilities: Airlines purposely differentiate their services to address commercial competition and offer a unique public identity. While all airlines use major airport infrastructure (runways, taxiways, taxilanes, ATC, etc.) the same way, differentiation of passenger-facing services often leads airlines to seek dedicated use of customized areas of the passenger terminal, that is, particularly for premium passengers. Airline operations are more efficient when focused on a concentrated area of the terminal. Spreading an airline's operations across an air terminal campus can lead to an overall reduction in facility utilization and a subsequent increase in total size and thus cost.

The most cost-efficient utilization of airport facilities is achieved when facilities are used consistently and constantly throughout the entire operating day. Certainty of the location of their chosen airline operator is also a passenger wayfinding requirement. Determining the optimum allocation of airport terminal facilities requires consultation with airline users. The outcome should be arrived at in a fair and transparent manner and should consider a range of occupancy scenarios that balance airline preferences with the efficient use of airport infrastructure and maximization of asset utilization and flexibility.

Passenger-baggage alignment: Passenger behaviour with regard to baggage (e.g. number of hold baggage, time to reach baggage claim) is interrelated with baggage performance (time of first bag, last bag, unload rate, etc.). Similarly, security throughput is impacted by both the time it takes to process passengers and their cabin baggage. The key point is that improvements made to passenger processing rates should be matched by improvements in processing bags, otherwise the lack of alignment between the two can become a constraint in the terminal design.

Passenger characteristics: Passenger characteristics that may be considered, not only in the context of pedestrian flows but in other amenities or design features including: business versus leisure; age and gender demographics; groups (family, corporate, tour, etc.); and local versus national versus international origin. Factors that influence behaviour include: familiarity with travel and the particular airport; signage, visibility and transparency; upstream facilities; and amount of dwell time in the airport (e.g. time between arrival at the airport and aircraft boarding, not required to queue, process through or travel between mandatory facilities). Passenger characteristics will have an influence on the type and capacity of facilities in the master plan.

Group size: There are two elements of group size that could impact space requirements. If the processing rate to be used in calculating the number of counters required is based on a transaction time per group, then this value is necessary to avoid overstating facility requirements. The other issue is queuing space. If well-wishers stand with passengers in the queue for boarding passes and/or baggage handling, they occupy space even though they do not require processing. Again, these parameters vary greatly between airports, airlines and even flights and should be agreed to with the project team. Without any data, if an assumption of one processing unit per group is used, the implication is that this could be an overstatement of processing demand and an understatement of queue space requirements.

Stakeholder consultation

1.3.18 It is very important that the appropriate stakeholders be consulted when establishing planning criteria to be used in the facilities requirements calculations. The level of consultation will depend on the nature of the study. Outline feasibility assessments may be undertaken based on requirements established with consultation of the relevant internal departments within the airport operator organization (as appropriate), such as terminal and airside operations, security, etc.

1.3.19 Consultation with all main users of the terminal facilities, such as the airlines, border control and security agencies, ground handling service providers, fire department, concessionaires, landside transport providers, etc., should be carried out throughout the master planning process. Effective consultation with users, particularly airlines, can lead to more informed decision-making and can generate new ideas while ensuring that the planned infrastructure is flexible, functional, and able to adapt to both changes in technology and the industry environment.

1.3.20 In general, the earlier in the process relevant internal and external stakeholders are invited to participate, the more benefit that can be derived from their input into the planning parameters. Early and ongoing regular consultation will also help avoid surprises or conflict in later stages of the planning and design process and greatly aid future buy-in of stakeholders into the proposed development plans and strategies.

1.4 PASSENGER AND AIRLINE SERVICE

Passenger characteristics

1.4.1 The characteristics of passengers and the airlines that serve them need to be considered when determining the type of facilities that will be required in the master plan and the amount of space required.

Passenger categories and types

1.4.2 People travel by air for many reasons. The most common differentiator is leisure versus business travel. However, other passenger profile parameters such as general familiarity with airports and related processes (check-in, security, immigration, etc.), size of the travelling group or length of trip often determine which terminal facilities and services may be utilized.

1.4.3 Depending on the airport's location and market, traffic may be either steady throughout the year or highly seasonally peaked, such as in a resort area or pilgrimage centre. Terminals must be designed to accommodate these peak demands.

Impact on requirements

1.4.4 Overall passenger flows can be further subdivided into functional routes. These include:

a) Departures. Passengers using an airport for the purpose of departing by air.

b) Arrivals. Passengers arriving by aircraft at an airport as a final destination.

c) Transit. Passengers who arrive and leave again on the same aircraft. These passengers may remain on the aircraft, in which case they do not create any requirements. Alternatively, it may be necessary to accommodate transit passengers in the passenger building for the duration of the aircraft's stay at the airport, for example to permit the aircraft cabin to be cleaned and to provide reasonable comfort and facilities.

d) Some transit passengers may also be subject to border controls. This applies where part of an aircraft's route is domestic and another part international. Passengers arriving from an international section may be destined for an airport at which border control facilities are not available. These passengers will need to pass the border controls at the transit airport. Some countries' immigration regulations do not recognize direct airside transit. In this case, all passengers, including those transferring on to connecting flights to a third country, must pass through that county's immigration and customs inspections.

e) Transfer. Some passengers arriving at an airport by air will be connecting with a flight to another destination on another aircraft. Some ticketing, booking and boarding pass issue facilities may be required for some transfer passengers. Planning must address this specific type of passenger flow or route. On deplaning the aircraft, transfer passengers join the standard airside arrival passenger flow. Depending on the type of transfer passenger and the regulatory requirements, a dedicated security check, which may include screening within the terminal, may be required before the transferring passenger can enter the security-restricted areas of the airport. Transfer passengers will not encounter the transfer airport's standard landside area.

f) Transfer passengers arriving on an international flight and transferring to another domestic destination within the arrival country, join the arriving international passenger flow. Once cleared through immigration into the destination country, and depending on the destination country's regulatory environment, transfer passengers may undergo security screening again prior to joining the airside domestic departing passenger flow.

g) Depending on the characteristics of the airline, some passengers may have extended layovers when connecting between flights to destinations that are served only once or twice per day. Airports hosting these types of connections may wish to provide domestic departure airside facilities adapted for these longer duration terminal stays.

Impact on border control and government agencies

1.4.5 Passenger flows can be further subdivided as:

a) International. Passengers travelling between countries and subject to inspection by government border control agencies.

b) Domestic. Passengers travelling on routes strictly within the boundaries of a single State and therefore not subject to government control inspection. For planning purposes, "domestic passengers" may also include passengers on routes exempted from government control inspection. This includes traffic within a customs union or an economic community of free trade area, in which the national governments have agreed on the free passage of people and goods (for example, the "Schengen Zone" of the European Union). Depending on the details of such agreements, traffic may be domestic in one direction and international in the other. Thus, the classification between domestic and international applies to the aircraft route and not the OaD of individual passengers.

Airline network characteristics

1.4.6 Airlines typically operate “hub-and-spoke” and/or “point-to-point network” models. Hub-and-spoke carriers typically have a hub airport from which connections to other airports, commonly referred to as outstations, are flown. In a pure point-to-point network, each airport acts as an independent point. Airlines that fly primarily point-to-point services typically do not schedule connections or offer ticketed transfer services.

1.4.7 An airport can be served by airlines operating both hub-and-spoke and point-to-point models and many airlines combine elements of both. To address flexibility and continuously evolving airline service models, airports should plan to facilitate both service models. Airport terminal planning should be based on the percentage of passengers connecting from one aircraft to another, which in turn affects both the landside and airside service requirements.

1.4.8 The greater the proportion of transfers, the greater the proportion of passenger processing and handling activities that need to be accommodated airside. Airport infrastructure planners must balance the requirements of landside origin and destination passenger processing facilities versus airside transfer passenger processing facilities.

1.4.9 Airlines using that same airport as an element in a point-to-point network and who are not necessarily affiliated with the dominant airline, may be assigned to different areas in the terminal or terminal complex.

1.4.10 At a hub airport or large point-to-point airport, the dominant airline may own or operationally control a portion of a terminal, sometimes with the ability to choose service providers or alter interior layouts to suit their specific needs. In the case of a hub facility, adjacencies are typically provided for airline alliance members and those with a business relationship with that dominant airline.

1.4.11 A hub operation usually has a high percentage of transfer passengers. Systems and resources are required to quickly move passengers and baggage between aircraft. At domestic hub airports or hub airports in an international common travel zone (e.g. Schengen), immigration requirements for transfer passengers do not exist and there may be lower or even no security requirements for these passengers as well. At international hub airports, there may be substantial immigration and security screening requirements, typically focused on international to domestic transfers.

1.4.12 The passengers transferring between aircraft do not enter terminal landside and therefore do not impose a processing or holding capacity requirement on a terminal’s landside facilities (check-in and surface access systems (roads, etc.)). Unfortunately, at some airports with no dedicated transfer facilities, transfer passengers must go landside and then join the conventional departure flow.

1.4.13 A hub and larger point-to-point airport may also serve as a specific airline’s operational “home base”. The home-based carrier will require space for cockpit and inflight crews who are starting or ending their duty times and require check-in and check-out facilities. However, these facilities need not necessarily be housed in the PTB. Consideration should be given to providing adjacent “non-terminal” accommodation as a less expensive alternate location for these airline-specific functional requirements.

1.4.14 Terminal capacity should be built to accommodate multi-handler operations and common-use facilities, so that capacity can be more efficiently used and overall space requirements and capital costs reduced. Airlines that operate in a common-use environment, share facilities such as gates and check-in positions and may require specific storage areas. Counter and gate allocation are performed by the airport operator and may take into consideration specific airlines’ preferences (“preferred use.(”

Key service types and requirements: full-service carriers, low-cost carriers, charter airlines

1.4.15 Passenger airlines operate a variety of business models. This section describes three of the most common models; however, it is important to keep in mind that the individual features of each model are constantly evolving as carriers respond to changes in the market environment and technology. Requirements will vary, but it is important to note that most airlines will share a common interest in infrastructure that is fit-for-purpose and cost-efficient to develop and operate. Understanding airline user requirements is critical to the development of a master plan and the terminal concepts that it may contain. One of the best means is to establish a consultation process with airlines is to collect information on requirements and inform of plans on terminal options.

1.4.16 Full-service carriers (FSCs) typically provide a hub-and-spoke network and multiple service levels to cater to a wide range of passengers, which will typically provide such airport amenities as service counters, lounges for premium passengers and PBBs. Such differentiated service offerings tend to require more facilities and space. It is important to note that most FSCs have made changes to their business model to lower costs by adopting many features found in low-cost carriers and, like those carriers, are taking advantage of the increased digitization of passenger processes (e.g. self-service) to increase customer convenience and generate greater efficiency.

1.4.17 Network carriers usually fly a more diverse fleet of short-haul and long-haul aircraft with longer turnaround times. Additional catering and other services are required, and with schedules at hubs coordinated around other flights, this may lead to some aircraft staying on the ground longer than the time required for turnaround itself. Departures are scheduled around pre-determined connection and transfer banks rather than minimal turnaround intervals.

1.4.18 Aircraft may also be scheduled to stay longer on the ground to accommodate arrival times at destination airports, particularly those with curfews and/or limited slot availability. Longer turnaround times may increase the total aircraft parking stand requirement. However, the less dense flight concentrations may soften peak flows and spread out demand for passenger facilities.

1.4.19 Low-cost carriers (LCCs) have played a major role in the expansion of aviation. While their business practices vary, LCCs have generally focused on serving point-to-point markets with a single class of service and aircraft type. These carriers prioritize high aircraft utilization, quick turnarounds that tend to utilize passenger and aircraft facilities for shorter periods of time. This model typically concentrates demand leading to substantial peaks and troughs in airport activity. LCCs value tight cost controls, including operating from airport terminal facilities that provide minimal levels of service at low costs to the airline. They emphasize a streamlined terminal experience with self-service and automated options that enable efficient passenger processing. LCCs typically require fewer passenger processing and customer service facilities, but often this results in longer waiting times leading to longer queues that require additional space.

1.4.20 LCCs generally prefer aircraft stands within walking distance (walk-in, walk-out) or a short bus ride to the boarding gate with dual stairs to expedite boarding and disembarkation. The short turnaround times reduces aircraft parking stand occupancy time. Some LCCs may also prefer closed gates to expedite the boarding process. LCCs have not traditionally catered to connecting traffic and therefore usually have simplified baggage handling needs. However, this is starting to change, as some LCCs are taking on some FSC characteristics to increase revenue, such as offering connections.

1.4.21 Charter airlines typically serve leisure and tourist destinations on a seasonal basis. Charter airlines may operate flights on a scheduled basis and offer seats directly to passengers often through tour operators. The charter model shares many characteristics with the low-cost model, whereby the focus is on limited services and amenities and the operation of a point-to-point network. Like LCCs, they generally require fewer passenger processing and customer service facilities Due to the nature of the “charter holiday” packages offered, passengers often stay for a week or longer, which can concentrate demand for services at an airport to a limited number of days in the week as opposed to daily frequencies.

1.5 DEVELOPMENT OF OPTIONS

1.5.1 After the strategic direction is set and requirements to meet forecasted demand are defined, the next step in the master planning process is to develop alternative options to meet that demand. Whether planning a new terminal building or expanding an existing one, the master plan process should consider a range of development concepts to meet the airport's strategic development objectives. Choosing the most appropriate development option requires a thorough and rigorous evaluation process that should include consultation with stakeholders, and in particular, airlines.

Terminal concept options development

1.5.2 The generation of terminal concept alternatives will be influenced by the following factors:

a) Is it an existing or new airport? A new airport will typically benefit from exploring a wide variety of terminal concepts, whereas the physical and operational constraints inherent at an existing airport may limit the number of deliverable development options.

b) The scale and characteristics of the traffic demand. A small regional airport with domestic OaD traffic may lead to a recommended simple single-level linear terminal concept. A large multi-sector hub airport on a "greenfield" site will typically require an extensive investigation and evaluation of alternative terminal concepts to ensure that the most appropriate concept is selected.

c) Is adequate land available? The most critical element for choosing concepts will be land availability (i.e. space between runways) and the percentage of contact stands required.

d) Achieving the correct balance of landside, terminal and airside facilities. In addition, there needs to be balanced capacity between landside (roads, curbs, parts of passenger terminals and parking), and airside (aircraft parking stands, airside road network and ancillary facilities). Variables affecting concept development include the provision of surface access connections and public transport links, which drive landside requirements, and the number and size of aircraft parking stands and their interface with airfield connectivity. Surface access, passenger processing in the terminal and airfield infrastructure must be balanced to achieve an efficient end-to-end passenger journey. A bottleneck in one part of the system will impact the capacity and passenger experience of the entire airport system.

Terminal design considerations and principles

1.5.3 Well-designed passenger buildings are usually the result of close cooperation between members of the planning team, including those whose task it is to lay down the requirements (airlines, airport operators, ground handlers and other key stakeholders, including the relevant civil aviation authority) and those, particularly architects and engineers, who translate the requirements into detailed designs. Consultation with users, particularly airlines, should be conducted throughout the master plan's development. Their inputs are especially important in determining facility requirements. While each group has its own primary responsibility, close collaboration across a multidisciplined team of planners and stakeholders can help achieve the desired outcome.

1.5.4 The following general design considerations and principles will help guide the development of viable terminal concepts during the options development phase.

Balanced and efficient design

1.5.5 The primary orientation of passenger terminals has traditionally been set by establishing the most straightforward path to and from ground transportation modes, through the terminal facilities and to and from the aircraft. Each process and procedure will have a respective passenger movement rate to accommodate a desired capacity and LoS. A balanced approach ensures that no single component of the terminal system causes a bottleneck when all other processes are adequately sized for the design throughput.

Flexibility

1.5.6 The design should be flexible enough to meet changing requirements. Airport terminals need to be robust enough to adapt to changes and trends without affecting the airport's fundamental operations. These may include changes to the market environment (traffic demand and airline operations); business processes and technology; and regulatory requirements. Flexibility needs to be an inherent element as the design progresses, as this enables the building to remain adaptable to future requirements.

1.5.7 In addition to a modular design approach, another strategy to build in flexibility is to cluster physical elements that are difficult or costly and disruptive to relocate, such as building structural elements, toilet blocks, vertical circulation (stairs, escalators, lifts, etc.), service risers and mechanical rooms immediately adjacent to processing areas. The goal is to avoid constraining the expansion of these processing areas and ensuring there is sufficient space adjacent to processing areas to enable simple, straightforward future expansion. Large structural spans and column-free spaces can also improve flexibility.

1.5.8 It is also recommended not to plan around specific equipment suppliers or specific pieces of equipment, as both the choice of supplier and type of equipment often change over the lifespan of a terminal building.

Expandability

1.5.9 Another important consideration is having a terminal building that can be expanded in a logical and cost-efficient manner as passenger demand increases over time. For this purpose, the terminal should incorporate a modular design philosophy that enables capacity enhancements to be added in a straightforward and balanced manner while not disrupting ongoing operations. Developing the terminal building with a uniform and repetitive structural grid and using uniform structural and mechanical components, allow for simpler and more predictable future expansion of the terminal building.

1.5.10 Sufficient space around the terminal building should be safeguarded for future growth by not locating significant non-terminal infrastructure immediately adjacent to the terminal building. Sufficient separation between the terminal and airport support facilities must be provided to allow for anticipated future growth and unanticipated future changes or requirements. Where available land is limited, interim uses for the resulting space are at grade car and rental car parking, airside equipment parking and storage, short-term commercial uses, or landscaping.

Travel and transfer distances

1.5.11 Travel and transfer distances should be as short as practically possible in terms of both time and distance. Where consistent with forecast passenger throughput requirements, compact terminals that minimize walking distances are beneficial both in terms of passenger experience as well as capital and operational expenditure. Where longer walking distances are unavoidable, these should be supported with moving walkways.

Separation of flows

1.5.12 There are three primary passenger flows in an airport terminal: departures, arrivals and transfers. Within each of these flows, passengers may be further separated into international and domestic and other possible variants, such as Schengen traffic in Europe. Each of these permutations will require a specific sequence and combination of functions, with some functions combined across multiple flows. Often functional separation is required by law or regulation and must be fully integrated into the basic planning principles.

1.5.13 Each flow should be designed to be simple, clear and intuitive. Complexity creates process inefficiencies and usually leads to reduced user satisfaction. Functional separation reduces visual and procedural complexity, making flows more intuitive and potentially reducing the need for extensive wayfinding assistance.

Passenger flow principles

1.5.14 The following principles support efficient passenger flows that also provide a low-stress and reliable passenger experience:

a) The passenger journey should be as direct, intuitive and unobstructed as possible. There should be minimal conflict with the flow of other passenger routes, baggage and vehicular traffic.

b) Overall walking distances should be minimized. Where longer walking distances are unavoidable, these should be supported with moving walkways. IATA recommends the use of mechanized systems (travellators, people movers, etc.) for walking distances more than 300 m. See below reference on automated transit systems.

c) Changes in level for pedestrian routes should be minimized. Level changes involving stairs, escalators and elevators can be disorienting for passengers, particularly where the direction of travel changes with a change of level.

d) All interior public spaces should be connected by paths or with identified lifts suitable for people with reduced mobility, and public corridors should be free of obstructions with level floor surfaces.

e) Flow routes should be planned to be intuitive and give maximum visual continuity from one functional step in the passenger process to the next (e.g. from check-in to immigration.(

f) Adequate standing or resting space should be provided at all major decision points so that persons can pause to receive the information without obstructing the general circulation of others. Flight information should be provided in alcoves adjacent to but not obstructing circulation routes.

g) A comprehensive wayfinding and signage strategy that is consistent and easy to understand should be in place to support orderly passenger flows. Decision points should be clear and unambiguous.

h) Departing passengers should have an opportunity to check in/drop off their hold baggage at the earliest point.

i) The capacity of passenger flows should be in balance with other systems such as baggage and aircraft turnaround time. Flows and capacities of all subsystems must be in balance.

j) It is recommended that commercial opportunities in air terminals (e.g. retail and FaB) be located “on the way” not “in the way” so as not to impede efficient passenger flows.

Automated transit systems

1.5.15 Wherever there are lengthy walking distances, an automated transit system should be provided, in addition to the general horizontal circulation space requirements. The selection of an appropriate transit system will depend upon the size of the terminal complex, taking into consideration overall travel distances and capacity sizing. The selection process may also be influenced by security requirements where passenger segregation must be maintained.

1.5.16 Various types of automated transit systems should be considered:

a) Moving walkways: The most common way to assist walking distances, for both departure and arrival passenger routes and should be considered for distances greater than 300 m. Typically, they consist of multiple sections of moving walkway, interspersed with zones without walkway, to allow intermediate access and egress, and should be sufficiently wide to enable passengers to pass one another. Where appropriate, contingency and redundancy measures may include duplicate parallel moving walkways.

b) Electric vehicles: Can be used to help passengers with reduced mobility (PRM) and those that require special assistance. Additional circulation space is needed to allow these vehicles to move freely and safely without obstruction to or from other passengers. This includes planning for sufficient space to enable vehicles to turn around and to provide dedicated areas for pick-up and drop-off, in addition to providing sufficient parking and charging areas.

c) Automated people mover (APM): Many larger airports feature an automated people mover (APM) system to transport passengers between terminals or within a large terminal itself, when walking distances lengthier and the number of people is higher than practical for systems such as moving walkways. APMs are commonly provided when a terminal is composed of various satellites or piers with routes crossing apron areas. Some APM systems connect the terminal(s) to other public transport systems and/or to allow people to travel through the airport city. A thorough assessment should be undertaken to identify demand levels that would warrant the commissioning of an APM and the type of technology that would provide the appropriate LoS. If future introduction of an APM is considered likely to support the selected terminal concept, adequate space should be put into the terminal design in order not to impede or prevent its future introduction. A useful resource to aid selection of an APM system is ACRP Report 37: Guidebook for Planning and Implementing Automated People Mover Systems at Airports (https://crp.trb.org/acrpwebresource2/acrp-report-37-guidebook-for-planning-and- implementing-automated-people-mover-systems-at-airports.(/

Accessibility

1.5.17 Special care should be taken to recognize and accommodate the needs of disabled passengers. It is critical to consider regulatory compliance and inclusive solutions. Planners can best make the building more accessible for those with reduced mobility by planning necessary features early in the design process.

1.5.18 Passenger terminals should fully respect the needs of PRM by offering them the greatest possible travelling comfort. Terminals should also provide suitable workplaces for employees with reduced mobility. A design and operational priority should be placed on providing the same accessibility to relevant facilities for all passengers and employees, including those of an ageing population that require assistance.

1.5.19 Annex 9 defines recommended practices for the facilitation of the transport of persons with disabilities. Specifically, it recommends that special assistance be provided to persons with disabilities to ensure that they receive the same services available to the general travelling public while respecting the dignity of the individual. For an airport or air terminal master plan, this means taking necessary steps to ensure that appropriate accessibility measures are in place along the entire passenger journey.

1.5.20 The Manual on Access to Air Transport by Persons with Disabilities (Doc 9984) elaborates on the relevant Standards and recommended practices (SARPs), whether on landside, inside the terminal or to access the aircraft. For a master plan, consultation with experts on accessible and universal building design should be undertaken at an early stage to inform key decisions. For example, the location and capacity of vertical circulation will be a key element in the journey for PRM.

1.5.21 Several States have developed design standards or building codes for people with reduced mobility which are applicable for airport passenger buildings. Europe has adopted Regulation (EC) No 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, and the United States has enacted the United States DOT Air Carrier Access Act (ACAA.(

Technology

1.5.22 Terminal options that are being developed need to consider the impact of technological change on space and capacity. The continuous evolution of technology has enabled better customer engagement and resulted in significant savings and efficiencies. The leveraging of digitization and biometrics is transforming airports, making the "passenger experience" not only faster and more secure, but also less stressful. For example, the increasing adoption of mobile and self-service technology has resulted in an evolution of the check-in area, while the introduction of advanced imaging technologies is improving the effectiveness and throughput of security screening checkpoints. New concepts, such as off-airport activities for processing passengers and hold baggage, are also being explored.

1.5.23 The layout and size of passenger terminals will be influenced by these innovations as they tend to increase efficiency and capacity. Therefore, the requirements analysis and subsequent development of options in the master plan must consider the role of technology in the passenger terminal, and whether the terminal concept is flexible enough to respond to the ongoing evolution in technology.

Security

1.5.24 The airport's security strategy should be part of the key design criteria from the outset. Engaging the airport security team and the appropriate authority for aviation security as early as possible will ensure the best outcome, reduce costs and mitigate the chance of a costly rework at a later stage. The decision on whether to have a centralized security screening checkpoint or several checkpoints is also an important consideration to the design of the building and its efficiency taking into account the need for staff screening.

Commercial

1.5.25 Airport master planning also includes the placement of passenger amenities, concessions and other services. Amenities enhance the passenger experience but should not obstruct the primary passenger flows or visual continuity. In terms of the master plan, it is important that the strategy and requirements be defined early in the master plan process to identify the space and type of facilities required.

1.5.26 Terminal retail offerings are best weighted towards the airside, where passengers will have passed all necessary processes prior to proceeding to board their flights and likely be more predisposed to the commercial opportunities. This also benefits the airlines, as it increases the certainty around their passengers' abilities to proceed to the gate in time.

1.5.27 The types of commercial facilities may include:

a) Food and beverage services (FaB): May include snack bars, coffee shops, restaurants and bars. The quantity and type of FaB will vary by location and social context.

b) Retail and other concessions: Retail provisions will vary depending on the location of the airport and the mix of traffic. International passengers will frequent duty free shops and specialty brand outlets selling clothing, jewellery and electronics. Retail offerings may also include news agents, pharmacies, and gift and souvenir shops.

c) Retail employee facilities and support space: Support space, such as break rooms and locker rooms, should be provided for employees of FaB and retail outlets. These facilities can be either centrally located or provided for clusters of outlets. Short-term storage for commercial facilities should be provided in proximity to the outlets. Long-term storage can be provided elsewhere in the terminal building or in a separate logistics facility. It is important to integrate the flow of goods to, and waste from, amenities to landside loading areas and required security screening facilities.

1.5.28 While ancillary non-aeronautical revenue (e.g. generated by concessions) is an important part of many operators' business plans, care should be taken to ensure that passenger flows are not unnecessarily impeded or complicated in the pursuit of commercial revenue, and that any required construction does not hinder the future flexibility or expandability of the airport's core functions.

Administrative support facilities

1.5.29 The airport authority and airlines generally require administrative support accommodation inside or conveniently adjacent to the terminal. Airport authority staff accommodation may include the airport management and operational staff. Airline accommodation may include administrative support areas for passenger processing areas (e.g. check-in operations offices) and flight crew briefing (flight planning, crew lounges, etc.(.

1.5.30 The range of facilities will vary depending on the size of the airport, but may include offices, equipment storage, locker rooms, meeting and training rooms, IT facilities and break rooms. At larger airports, it may be more cost- effective to provide separate administrative office building facilities outside but near the PTB, especially for airport and airline staff not involved in day-to-day terminal operations.

1.6 TERMINAL CONCEPTS

1.6.1 The option development step in the master plan process involves creating and analysing passenger terminal concepts that can be refined into possible options. Most airports will combine elements of various terminal concepts to suit their needs and local context. Different passenger terminal configurations have an impact on the following key master planning criteria:

a) airside capacity, apron stand capacity;

b) passenger facility capacity;

c) support facility capacity;

d) landside surface access and public transport systems capacity;

e) passenger experience, walking times, wayfinding, human scale;

f) passenger screening processes including queuing times;

g) minimum connect times for transfers;

h) ease of airside aircraft circulation;

i) airside operability;

j) accessibility from landside for passengers;

k) option for commercial activities and non-aeronautical revenue;

l) security (controlled access;(

m) future flexibility that can accommodate changes in operating models, airport business models, etc;.

n) modularity and expandability;

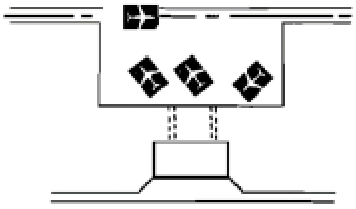
o) capital and operating expenses; and

p) sustainability aspects.

1.6.2 The capacity limitations of a specific terminal configuration can only be determined in the context of the individual project. Benchmarking can assist in determining whether a particular configuration may be suitable in a specific case.

1.6.3 Passenger terminals come in many different shapes. However, to simplify the various generic types of typical terminal concepts, the following diagrams are presented:

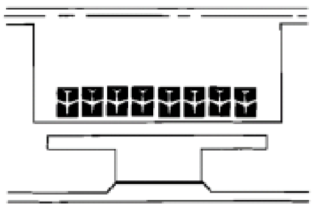
Simple concept:



1.6.4 The simple terminal concept will typically consist of a single level structure with a side-by-side layout of departures and arrivals processing areas. A common airside departures holdroom is provided with several direct exits (terminal gates) to the aircraft parking apron. Passengers typically access the aircraft by walking across the apron and boarding the aircraft via aircraft stairs.

1.6.5 The simple terminal layout facilitates the movement of passengers from curb to aircraft without any level changes and is applicable to airports with low to moderate airline activity. The aircraft parking apron provides close-in aircraft parking stands for a limited number of aircraft.

Linear concept:

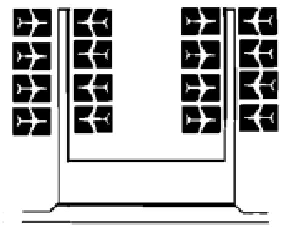


1.6.6 Linear terminal concepts are an extrapolation of the simple terminal concept, providing additional apron frontage and gates, and more space within the terminal building for passenger and baggage processing. It is recommended that the passenger concourse should have pier boarding gates on both sides.

1.6.7 If designed with a modular approach, the straight geometry of linear buildings makes them easier to expand without creating significant interference to passenger processing or aircraft operations. The potential for longer passenger walking distances within the terminal are an additional outcome, which may require mechanical system remediation such as travellators or APM systems depending on the LoS selected and available budget to accommodate these facilities. Arranging facilities vertically through multiple building levels allows for a more efficient use of land by reducing the building footprint. Arranging terminal facilities vertically also serves to segregate passenger flows (i.e. arriving and departing international passengers.(

1.6.8 The linear configuration's simplified landside access and adequate curb length lends itself to convenient adjacent vehicle parking on the landside, and extendable airside corridors serving either bridged or walk-out aircraft gates.

Pier concept:

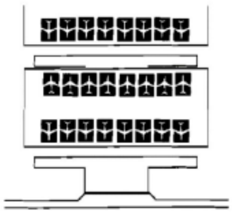


1.6.9 The pier concept processes passengers and baggage through one central building and concentrates aircraft gates and holdrooms on both sides of one or more concourses attached to the terminal processor. The pier concept fully separates passenger processing from concourse activities, thus enabling each element to develop according to its own requirements. Piers can be designed as simple single-level facilities serving walk-out gates, or as multi-level operations with segregated passenger flows to meet security and/or government agency requirements. Multi-level piers also lend themselves to the implementation of PBBs, facilitating direct aircraft access.

1.6.10 Advantages of the pier concept include gaining passenger processing and commercial retail economies of scale, through the use of a central building although such areas can also experience congestion during peak hours. The pier concept provides one of the most economical means of adding gates by extending a pier or building a new one. However, this should not be done without ensuring that a balance is maintained with surface access and passenger processing capacity and that airfield connectivity is not compromised.

1.6.11 Pier configurations must be carefully planned in conjunction with aircraft aprons and gates to optimize the available space and ensure a safe and efficient airside operation. Where possible, dual taxilane access between the piers should be used to avoid any conflicts or operational constraints caused by aircraft push-back. The distance between piers is determined by the size of aircraft the facility is designed to accommodate and the length of the piers.

Satellite concept:



1.6.12 The satellite configuration includes one or more freestanding concourses accommodating passenger holdrooms, perimeter aircraft gates and parking stands that are connected to a single centralized passenger processing terminal building via an underground, at-grade, or overhead connector. The main terminal accommodates the primary passenger and baggage processing functions and support facilities and is typically connected directly to some aircraft parking stands.

1.6.13 A variation of the satellite concept involves a remote processor concept. In this configuration, the passenger processing terminal building is not served by any aircraft parking stands. All aircraft parking stands are located around airside satellite concourses. This concept is applicable where the airside area is too remote from the main landside access, or to connect additional passenger processing facilities into existing airports where no more development frontage is available on the airside and landside boundary.

1.6.14 The terminal and its satellites can be separated by one or more aircraft taxilanes, and the connector can be below ground, or less commonly, elevated above via a bridge structure. Connections are either pedestrian corridors or APM system links. To maintain reasonable passenger walking distances, only satellites separated from the passenger terminal by a single aircraft taxilane should be considered as “walkable” with provisions included for moving walkways.

1.6.15 Larger developments with multiple satellites, wider airside separations with multiple taxiways between the processor terminal processor and satellite(s), or where satellites are added to existing large terminals should include APM systems for transporting passengers. APM systems must maintain the required passenger segregations for departing, arriving and connecting passengers.

1.6.16 Although apron level baggage routing between terminals and satellites is provided at some airports, a mechanized below-ground baggage distribution system is recommended to minimize airside road congestion and enhance airside safety.

1.6.17 The satellite concept provides an opportunity for incremental airside growth which does not impact the operations of the main terminal facility; however, care must be taken that the terminal processor and landside elements are kept in balance with the expansion.

1.6.18 There are many advantages to the satellite concept, including the efficiency in terms of maximizing the amount of contact stands, but the design is best suited for larger airports with a transfer traffic. Operating multiple satellite concourses adds complexity and costs to both build and operate. For example, a more sophisticated hold BHS and an APM may be required to transport cabin baggage and passengers. In addition, airlines may need to run duplicate activities, such as commercial important passenger lounges, across multiple concourses. Aside from the economic costs, the passenger experience can also be affected by having to walk in long connecting corridors or ride an APM.

Passenger terminal process levels

1.6.19 The terminal concepts described above, and their associated roads and curbs can be developed on single, double or multiple levels, to address different types of passenger demands. Four representative configurations are outlined below:

a) Single-level road or single-level terminal. Passenger departure and arrival processing is on the same level and separated horizontally. Passenger boarding of aircraft is typically by aircraft or mobile stairs.

b) Single-level road or double-level terminal. Passenger arrival processing in the terminal is on the lower level, with departure passenger processing, departure lounges and PBBs on the upper level. Access to the departures level is facilitated via pedestrian vertical circulation banks (stairs, escalators, elevators, etc.) inside the passenger terminal building.

c) Double-level road or double-level terminal. Passenger departure roadways, curbs, processing and PBBs are on the upper level, with arrivals processing, curbs and roads on the lower level.

d) Multi-level roads or multi-level terminal. Variations of this combination can be considered for very large terminals. It will provide the opportunity for further separation of vehicular traffic on the roads and curbs (e.g. public transport on the lowest level), for intermediate terminal levels between arrivals and departures to separate passenger flows, and for direct bridge connections for passengers to adjacent multi-level parking garages. It also can address access from grade, elevated or subsurface airport rail link.

Passenger terminal process configuration

1.6.20 Another factor in developing and evaluating passenger terminal options is functionality, including the placement of individual passenger processing facilities within the terminal building configuration.

1.6.21 Passenger flows will be impacted by the type of terminal operation, which include the following models:

a) international operations only;

b) domestic operations only;

c) both international and domestic operations under one roof or in connected buildings; and

d) separate international and domestic terminals which can be linked by concourses or walkways, bussing or people-mover systems.

1.6.22 The exact sequence and types of passenger processes depends on the type of operations (domestic, international, transfer and transit) under consideration and the regulatory requirements. The general order of most passenger processes are as follows:

Departures:

a) entry to departures, processing and check-in hall;

b) check-in;

c) boarding pass check;

d) security screening checkpoint;

e) emigration (outbound passport control), for international travellers (some States only;(

f) departures lounge; and

g) holdrooms and gate lounges.

Arrivals:

a) immigration (inbound passport control), for international travellers;

b) baggage reclaim;

c) customs for international travel; and

d) exit via arrivals hall.

Transfers and transit:

a) boarding pass check;

b) inbound and outbound passport control for travel between international and domestic origins and/or destination pairs;

c) security screening checkpoint;

d) departures lounge, for longer transfer/transits; and

e) holdrooms and gate lounges.

1.6.23 Additional passenger processing and inspection may be required for each of the above three categories to meet the specific requirements of individual government agencies.

Passenger processing facilities

1.6.24 A passenger terminal process configuration is made up of many subsystems that are used to process passengers whether they are departing, arriving or transferring and transiting. This section provides a brief description of the primary processing facilities that planners need to consider when assessing space requirements and developing terminal options.

1.7 PASSENGER DEPARTURE FLOW AND PROCESS

Departures and arrivals halls

1.7.1 The departures and arrivals halls are public spaces that form an interface with landside facilities, such as ground transportation and car parking. The departures hall can include:

a) airline ticket sales;

b) information – airline and airport; and

c) retail and FaB.

1.7.2 Some airport terminals may include a landside retail zone with predominantly a FaB offering to allow passengers to bid farewell to family and friends in a relaxed environment before the departing passengers enter the airside departure areas. This provision should be determined in consultation with retail planners, based on the passenger to well-wisher (family and friends) ratio.

1.7.3 The departures hall may be integrated with or directly connected to the arrivals hall, which often occurs in small to medium-sized terminals. Most larger terminals have departures and arrivals hall links via a concourse or walkway, or by a vertical transportation core in a multi-level terminal. The arrivals hall includes facilities for the passengers and meeters and greeters, such as:

a) waiting zones, including seating;

b) general information, including flight arrival times;

c) tourist and hotel information;

d) ground transportation information and ticketing;

e) retail – with the main emphasis on FaB and convenience outlets; and

f) amenities.

Check-in

1.7.4 The check-in and bag drop operation is typically the first process experienced by most departing passengers and has been traditionally carried out by staffed check-in counters. However, changing airline processes and passenger behaviour enabled by the increasing adoption of mobile and self-service technology, has resulted in an evolution of the check-in area.

1.7.5 Most airlines have embraced new technologies and incorporated a high-level of self-service check-in and hold baggage drop for domestic and international operations. It is recommended that a level of self-service should be included to support the emerging new technologies and innovation in airport terminal operations.

1.7.6 It is also recommended that extensive consultation be undertaken to determine the needs of each airline stakeholder and its customers. This consultation process should also include relevant airport authority representatives.

1.7.7 The factors that influence the deployment of self-service check-in and bag drop systems include:

a) airport facilities and IT systems (including integration of biometrics for passenger identification and verification for travel;(

b) airline business models and level of innovation in customer service;

c) level of integration with code share or other airline business partners; and

d) future integration of new technologies and trends in airport systems worldwide.

1.7.8 The use of technology and advanced processes in the check-in hall can result in reduced space requirements and a smaller footprint for the terminal processor which can have a material impact on the master plan.

Check-in systems

1.7.9 Check-in systems can vary significantly between airports, based on a range of commercial, operational and technological considerations. Types of systems may include:

a) dedicated – airline specific; and

b) common use – available to any airline for the duration of their check-in procedures.

1.7.10 Boarding passes and bag-tagging can be generated by:

a) conventional check-in: agents behind a counter;

b) self-serve off-airport internet check-in – home or office computer, mobile phone; and

c) curb-side check-in: almost exclusively seen in the United States, with check-in facilities provided directly at the departures curb before entry into the passenger terminal.

1.7.11 Passenger hold baggage is processed:

a) at conventional check-in;

b) at agent-staffed bag drop counters, used by passengers who have used a self-serve option for generating a boarding pass;

c) at self-bag drop counters, used by passengers who have used the self-serve option both for check-in and bag-tagging. Often all these processes are integrated into a single processing unit;

d) remote check-in – at long-stay car parks, hotels, or rail stations with airport connections. (This process may also be precluded in some States for hold baggage security reasons;(.

e) curb-side check-in – check-in process and acceptance of hold baggage at the departures curb, traditionally aimed at relieving the passenger as soon as possible of their luggage. (This process may be precluded in some States for hold baggage security reasons.); and

f) future trends and new technologies – innovation in the check-in and bag drop procedures.

Check-in hall layouts

1.7.12 The physical layout of check-in counters will be impacted by a range of commercial, operational, and technological considerations, as well as by the relationship between the check-in process and departing passenger flows. Check-in counter layouts may include:

a) conventional – check-in counters with check-in agents and traditional baggage conveyors;

b) linear – conventional check-in system and bag drops with a line of counters connected to a collector conveyor behind;

c) island – conventional check-in system and bag drops with back-to-back counters and central collector conveyors;

d) two-step self-service process;

e) kiosk – to allow passengers to undertake self-service check-in and optionally bag-tagging;

f) bag drop – to allow passengers to drop their bags at agent-staffed bag tag and drop counters or in a self-service configuration; and

g) one-step self-service process: integrated self-serve check-in, bag tag and bag drop units, arranged in a linear or island arrangement.

1.7.13 In addition to the above, the following facilities may support the primary check-in process:

a) assistance and ticketing counters – service counters to allow passengers to seek help, including rebooking, reseating, paying excess bag or weight charges, and ticketing; and

b) repack – benches to allow passengers to repack suitcases (adjusting weight to meet airline requirements and avoid additional charges.(

Boarding pass check

1.7.14 Following check-in and before going through Security and gaining access to the airside, a check is made to verify that passengers possess a valid boarding pass. The primary purpose of this check is to ensure that only travelling passengers with a valid ticket proceed for further passenger processing and enter the airside. The boarding pass check does not form part of an official government border control and is typically done prior to the security screening or passport control. Verification is either undertaken manually by a member of airport staff, or through automated boarding pass readers. Whatever process is used, it should be seamless and avoid creating queues or bottlenecks.

Passenger security

1.7.15 Security screening for departing passengers and their cabin baggage typically follows the check-in and hold baggage drop process and can be centralized in one checkpoint or decentralized across multiple checkpoints. In addition to space for the security lanes and queuing, space will also be required for inspection and administrative areas, including viewing areas for security officers, which should have a clear view of all checkpoint lanes and search rooms.

1.7.16 Security screening may include conventional or enhanced procedures, with the latter incorporating new technologies and processes. The capability and layout of security screening checkpoints can have a big impact on efficiency and balanced capacity and are therefore an important consideration in developing terminal options to meet requirements. For more information, please refer to Doc 8973.

a) Conventional security

A typical conventional process includes a queue zone, unpacking area, screening of passengers (archway metal detectors) and cabin baggage (X-ray screening machine), collection of articles and cabin bags, packing zone and trace detection monitoring.

b) Enhanced security

Enhanced processes may include technological tools such as the use of body scanners and CT screening machines, and process innovation, such as the automation of bin returns, multiple divestment points and matrix screening.

c) Risk-based approach

This includes trusted traveller programmes such as TSA PreCheck, Nexus and Global Entry, which are aimed at segregating low-risk passengers from conventional processes to provide an expedited experience and/or alternative screening process, which acknowledges the lower risk that these passengers represent by waiving some screening requirements (e.g. laptops removed from bags, shoe removal.(

Future trends and new technology

1.7.17 Emerging threats and new technologies are consistently impacting the delivery of passenger screening services and may in turn impact physical requirements of facilities. The impact of new approaches to the screening of passenger and their personal belongings and cabin baggage, supported by new technologies and processes, should be considered during the master planning period. This may include the integration of biometrics to verify and validate passenger identification for travel, as well as the introduction of advanced imaging technologies to increase processing times and enhance detection of anomalies that may raise concern.

Travel documents and authorizations

1.7.18 Many jurisdictions require airports to incorporate emigration (outbound passport control) procedures to meet specific national regulations regulatory requirements. An international passenger's identity is verified together with visa (if required) and other checks as required by the destination State. The facility can be located before or after passenger security screening, taking into account the need for departing passenger flows to be monitored and controlled. The process can be manned or handled through passenger self-service facilities supported by new technologies.

Departure lounge

1.7.19 The departure lounge is a common airside passenger waiting area, where most passengers spend their dwell-time before proceeding to their designated holdroom or gate lounge to board their flight. The facilities provided in the departures lounge can include, but are not limited to, general seating, commercial facilities including duty free, retail and FaB offers and welfare facilities.

Holdrooms and gate lounges

1.7.20 Holdrooms (also referred to as gate lounges) provide space for seating, circulation, and aircraft boarding operations. The boarding area consists of airline agent desks and associated queue areas. Limited commercial offerings can be blended into layouts to benefit from the concentration of passengers, but these should not “dilute” the central commercial offerings in the departure lounges or obstruct passenger flows.

1.7.21 There are several factors influencing the size and number of holdrooms required, including:

a) departing passenger demand, based on an agreed busy or peak period;

b) number of contact or bussing gates required to meet the peak demand; and

c) the maximum aircraft size and passenger load to be accommodated.

1.7.22 Holdrooms may be “closed” – dedicated to single aircraft gates and departing passenger loads, or “open” – shared by a number of gates, with seating and supporting facilities sized for combined passenger loads based on the planned peak hour departures from adjacent aircraft gates.

1.7.23 The required capacity of a holdroom is a function of the number of passengers that need to be accommodated for an average dwell time prior to boarding the aircraft. This number can be determined by applying an agreed load factor to the forecast aircraft demand and other factors, such as the call to gate strategy, passengers within airline lounges or nearby commercial and FaB facilities, and the airline model.

1.7.24 If the objective is to understand the aggregate demand, then the enplaning peak hour volume can be used directly. More often, the analysis is required for an open group of gates or a single gate closed holdroom. The holdroom concept impacts the appropriate level of disaggregation. For instance, if the terminal uses dedicated gate holdrooms (i.e. specific to one airline only) without cross-utilization, then the calculation of a single holdroom demand is appropriate.

1.7.25 However, if there is shared seating or an overlap of “open” holdrooms servicing multiple gates, then these should be evaluated as a group. In either case, it is necessary to compare the total capacity to the area under study to determine the proportion of the peak hour to be used. The comparison should be made with the active departing gates during the peak hour, considering the seating capacity of the aircraft using those gates. In general, gate hold rooms require more space if they are enclosed and less space if they are open. This is because in an open gate concept, passengers have the flexibility to seat themselves further away from the gate boarding area although typically within the line-of-sight of their assigned gate.

1.7.26 Concession strategy. Some airports employ a “call-to-gate” concessions strategy that is primarily post-security and, in some cases, closely integrated with holdroom capacity. Passengers in the departure lounge area are advised when their gate will be announced, usually a fixed time prior to departure time (typically 45 to 50 minutes). This can have an impact on the terminal holdroom requirements in the master plan, as a portion of the passengers that would normally be sitting there will instead be in the departure lounge space.

1.8 PASSENGER ARRIVAL FLOW AND PROCESS

Immigration

1.8.1 Arriving international passengers are required to pass through immigration (inbound passport control), a government border control process required to legally enter the country of arrival. This is an international traveller border control process whereby a passenger's identity is verified alongside potential visa and other checks required by the State.

a) Operational requirements: The location of border controls, and the stage in the passenger processing system at which they are applied, are important in maintaining free and continuous passenger flow. Where the State requires varying degrees of inspection of documents depending on the status of passengers, segregation should be put in place. The use of dedicated lanes for passengers with low service times will speed up the overall flow of facilities. Dedicated lanes should also be provided for passengers with reduced mobility, airline crews, diplomats, VIPs, etc.

b) Location of border controls: This should take the following into consideration:

(1 Passenger routings from the aircraft to the border control facilities should be as short and direct as possible with minimized walking distances.

(2 No cross-circulation between international and domestic passengers.

(3 No opportunity for international passengers to bypass the facility.

c) Processing requirements: The capacity required for each authority and procedure is a function of the service time, passenger flow rate, and proportion of passengers inspected. It is important that the correct number of facilities are allocated to each passenger type to ensure optimal flow of passengers. Processing areas should be supported by border agency offices, including observation and interview rooms, and staff amenities.

d) Current operations:

(1 Conventional: Counters and queue access zones controlled by government border agencies.

(2 Enhanced: Incorporating a level of self-service kiosk processing for eligible travellers in combination with a staffed counter. These enhanced technology measures tend to reduce staffing requirements as counter-processing times are reduced.

(3 Automated gates: These self-service lanes typically incorporate a passport scan with a level of biometrics for passenger identification and verification. This technical solution enables a single member of border control staff to monitor multiple processing lanes.

e) Future trends and new technologies: Increased availability of trusted traveller programmes, and online processes to clear arriving passengers, thereby reducing the inbound processing time. These programmes may require a two-stage process for passengers (e.g. a kiosk to determine eligibility followed by an expedited processing lane), depending on entry visa requirements.

Health inspection

1.8.2 Unless specific regulatory measures are in place, health control measures are integrated with immigration control. Where the State requires medical inspection of certain individual passengers, the facilities required should be defined by the medical authorities with jurisdiction. The flow of passengers to these special medical facilities should not disrupt the main arrivals passenger flow. Facilities should be designed to allow additional controls to be put in place when required by epidemiological conditions. If additional health inspections are required for all passengers, it should be carried out in such a way that it minimizes disruption to passenger flows. The impact on arrivals capacity needs to be assessed and adequate space for processing, queuing and circulation secured.

Hold baggage reclaim

1.8.3 It is best to have a single consolidated hold baggage reclaim hall where arriving passengers can collect their hold baggage. These halls can take considerable space and are an important consideration in developing master plan requirements and terminal options.

1.8.4 Hold baggage is typically presented to passengers on conveyor belt or "carousel" systems which can be provided as linear-type belts, L, T or U shaped. The conveying surface can be either semi-inclined or horizontal.

1.8.5 Hold baggage reclaim hall dimensions are mainly driven by the space occupied by the hold baggage claim belts as well as the distances separating these devices from each other, walls and other obstacles. The size of claim belts is determined by formulas that consider aircraft sizes as well as passenger and hold baggage volumes. The area around the belts consists of a retrieval area for the motion of collecting a hold baggage and a peripheral area that is used to wait, park a trolley or circulate into and out of the retrieval area.

1.8.6 In addition to the claim belts, hold baggage reclaim halls should provide:

a) ample circulation space for passengers with trolleys and hold baggage;

b) space for passengers to wait in case hold baggage delivery is delayed;

c) areas for storing hold baggage for passengers who are delayed in arriving to the hold baggage reclaim hall;

d) facilities to store misrouted or unclaimed hold baggage;

e) trolleys and trolley parking spaces;

f) dedicated out-of-gauge (OOG) baggage claim facilities; g lost baggage services;

h) seating and toilets;

i) clear wayfinding and signage; and

j) exits that are adequately sized for passenger volumes and include access control.

1.8.7 The provision of exit channels depends on the building layout and whether access to customs or other control points is required.

Customs

1.8.8 Arriving international passengers are typically required to pass through customs control facilities located between baggage reclaim and the arrivals hall in international terminals, and may include X-ray machines, supporting queue zones and search areas. It may also include support facilities such as duty collection, lab rooms for trace detection, offices or supervision and control rooms, interview and holding rooms, and staff amenities. As part of the master planning process the requirements need to be identified and then incorporated into terminal options.

1.8.9 Customs processing requirements vary by location or agency. Customs officials are often aware of specific passengers before they enter the customs area and use electronic means to identify such individuals. There may be referrals from customs to quarantine and vice versa.

1.8.10 Annex 9 recommends that at major international airports, States introduce in close cooperation with the airport operators and other regulatory agencies, a dual channel system for the clearance of arriving passengers and their baggage. The system shall allow the passengers to choose between two types of channels:

a) Green channel: for passengers having with them no goods or only goods which can be admitted free of import duties and taxes and which are not subject to import prohibitions or restrictions.

b) Red channel: for other passengers with goods to declare.

c) It is possible for regulatory agencies to apply random or selective checks to these channel streams without interrupting the normal fast, unimpeded flow. The streams in the red channel should flow past customs officers in the normal way.

1.8.11 Specifications for inspection facilities will vary by agency and jurisdiction, and will typically also include private interview rooms, waiting areas and detention zones.

1.9 TRANSIT AND TRANSFER FLOW AND PROCESS

1.9.1 Transit passengers are defined as those passengers who continue their journey on the same aircraft or flight.

1.9.2 Transfer passengers are those who arrive at a terminal on a flight, and then board and depart on another aircraft or flight.

1.9.3 Some airports may not have transfer traffic and operate solely as OaD airports, and others may be major hubs with over 50 per cent of their passenger traffic connecting between arriving and departing flights. Projecting transfer operations at an airport is a challenging exercise because it is generally the result of the strategic decision of an airline and how it markets its connecting flights. Establishing growth scenarios for the transit and transfer component of traffic will therefore require airline stakeholder consultations.

1.9.4 It is not unusual for an airport to experience significant shifts in transit and transfer passengers over the planning period of their master plan.

Transit passengers

1.9.5 The transit process was historically a requirement for flights that could not reach their destination non-stop. More generally today, transit passenger operations typically result when a flight stops to board additional passengers, and passengers may be required to leave the aircraft for the duration of the stop.

1.9.6 Transit passengers may be required to deplane their aircraft, along with transfers and arriving passengers who have reached their destination. They are typically directed (by signage) to the departure holdroom for their ongoing flight following a boarding pass check. If the passenger security standards at their originating airport (or country) do not meet the standards of their transiting airport (or country), they will need to pass through transit security screening before entering the holdroom and re-boarding their flight. Holdrooms should include passenger assistance counters staffed by airline agents or airport staff and/or interactive information displays.

1.9.7 Additional passenger processing and inspection may also be required to meet the specific requirements of individual government agencies for international operations.

Transfer passengers

1.9.8 Transfer passengers deplane their aircraft and are directed (by signage) to the transfer desk and transfer security for screening as required, and passport control if the transfer is between international or domestic flights. Passengers will then enter the departure holdroom to await boarding of their next flight. The holdroom may include airline transfer desks in a dedicated area to assist passengers.

1.9.9 Additional passenger processing and inspection may also be required to meet the specific requirements of individual government agencies for international operations.

Minimum connection time

1.9.10 The minimum connection time (MCT) is the shortest time required to transfer a passenger and their bags from the furthest gate to the furthest gate. The times for each type may differ and include:

a) domestic to domestic;

b) international to international;

c) domestic to international; and

d) international to domestic.

1.9.11 MCTs are used to build connected flight offerings and are a major factor in how systems validate what connecting flight options are to be displayed and sold. A shorter total journey time is a competitive advantage for an airline; however, this must be balanced against the need for a robust and reliable operation. It is critical that MCTs accurately reflect the true journey times of passengers and bags. Unrealistic MCTs can create misconnections leading to additional costs for airlines and customer dissatisfaction.

1.10 HOLD BAGGAGE LOGISTICS

1.10.1 Hold baggage logistics at an airport consist of passenger facing arrivals and departures operations through hold baggage check-in, reclaim and the processing thereof, including transfer security requirements and customs screening, sortation, loading and unloading. A BHS consists of the different processes and checks to transport passenger hold baggage from check-in at a departure airport, onto a plane’s cargo hold and then to a collection point at an arrival airport.

1.10.2 The hold baggage logistics planning and design process and resulting system layout will be influenced by the type of airport and its traffic characteristics, which may range from small primarily origin or destination airports, to LCC airline terminal operations, to regional hubs, and to global mega-hubs.

1.10.3 Hold baggage handling is one of the key logistical functions carried out at an airport. Hold baggage handling processes and systems take up considerable space within a terminal building and can have a big impact on defining the overall size of the terminal. The capital cost of delivering new BHSs can also be a major component of the overall capital costs of the terminal and affect the affordability of the overall master plan.

1.10.4 In addition, the processing of passengers and baggage are fully interdependent and therefore any constraint in the handling of baggage can limit the master plan’s overall passenger capacity.

1.10.5 The following principles apply when planning and designing a BHS:

a) The BHS should be designed with size of the airport and types of passengers (e.g. domestic, international, transfer) in mind, incorporating security screening requirements. MCT targets should be aligned with the master plan.

b) The phasing of the BHS should be consistent with the airport's master plan.

c) Hold baggage and passenger flows should be coordinated with respect to processing time and capacity, so that passengers do not have an excessively long wait before their hold baggage arrives at the hold baggage reclaim facilities (leading to a poor passenger experience), nor should the hold baggage arrive too early, taking up reclaim unit capacity and causing potential congestion in the baggage delivery system.

d) Hold baggage flow routes should not conflict with passenger or vehicular flows.

e) BHS maintenance and operations routes should be accessible so that baggage can be recovered quickly from any system failures for any point in the overall system.

f) The baggage system should minimize the number of individual handling operations, such as transfers between different types of vehicles, and the flow should be steady and uninterrupted.

g) Passengers should have an opportunity to check-in their bags at the earliest possible opportunity.

h) Passengers should not need to worry about their checked-in hold baggage and should be assured that they will be delivered to them in good condition at their intended destination.

i) Ideally, passengers should be informed of the position of their hold baggage in the processing chain from check-in to delivery.

j) Hold baggage claim systems should provide easy ergonomics to allow self-retrieval by the passenger.

k) Passengers should have the opportunity to perform as many self-service operations as technically and legally possible, but human assistance should be readily available when requested or needed.

l) The whole process should offer a high level of robustness to cope with disturbances and high level of resilience to allow swift recovery. System redundancy planning must be integrated into the BHS plan from the initial planning stages.

m) Opportunities should be taken of new technology and innovations where they simplify and improve processes and systems.

n) Reducing mishandling has become an industry priority and the tracking of bags at key points in the journey (acceptance, loading, transfer and arrival) is now an industry standard (IATA Resolution 7531.(

o) In addition to the typical range of activities and processes associated with the departures, arrivals and transfer flows, emerging modes of operation should be considered which could cover an end-to-end process: from home or off-site check-in to home or hotel delivery.

p) Security procedures should be established and implemented to meet agreed local and international standards.

q) The BHS should ensure compliance with local health and safety requirements for the staff.

r) Hold baggage handling processes should be optimized to meet the best practice in terms of environmental constraints.

.1 See https://www.iata.org/en/programs/ops-infra/baggage/baggage-tracking /Cabin baggage and passenger type

1.10.6 Not all bags are processed separately from the passengers. Cabin baggage and personal belongings will remain with the passengers during their entire journey. The percentage of baggage handled directly by the passengers will depend on the type of passengers, the duration of the flight and the commercial policy of the airline. This percentage may vary in the future, depending upon changes to the airline commercial policy and quality of the baggage processing such as potential for missing checked-in hold baggage and the evolution of aircraft design and airline operations (size of overhead compartments, airline commercial policy – one baggage only, time to board the aircraft, etc.). Cabin baggage and hold baggage policies may change quickly and with short notice, so baggage handling and processing system designs should be flexible to accommodate change.

1.10.7 All baggage separated from the passengers will be loaded in the aircraft hold and will follow the same process in terms of flow, security, storage, whatever their dimensions or type, and whatever technology is in use.

1.10.8 All checked-in hold baggage are tagged to clearly identify their owner, and hold baggage and their owners are usually verified electronically through a baggage reconciliation system.

Remote hold baggage check-in and delivery

1.10.9 The off-airport processing of hold baggage is a consideration for the master plan as it can reduce the number of touchpoints required at the airport and can influence the size and scope of the terminal. Some airports provide hold baggage check-in facilities at off-airport locations such as hotel lobbies or specially designated terminals in the city (cruise terminals, rail stations, etc.). Remote checked-in hold baggage is typically screened at the airport, although bonded transport to the airport is also used. For security reasons, the system must guarantee the security of the hold baggage from the check-in facility to the aircraft hold, to minimize passenger and hold baggage matching problems at the airport prior to boarding.

1.10.10 Some travellers may wish to have their hold baggage delivered to specific places outside the boundaries of the airport. Such travellers include hotel guests, members of tour groups or cruise passengers who have their bags delivered to a hotel or to cruise terminals, etc. Specific facilities should be provided at the airport to be able to identify and gather the inbound bags per local final destination, comply with local customs inspection rules and interface with final transportation system (bus, train, van, etc.(.

Departures hold baggage process

1.10.11 The hold baggage departure process is made up of interconnected elements that need to be balanced. It is important to understand the requirements and possible options for developing a hold baggage process as it has a significant impact on the capacity that the master plan can deliver and its overall costs.

1.10.12 The departure hold baggage process must incorporate several operations, the order of which may vary upon local constraints. Usually after being checked in, hold baggage is first identified, then security screened and, where such controls exist, simultaneously submitted to customs inspection. It may then optionally be stored for a period before sorting. Eventually, it must be sorted into individual flights and then further sorted into sub-groups (i.e. segregations) for a flight such as by class of travel, transfer hold baggage, destination airports in case of multiple stops and/or the particular aircraft holds in which it is to be carried. Then, the subgroups are loaded onto either a cart or into a container that will be loaded into the aircraft hold. Carts or containers are then driven to the aircraft parking stand where the hold baggage are loaded in the aircraft hold.

1.10.13 The BHS is designed to address for each of these different functions. The location of the hold baggage sortation and make-up hall is usually dependent on the general arrangement of the terminal building and may be beside the passenger departure area (in small airports), below the passenger departure area, in a basement, or in a remote facility connected by high-speed conveyors to the PTB in some large-scale airports.

Baggage handling system

1.10.14 The outbound baggage system accommodates check-in, security (and in some cases customs) screening, baggage sortation and baggage make-up. The types of systems vary from simple manual systems to individual carrier systems which may be entirely passive on a track or able to move independently in a designated space. The choice of system will depend upon the peak flow capacity required, the distance the hold baggage need to travel, the desired LoS and the complexity of operations. Local factors such as the cost and availability of manual labour and the skills of local labour for the operation and maintenance of mechanical equipment should also be considered.

1.10.15 Small airports can often function with manual systems or simple automatic conveyors, but the rate of traffic movement and quantity of baggage can quickly exceed the capacity of manual systems, therefore mechanical and/or automatic screening, storage, sorting and baggage make-up systems are often required.

a) The sortation system is linked with the check-in system and these functions are often completely integrated. Even where the two systems are functionally separate, the allocation of check-in positions can determine the form of the baggage sorting system. Thus, the concept of operations for check-in (common use, preferential or dedicated check-in desk allocation) should be defined at the earliest stage.

b) There should be a dedicated OOG acceptance point and process.

c) Shared baggage sorting systems, which serve all check-in positions and all aircraft operators have considerable cost and space advantages and usually systems that accommodate any input to any output allow operational flexibility.

d) Due to the very high cost of sophisticated hold baggage screening equipment, the implementation of the security process should take fully into account the system engineering requirements to optimize capital and operational costs.

e) For medium to large airports, the passenger volumes and corresponding hold baggage volumes lead to large-size and complex hold BHSs with multiple tile tray sorters and high-capacity destination coded vehicles. The definition of the volume and location of these systems and the need for their possible interconnection in case of multiple terminals is a fundamental consideration during the earliest planning phases of the terminal design project. These functional considerations have a substantial impact on the arrangement of the passenger terminal campus, as well as the cost and time schedule of the overall project.

f) Terminal size influences how the hold baggage process is managed. For example, where transfer volumes are low, the screening operation may take place close to the check-in area while the final sorting process is located as close as possible to the aircraft parking stands.

g) When many hold baggage need to be handled simultaneously or must travel long distances, sophisticated automated technologies offering high throughput and high reliability will need to be considered.

h) The breakdown of the system between the various functional areas and the sizing of these areas will have a considerable impact on the terminal building layout, as well as the overall passenger and baggage operational performance of the airport.

Security screening

1.10.16 It is a mandatory requirement at all international airports that all hold baggage be security screened prior to loading into the aircraft hold. Some States permit transfer bags arriving from an airport with which a one-stop arrangement exists, to be processed without the need for screening and to be fed directly into the sortation system. The techniques for hold baggage security screening are extremely varied and depend on factors such as local regulations and baggage sizes.

1.10.17 The amount of space and infrastructure required for this process needs to be considered carefully. The latest generations of hold baggage screening systems are more capable but also larger and heavier than the previous generation and have sometimes required structural enabling works and an upgraded power supply. The regulatory requirements and the technology to be used for security can have a significant impact on space requirements and costs.

Baggage make-up and delivery to the apron

1.10.18 Departing bags are delivered via a system of carousels, chutes or laterals to hold baggage make-up positions where they are loaded into unit loading device (ULD) containers or baggage cart. The hold baggage make-up room requires parking positions for empty and filled containers, dollies and/or carts with sufficient height for easy manoeuvring of vehicles. Properly sized, multiple lanes are required to enable easy traffic movement and maintain a safe and efficient operation including easy access to and from the apron. The space requirements of the hold baggage makeup area are relevant to the master planning.

Arrivals baggage process

1.10.19 Once an aircraft has stopped at its designated aircraft stand, loose baggage or containers are placed on tug and dolly trains and towed to the offload area of the inbound BHS. Hold baggage is then either directed to the designated baggage reclaim device or to the transfer element of the baggage departure system. Usually, terminating and transfer hold baggage are segregated in the aircraft hold to ease the handling process at the arrival airport.

1.10.20 Transfer input points provide a means of loading transfer hold baggage back into the departure bag system for subsequent processing and sortation. Arrival bags are delivered to the baggage reclaim system. Delays in baggage handling often occur at the offload point and achieving delivery of hold baggage to the reclaim area at a rate that matches the passenger flow rate is one of the most important elements of the airport baggage operation.

Baggage reclaim system

1.10.21 Hold baggage is usually fed directly onto a reclaim belt. In some airports, based on regulatory requirements, in-line embedded customs inspection machines are also included. The most common hold baggage reclaim device is the baggage carousel, of which there are several variants. Hold baggage is typically presented to passengers on rotating inclined carrousels or flatbed “racetracks” and manually retrieved by the passengers from the reclaim device. Smaller airports served by smaller aircraft types are sometimes equipped with simpler linear reclaim belts.

Customs inspection

1.10.22 Arriving international passengers are typically required to pass through customs' control facilities as part of the government system controlling of the flow of goods into a country and customs inspection of all hold baggage may be performed.

1.10.23 Inbound baggage screening can take place in-line within the inbound BHS, with an additional control at the exit of the passenger claim room. Inspection machines are embedded between the baggage system off-load line and the reclaim delivery area. Bags which are suspected of containing illegal items may be invisibly marked, allowing the hold baggage and passenger to be identified when leaving the claim area.

1.10.24 Airport planners should observe regulatory requirements and consult with government inspection agencies during the earliest stages of the terminal development process. Useful reference material can be found in Annexes 9 – Facilitation and 17 – Aviation Security and Doc 8973.

Transfer hold baggage process

1.10.25 Arriving transfer hold baggage are usually inserted via dedicated transfers offloads into the main departures security screening system and then onwards to main sortation and make-up. In cases where transfer bags do not require additional screening, they can be directly inserted into the sortation system. Where regulations do require some type of screening, there can be an impact on the transfer process and the space required.

1.10.26 Where an independent transfer hold baggage system is implemented, the hold baggage is offloaded from the container or cart, identified, screened for security, possibly stored to wait for the flight to be ready for make-up, then sorted and loaded into the outbound container or cart. In some States, hold baggage transferring from an international inbound flight to a domestic outbound flight may need to be collected by the passenger as a terminating hold baggage from the claim area and then cleared by customers before being rechecked for transfer.

1.11 TERMINAL INTERFACES

1.11.1 How the terminal is integrated with the airfield and landside facilities and surface access is an important aspect of the master plan. How achieving the correct balance of surface access, landside, terminal and airside facilities and smoothly integrating them is a big driver of efficiency.

Terminal interface with the airport apron

1.11.2 A variety of systems for moving passengers between the PTB and the aircraft exist. The most appropriate system will depend on the types of traffic and operations. This should be identified during the requirements analysis phase in consultation with airline users. The most important consideration is to maintain safe and free movement of aircraft, vehicles and passengers while avoiding operational conflicts. The choice of interface (e.g. PBBs, passenger boarding stairs, buses) will need to be accounted in the space requirements and airport layout in the master plan.

Departures: Airside exits

1.11.3 Upon departure from the gate holdroom, there are various means of providing access to the aircraft. The type and arrangement of this connection depends on a few factors, including passenger terminal configuration and aircraft size. The type of connection between the passenger building and aircraft should be consistent with the size of the aircraft. Access control is necessary to ensure that only authorized passengers and staff can pass to the airside and board the aircraft. Such control is usually carried out by airline staff at the gate holdroom exits from the terminal. The most common means of aircraft access are set out below.

Aircraft boarding stairs and ramps

1.11.4 Boarding stairs are a common means of providing access to aircraft, typically provided as mobile GSE units. Smaller regional aircraft are often equipped with integrated internal aircraft access stairs. Passenger boarding stairs enable aircraft to be accessed from both the front and rear doors which can facilitate quicker boarding and deplaning.

1.11.5 Mobile pedestrian ramp systems for aircraft access from the apron are less common. These operate in a similar manner to passenger stairs. Ramps have the benefit of being more suitable to passengers of reduced mobility, including allowing passengers in wheelchairs to use them. Ramp equipment typically takes up substantially more space on the apron than passenger stairs, especially for aircraft with greater sill heights.

Airside buses

1.11.6 When buses are to be used to transport passengers between the terminal and aircraft stands, specially designed airport passenger buses should be considered. These vehicles should have a low floor height, wide doors and minimum seating around the sides of the cabin. The capacity and dimensions of the bus should be in accordance with the aircraft types to be served and airside road network conditions prevailing at the airport. Bus loading positions should be as close as possible to the terminal airside departures lounge, to reduce the walking distance and hence the time required for passengers to get from the airside lounge to the aircraft.

1.11.7 Similarly, airside buses should deliver inbound passengers as close as possible to airside transfer routes and to arrivals processing zones such as inbound immigration and hold baggage reclaim.

Fixed links and passenger boarding bridges

1.11.8 PBBs are movable enclosed connectors which extend from the airport terminal “fixed link” element to the aircraft. One end of the airbridge is attached to the fixed link facility and the opposite mobile end is used to dock onto the aircraft. These assemblies, elevated above the apron, enable passengers to walk directly from the terminal building into the aircraft, typically, and allow passengers to be completely segregated from apron operations. Despite the simplicity of their concept, PBBs are typically highly complex and costly pieces of equipment that require trained operators for their operation.

1.11.9 PBBs can be provided in a variety of configurations, with a single PBB per aircraft stand the most common. MARS stands are able to serve an aircraft, typically a wide body, with two bridges simultaneously. Alternatively, these stands can also serve two narrow body aircraft simultaneously. The number and type of contact gates should be determined during the requirements analysis phase in consultation with the airlines.

Arrivals: Airside entrances

1.11.10 Upon arrival, passengers enter the PTB through the following typical means of entry:

a) walk across the apron from the aircraft to the arrivals entry point;

b) enter the terminal building via an airside bus drop-off point; and

c) enter the terminal building via a PBB.

Terminal interface with the landside system

Connection to building curb

1.11.11 Passenger building entrances, exits and curb areas are important parts of the total airport system. The principal components of the terminal interface with the landside system are:

a) vehicular traffic lanes, through-lanes, bypass lanes, curb and manoeuvring lanes;

b) raised sidewalks and pavements;

c) building openings, entrances and exits;

d) signage; directional, for information and for identification; and

e) pedestrian at-grade and elevated roadway crossings.

1.11.12 The necessary curb lengths and the vehicular traffic lanes will greatly influence the passenger building configuration, and likewise the PTB concept will influence the configuration of the curb layout. The road in front of the terminal includes pick-up and drop-off lanes, manoeuvring lanes to access and leave the load and unload lanes and through-traffic lanes. The departures' drop-off function can be provided on a single-level or split-level forecourt. It should cater to different modes of transport with passengers using private and rental cars, taxis, on-demand transport, shuttles and buses. At larger terminals, special lanes should be reserved and segregate for buses and taxis to increase capacity. There should be dedicated pathways for passengers going to and from car parks and public transit.

Signage

1.11.13 On the drop-off curb, passenger orientation is the key element. Directional and information signage facilitates the flow of passengers to their desired locations. The Council of ICAO recognized this need when they decided that a set of uniform signs should be developed for use at international airports throughout the world. This action was taken to assist air travellers in locating various facilities and services such as check-in counters, baggage reclaim areas, post offices, toilets and banks. The ICAO publication International Signs to Provide Guidance to Persons at Airports and Marine Terminals (Doc 9636) contains guidance on the provision of directional and information signage.

1.12 TERMINAL EVALUATION CRITERIA

1.12.1 The approach to terminal concept evaluation and selection varies from airport to airport. At a new airport there will be a greater opportunity to explore a wide variety of options and concepts and terminal configurations. Options and concepts available for consideration at existing airports may be limited and perhaps more focused on improving existing internal layouts and flows.

1.12.2 The evaluation process is an iterative process that can be carried out in stages. As a first step, a primarily qualitative screening is performed to reduce the number of options to a manageable level. This screening may involve technical, environmental and financial feasibility factors. Retained and eliminated options should be documented. It should be noted that environmental planning evaluations should be conducted in parallel with options development. A two-way flow of information on the location and layout of alternatives is essential.

1.12.3 Once identified, the short-listed options can then be further developed to better understand form, functionality, cost and constructability. During this time, the evaluation criteria are developed in more detail. The options are further developed to include an assessment of all quantitative elements (e.g. capability, capacity) and will include conceptual layouts.

1.12.4 The evaluation criteria to be identified as a key part of the options development and evaluation phase with airline stakeholder's involvement is essential for assessing the most critical factors against and highlight the differences between options. The following evaluation criteria is intended to be generic in nature and should be tailored to suit specific terminal concept.

Evaluation criteria

Site compatibility:

- Geometric compatibility with site and interface with airside and landside, including runway zoning and ATC line-of-sight.

Balanced development:

- Capacity of terminal to balance with the current and future capacity of the airfield (runways, taxiways, apron.(
- Capacity to handle the forecasted peak hour flow of passengers through the terminal and the anticipated passenger segments (e.g. transfer.(

Apron layout:

- Apron configuration and aircraft flows.

Aircraft gate capacity and flexibility:

- Number of gates and flexibility to accommodate different aircraft types.

Landside capacity and flexibility:

- Curb lengths, parking capacity and assignment flexibility.

Ease of terminal expansion:

- Ability to expand facilities without major impact on operations.

Flexibility for change:

- Ability to adapt terminal facilities to new processing and operational requirements.

Passenger flows and orientation:

- Direct intuitive flows with minimum changes in level and lateral movement, and no backtracking.

Walking distances:

- Distance from last processor to departure gate.

Retail and commercial development potential:

- Location, convenience and passenger exposure (footfall.(

Capital and operating costs:

- Comparative cost of alternatives.

Construction phasing (if applicable:(

- Impact on operations and levels of service.

Land-use planning

- Compatible and efficient use of land.

Environmental impact:

- Comparative impact of the development on and around the airport site.

1.12.5 A matrix can be a useful method for recording and comparing how each of the options performs.

Chapter 2 Ground Transportation Facilities

2.1 ABOUT THIS CHAPTER

This chapter deals with the planning of the elements of the airport required for the accommodation of ground transportation of passengers, hold baggage and employees to, from and within the airport. To adequately plan airport ground transportation facilities, data must be developed from the fundamental planning forecasts. In addition to estimates of future passenger levels, forecasts must also be made of airport employees, visitors and logistics supply. Other inputs include the arrival rates for arriving and departing passengers on the design day, the modal split, the occupancy of each vehicle type (private car, taxi, bus, etc.), dwell times and the number of meeters, greeters and other visitors.

2.2 GENERAL CONSIDERATIONS

2.2.1 Ground transportation to and from most airports is provided by two primary modes, namely private automobile and public transport, mainly taxis and buses. Increasingly, many airports are also served by some means of mass transit system other than buses, such as train, metro or monorail. Operations and requirements for automobiles to access the airport vary across a broad range of functional classifications. Furthermore, airport master plans must be developed to provide infrastructure with the flexibility to evolve as the automobile mode shifts from traditional parking and curb-side operations to continued growth in smartphone application-based services, the eventual integration of autonomous vehicles (AVs) into the airport environment and other future developments.

Master plan objectives as they relate to the landside

2.2.2 Prior to initiating landside master planning services, the airport authority should establish planning objectives that address specific issues and concerns of the authority. The objectives should provide facilities that meet anticipated traffic demand, are safe and operationally and financially efficient. Access should also be easily understandable and provide an acceptable LoS for the users while also being reliable and affordable. In addition, facilities should also be sufficiently flexible to accommodate evolving technologies and vehicles modes, as well as expandable to meet future demands and changing mode shares.

Planning principles

2.2.3 Master plan solutions should be developed for identifying and evaluating ground transportation alternatives. The planning principles should serve as a foundation for the selection and refinement of recommended master plan concepts and alternatives. The following factors and principles should be among the criteria used to develop and evaluate potential master plan ground transportation solutions and strategies:

a) Best practice: potential solutions should be consistent with industry best practice based on a review and consideration of operations and facilities at peer airports. The surface access strategy should aim to provide convenient and affordable access with reliable journey time to and from the airport.

b) User characteristics: facilities should be planned to accommodate existing user characteristics but with the flexibility to address evolving demographics and trends (e.g. reduction in vehicle ownership by younger generations and increased use of public transport.(

c) Demand, capacity and LoS: facilities should be properly sized to provide sufficient capacity that balances facility cost with an appropriate policy-based LoS for the user.

d) Balanced capacity: In developing a landside ground transportation solution, the overall requirements of the master plan and the potentially competing needs for airfield, terminal and service facility development should be considered so that balanced capacity is achieved across all these components.

e) Context of the surrounding area and link to transport policy: landside facilities should be defined to interface with the surrounding communities, support regional economic growth and be consistent with the policy requirements of the local and national governments.

f) Modes of access: facilities should be defined to accommodate the demands and operational requirements of exiting vehicular modes, but also include consideration of future technologies the increase efficiencies and emerging trends that may result in changes in modes of access.

g) Traffic segregation: ideally, roadway access facilities and parking facilities should be planned to segregate pedestrians from service-related functions to provide for improved efficiencies and LoS.

h) Security: ensure flexibility to accommodate existing and potentially evolving security measures.

i) Revenue generation: identify revenue-generating strategies that support recovery of the capital, operating and maintenance costs related to landside ground transportation facilities.

2.3 GROUND TRANSPORTATION TRAFFIC DATA

2.3.1 Data serves as the basis for ground transportation master planning. Demand and capacity analysis and future facility requirements are based on the collection of data.

Existing condition data collection

2.3.2 Data collection that defines the existing condition needs to be conducted and the resulting information needs to be organized to support tabulation. The results are used to analyse traffic volumes on main traffic segments of the airport. Key components of the data collection phase include:

a) Data collection logistics: prior to initiating original data collection, the master planner should obtain and review available historical data and information from the airport authority for the purpose of reviewing traffic peaking characteristics.

b) Airline passenger surveys: airline passenger surveys are a critical source for obtaining an understanding of passenger characteristics and behaviour patterns. Passenger surveys quantify actual use characteristics such as vehicle mode choice, group size, time of arrival, parking lot use, etc. Passenger surveys are typically conducted in the departure lounge or as intercept surveys prior to entering the security line.

c) Traffic surveys and observations: the master planner should gather field measurements and observations of traffic operations to support a solid understanding of existing conditions and collect roadway traffic data, curb-side activity data, public parking activity data and employee parking data.

d) Benchmarking of peer airports: in addition to data provided by the subject airport, information obtained from similar peer airports (e.g. similar in size, character, activity level and/or geographic location) and from airports that are recognized as providing facilities or operations that are considered to be of high quality, is also valuable in the master planning process. This exercise is especially valuable in the case of greenfield airport developments. Benchmarking provides a basis on which to identify the range of ground transportation options that should be considered at the subject airport and the general physical characteristics, operational requirements and financial implications of a solution based on the experiences from other airports.

Assessment of existing conditions

2.3.3 Upon completion of the data collection, the master planner will commence with the summary and analyses of the data and observations to define existing conditions. Facility conditions, sizes and activity levels will be summarized. Key issues and areas requiring improvement will be identified and noted. Analyses of the data will define existing operational conditions that include such information as vehicular volumes and characteristics, and parking demands and revenues. Existing conditions will provide a baseline for the analysis of future conditions. Projects currently underway or that have been approved and funded should also be considered as an “existing condition” and be reflected for purposes of establishing future demands and requirements.

Ground transportation level of service

2.3.4 As part of the evaluation of existing conditions and the development and definition of future ground transportation improvements, the master planner must estimate the LoS at which the existing ground transportation facilities are operating and the target LoS that future facilities should provide in terms of space per passenger and queuing time.

Roadway

2.3.5 The first step in analysing airport access roadways involves the establishment of existing roadway volumes throughout the roadway network surrounding the airport site. This provides an important baseline for all subsequent analyses. Future year roadway volumes are estimated through the development of various techniques that include straight- line extrapolation of demand through to more involved trip generation and trip distribution modelling. The former approach is simple and may be appropriate for smaller airports where the roadway network is simple and travel characteristics may be relatively stable. The latter approach requires more detailed analyses of the characteristics of the individual vehicle modes including the anticipated travel patterns and projected growth rates for each. After future year volumes have been established, the master planner will prepare the future LoS targets and identify anticipated deficiencies that might be expected over the planning horizon being analysed as part of the master plan.

Curb-side capacity

2.3.6 The terminal curb-side drop-off and pick-up is an important step in a traveller’s journey. If a curb-side location is too crowded or chaotic, it will negatively impact the passenger’s journey, their perception of the airport, the overall experience and may also create safety and security concerns. It is important to size the curbs appropriately to ensure an efficient and positive passenger experience.

2.3.7 Curb-side peak hour volumes are estimated for the departure and arrival peak hours using figures obtained from the roadway demand analyses or an independent analysis of curb-side volumes. The curb length required is affected by the numbers, average size and characteristics of vehicles. The use of cars by passengers may be influenced by the availability of public transport systems, particularly a dedicated town centre to an airport connection. The distribution of passengers by travel modes and the numbers and types of vehicles to be accommodated can be obtained from the roadway traffic surveys, airline passenger surveys and operational and economic forecasts.

2.3.8 The minimum time necessary to unload passengers and baggage depends upon the average number of passengers per vehicle and the average number of baggage per passenger. Occupancy time (or dwell time) should be limited to ensure that there is always space available to unload passengers and baggage without congestion or delay. This limitation depends on the rate of arrival of vehicles and the total number of spaces available.

2.3.9 An analysis of curb space utilization by the various types of vehicles should be performed. Curb areas for buses, limousines and courtesy cars should be specifically designated. Similarly, queues for taxis and car-sharing transport services should be designated and controlled. Pick-up of passengers by taxis and car-sharing transport services at the arrivals road sections can be controlled by dispatching from a designated off-curb taxi holding area.

2.3.10 The loading and unloading of passengers by private vehicles and unloading by taxis and other commercial vehicles at the departures curb-side is a somewhat random process. Orderly performance therefore depends on the arrangement and organization of the kerb lanes, building openings and signage or wayfinding.

2.3.11 Vehicular curb manoeuvring lanes are provided for the purpose of bypassing the lanes where passengers are loading and unloading with bags. The dimensions in length and width of the curbs need to be such that traffic volumes generated for the design year during peak periods will be processed without undue delays. The curb manoeuvring lane width should permit manoeuvring to take place without interfering with the flow of traffic.

2.3.12 Each vehicle should occupy a curb space only for the time it takes to load or unload passengers and baggage, and to manoeuvre into and out of the space. This total time is identified as the “active dwell time per vehicle”. Strict policing is often necessary at high-volume airports to minimize dwell time and keep vehicles moving along to promote efficient traffic flow.

2.3.13 The required curb length is calculated by the following steps:

a) determine the design hour passengers enplaning and deplaning. The design period for deplaning passengers is identified as the 10–20 minute peak within the peak hour (a 20-minute peak can be equivalent to 50 per cent of the peak-hour traffic). The design hour for enplaning passengers will be less concentrated and depend upon their presentation profile;

b) identify the percentage of transfer passengers and deduct from the total design hour requirement to find the number of passengers entering the airport using the road or curb system;

c) determine the modal preference by vehicular type;

d) determine the percentage of passengers that go directly to the parking facility and do not use the curb system;

e) determine the visitor ratio of passengers to visitors and applying this figure to the percentage of passengers using private vehicles;

f) determine vehicle occupant load and the average curb dwell time for that type of vehicle; and

g) calculate the linear curb-side demand by multiplying the peak period vehicle volume by the average dwell time and then multiplying by the average length for that type of vehicle.

Commercial vehicle staging

2.3.14 Commercial vehicles such as taxis and buses can be staged on sites away from the forecourt road system but in the vicinity of the airport site. Staged vehicles can then be called forward close to the time they are required, thereby reducing prime forecourt frontage occupancy and the demand for parking and waiting areas.

2.3.15 The approach for analysing commercial vehicle staging will depend on the available data and information. Taxi pickup operations and many commercial vehicle activities are actively managed, therefore staging area and curb-side stand occupancy is heavily influenced by operational considerations. Consideration should also be given to application-based rideshare staging areas.

Public parking

2.3.16 Car parking strategy should include both short- and long-term. For master planning purposes, public parking demand can be developed based on historical counts of actual car parking occupancy representing the demands within the car park during peak hours. A profile of peak daily occupancy by car park can be summarized for a full year which will then provide a seasonal peaking characteristic distribution of the magnitude of the parking demand.

2.3.17 Where historical information is not available, the benchmarking approach can be applied. After the design- day demand has been determined, the parking requirements should be calculated as a function of the demand. It is recommended that an additional parking space buffer be added to the calculated parking demand, to simplify the search for available spaces. Technology can reduce this buffer.

Other ground transportation facilities

2.3.18 The approach set out above outlines key considerations for calculating demand or capacity and facility requirements for the primary vehicular ground transportation and parking components to be addressed in a master plan. The master plan should also provide for other ground transportation facilities including:

a) car parking entry and exit plazas;

b) employee car parking;

c) rental car facilities;

d) bus and coach stations; and

e) rail and people mover alignments and stations.

2.4 GROUND TRANSPORTATION SYSTEM CONFIGURATION

2.4.1 The ground transportation system configuration should be determined during the early stages of the airport master plan since it influences the design of the passenger terminal. Options should be developed for each transport mode.

2.4.2 Once this configuration is determined, it can be linked to the broader road network. The configuration of the road directly in front of the terminal and the provision of vehicular parking are also important elements in defining the overall ground transportation system. For larger airports, it may be advantageous to incorporate rail access as part of a ground transportation centre.

2.4.3 Vehicular access, including the transition to ever-increasing on-demand services and eventual integration of AVs, will continue to impact the overall ground transportation access systems.

Vehicle Access

Single level curb-side

2.4.4 With a single level curb-side, all vehicular arrival and departure activities take place at the ground level. This configuration is typical at small- to medium-sized airports where all passengers enter and exit on one level of the terminal. The configuration of the terminal should provide lateral separation inside for arriving and departing passengers so that appropriate signage can be placed on the roadways and curbs to direct vehicles to the appropriate part of the frontage.

Multi-level curb-side

2.4.5 Multi-level curb-sides are more complex and costly than single-level curbs but offer greater capacity, flexibility, and the ability to tailor signage, services and the terminal-frontage interface more precisely. A multi-level curb can also more easily accommodate passengers where departure and arrival peaks are at similar times of the day. This configuration is best suited for larger airports.

Plaza configuration

2.4.6 With a plaza configuration, a large public plaza (or meeting area) is provided directly in front of the terminal. The large plaza space provides additional curb frontage where vehicles can drop-off and collect passengers. The key benefits are that it provides ample waiting space for passengers and increases curb frontage space. It also eliminates pedestrian-vehicle conflicts.

Remote drop-off area

2.4.7 A remote drop-off area (or “kiss and ride”) should be considered at those airports where there is limited space for roads adjacent to the terminal. This configuration will lessen the demand and construction of an approach roadway network but there must be an effective transportation system in place to bring passengers from the remote drop-off areas to the terminal. Adoption of a remote drop-off can also be promoted if there is fee-controlled access to the terminal frontage.

Rail Access

2.4.8 Rail access can be a powerful amenity not only for the airport operation, but for regional economic development. Depending on the nature of the rail service, it can serve as an important access mode for passengers and a primary commute mode for airport. Rail access provides a reliable journey time, particularly where routes to airports are congested.

2.4.9 Smaller airports without the passenger volumes to justify dedicated rail links can be intermediate stops on local commuter or intercity rail links that exist and operate independent of the airport. Where these commuter rail services exist near an airport, but not necessarily on the property, airports should investigate providing “last-mile” links between the airport and the nearest station (e.g. shuttle bus service, light rail link.(

2.4.10 Airports should remain cognizant that rail services operating independently of airports may not have the service or amenities that air passengers expect, such as luggage racks or a wide service span that encompasses very early morning or late night or overnight flights. For larger airports with greater passenger demand and/or limited space for roads and curbs, it may be advantageous to provide rail access to the terminal either within the terminal or adjacent to the terminal.

In-terminal

2.4.11 An in-terminal rail station is the most desirable from a passenger point of view and will attract the most passengers but development is expensive, especially if the rail alignment and station must be retrofitted into an existing terminal.

Terminal-adjacent

2.4.12 A terminal-adjacent location for rail access will derive many of the same benefits of an in-terminal facility without the space and implementation drawbacks. However, the connector between the terminal and rail station must be short, legible and attractive to encourage its use.

Intermodal access: ground transportation centre

2.4.13 An intermodal hub or ground transportation centre (GTC) combines multiple ground transportation modes and services into a single location, such as light and heavy rail (train, tram, metro), surface vehicle transportation modes including bus, private hire vehicle and rental car services which may offer a combination of local, regional, national and/or international connectivity. A GTC promotes ease of transfer between various surface transport modes and/or between transport modes and the airport terminal facilities.

2.4.14 A GTC, typically located adjacent to the terminal frontage, consolidates passengers arriving at the airport via all modes of transport, and may serve as a local, regional or national interchange hub serving traffic not directly related to the airport (e.g. rail interchange hub or providing local access to national and international high-speed rail services). A GTC allows many of the functions of various transportation providers to be consolidated at a single location, freeing up airport land for other operational purposes.

2.4.15 Intermodal centres, such as GTCs, provide an efficient use of airport land, especially at airports with multiple terminals and transportation operators. Providing a ground transportation centre for intermodal access requires a high-quality connection between the terminal and ground transportation centre, which can include, for example, a pedestrian link or automated people mover system.

2.5 ACCESS ROADS

2.5.1 Access roads provide the surface access routes for passengers, employees and goods to enter the airport and its various functional areas, including the passenger terminal forecourt. Using surveys, traffic demand by vehicle type can be determined for peak hours on specific roadway segments as well as at points of entry and exit. The number of traffic lanes required can be estimated from this basic information.

2.5.2 The typology, sizing and design of public access roads may adhere to local codes and standards. When designing roadways and developing signage, airports should remain aware that many users will access the airport infrequently and may not be familiar with the layout. In addition, the multiple convergence and divergence points of roadways often create confusing environments. As a result, every effort should be made to adhere to road design and sign placement standards.

2.5.3 Technology is rapidly evolving and should be used to improve safety, efficiency and the overall user experience. Various technologies can be used to monitor traffic conditions and provide real-time information. Implementing dynamic signage allows for flexibility of airport operations and enables airports to communicate real-time information to drivers of approaching vehicles.

2.6 PASSENGER BUILDING AND CURB INTERFACE

2.6.1 The interface between the building and the road is referred to as the passenger waiting area, curb-side, pavement or sidewalk. This area is a critical transition point for passengers and should be treated as a gateway between the airport and the surrounding environment. Developing a clear and legible layout is important to prevent passenger confusion and a deteriorated passenger experience.

Passenger waiting area

2.6.2 Passenger waiting areas should be sized with adequate room for passengers to manoeuvre, keeping in mind that passengers may be in large parties, carrying luggage, pushing carts, trolleys or children in strollers. Adequate provision must also be made for passengers in wheelchairs. The curb should be of sufficient area so that at peak hours, people on the curb and drivers of vehicles have a clear view and can recognize each other.

Curb-side lane configuration

2.6.3 For the shortest flow route, the unloading points should be as close as possible to the first processing positions in the passenger building, considering security considerations. For straight and direct flows, it should be possible to enter the building directly from the unloading points at any point along its frontage. The unloading area should ideally be located on the same level as the passenger departures floor consistent with other functional and regulatory requirements.

2.6.4 It is advisable to provide at least a three-lane configuration: one curb-side parking lane, one lane suitable for manoeuvring in and out of parking spaces, and one through or bypass lane. For high volume locations additional parking, manoeuvring and through lanes may be required.

2.6.5 Curb space integrated into a parking structure is a solution for space-constrained airport developments and/or airports looking for additional curb space to meet increasing demand. Parking structure vehicle loading can be utilized for specialized modes, such as charter buses, where it is advantageous to separate easily defined groups of passengers from the terminal curb-side. A curb in the parking structure is also advantageous when passengers will be boarding or alighting from a vehicle with a very long dwell time (such as tour buses.(

Allocation of vehicle types at the curb

2.6.6 Separating vehicles at the curb is highly advisable, based on operational requirements. This helps distribute traffic demands along the building frontage and promotes efficient and safe traffic operations. Separate lanes can be provided for taxis and private hire vehicles, buses and private cars.

2.6.7 Ideally, private vehicle traffic will be segregated from commercial vehicles by using designated areas for passenger pickup and drop-off. For example, many airports will provide an inner curb-side separated by a pedestrian island serving an outer curb-side. Vehicle allocation assignment to the various curb-side areas will be based on policy decisions on part of the airport authority. Some airports have assigned commercial vehicles to the inner curb-side to provide preferential space. The outer curb-side is designated for the local traveller primarily using private cars. Assigning commercial vehicle traffic to the inner curb-side promotes pedestrian safety by reducing pedestrian crossings of other traffic lanes.

2.6.8 After the general assignment of private and commercial vehicle traffic has been determined, a specific allocation of commercial vehicles along the frontage should also be considered in the planning process. The allocation of commercial vehicles will consider such factors as customer levels of service. For example, passengers paying a higher fare for service may expect better conditions such as shorter walking distances and covered pedestrian areas.

Signage and wayfinding

2.6.9 Signage on the curb should be easily understandable by the passenger and the driver, and relevant signs must be easily read from a car without providing undue distractions to the driver. Dynamic signage technology can increase the wayfinding message flexibility.

2.6.10 The terminal building entrances and exits, with their signage, can act as considered points for potential vehicular traffic accumulation. The planner needs to establish the relationship between the possible number and location of terminal openings, the terminal functions with which they connect and the total required curb length. An effective signage strategy can assist in achieving a more even distribution of traffic along the available curb length.

Staff access

2.6.11 As part of the curb-side allocation process described previously, the curb-side planning process should consider providing a designated zone for vehicles transporting airline and airport staff from hotels and/or from remote parking areas.

Technology

2.6.12 Technology at the curb can be used to monitor curb-side road congestion as well as passenger conditions (such as queues for taxis or public transit). Airports may choose to implement a “smart curb” arrangement that can increase the efficiency of the departures and/or arrivals curb-side processes. These smart curbs may provide real-time information areas where departing passengers are able to receive flight information before proceeding to the passenger screening area and for arriving passengers trying to determine the best mode of transport to use when exiting the airport. These facilities may also include the use of variable message signage to help actively distribute curb-side demand based on projected or real-time changes in airline activity.

2.6.13 Curb-sides should also be planned to consider current and future changes in technology. For example, the emergence of on-demand smartphone application-based transportation services have led to a shift in demand from parking and other transportation modes to increased curb-side drop-off and pick up. Airports must address this increased demand by providing designated areas at the curb-side or near the terminal building (such as within an adjacent parking structure.(

2.6.14 Furthermore, emerging technologies, such as the anticipated shift in use of AVs, will also likely result in additional demand for curb-side facilities. As AVs have the potential to become notably more prevalent over time, they will potentially begin dropping off and picking up passengers at the airport curb-side. AVs may initially not operate efficiently in a congested curb-side environment given the amount of stop-start vehicle movements, pedestrian activity and proximity of other vehicles (e.g. double parking). A location away from the congestion and dynamic nature of the existing terminal curb-side activity may be more operationally effective.

2.7 VEHICLE PARKING Planning principles

2.7.1 Two basic principles govern the provision of vehicle parking:

a) parking should be located as close as possible to the area served; and

b) parking should occupy the least possible ground area.

2.7.2 The smaller the ground area, the closer the parking facilities will be to the functional area. This is particularly important when pedestrian movement between the vehicle parking and functional area is necessary but it is also important in reducing vehicle movements and thus road requirements, and speeding up service times. These objectives can be achieved by developing multi-level car parking. Due to the combined factors of the inherent higher cost of multi-level car parking and their typical closer proximity to the passenger terminal, these facilities typically lend themselves to premium car parking services such as short stay parking.

2.7.3 The location and use of vehicle parking should normally be determined by the vehicle parking period. As the parking period increases, consideration should be given to locating parking at more remote positions such as on the airport perimeter with shuttle bus services connecting passengers to the terminal. This is also relevant in the case of staff car parking. Longer term parking facilities are typically surface-level facilities. Similar sites also lend themselves to valet or block parking facilities.

Types and location

2.7.4 Since many users of parking will be local to the airport, it is possible to provide a wide range of parking products in line with local practices in terms of form, payment and amenities such as the following:

Short duration

2.7.5 Providing free short-duration parking, typically under 30 minutes, can be used to reduce volumes on terminal frontages and provide a service to drivers who are waiting for their guests to arrive.

Short-term parking

2.7.6 Short-term parking is typically used for durations from 2 to 6 hours. In some cases, travellers who place a high value on time and convenience may opt to park for up to 72 hours in short-term parking. Beyond 72 hours, typical rate structures will often make this situation undesirable and uncompetitive with long-term parking or commercial for-hire transport.

Long-term parking

2.7.7 Long-term parking is typically used for stays from 3 to 14 days. Long-term parking areas have low turnover, and thus high space requirements. As the average daily yield per space is relatively low, these facilities are usually placed on the outer edges of the airport property and connected to the terminals by shuttle bus. It is essential that buses are of sufficient quality and frequency so that passengers have enough time to park in the lot, board a shuttle bus and make it to their flight in a timely manner.

Valet and block parking

2.7.8 Valet or block parking facilities can be used as a premium service offer and/or a means to reduce space requirements immediately adjacent to the PTB. Passengers drop-off their cars at dedicated locations, typically close to the terminal. Staff then park the cars, at far greater densities than private drivers could, linked to management of the adjacent or remote parking area utilization based on duration of stay to be able to return the car at the terminal pick-up point to the passenger at the designated time.

Employee parking

2.7.9 Employee parking is nearly always placed in remote locations or those less suitable to public car parking and is usually served by a shuttle bus connection. These buses are often dedicated to employees only and employees must show their ID badges upon boarding. As with the long-term parking areas, this shuttle bus service must be frequent enough that employees can park and reach their place of work in time for the start of their shifts.

Rental car parking

2.7.10 Rental car parking should be in a discrete and designated area with adequate and substantial signage, as many rental car users will not be local to the airport and will be unfamiliar with the specific airport environment. Another solution is to place rental cars in remote locations removed from the airport terminal. This may be desirable to rental car companies themselves, as they require substantial additional space for light vehicle maintenance, cleaning and storage for cars not immediately available to rent. Such sites can be served by a general airport shuttle bus link and/or transportation arranged by individual or a group of rental car companies.

Technology

2.7.11 Technology should be evaluated for every aspect of parking operations. Technology can help maximize utilization of parking garages by identifying areas where there are available parking spaces. Varying degrees of electronic payment systems should be considered to reduce the payment transaction time and improve access and egress operations.

2.8 OTHER CONSIDERATIONS

Security

2.8.1 Security is an overarching concern among airport operators. Recognizing that both the landside and airside of an airport are vulnerable areas prone to hazards and threats, access to airside by persons other than passengers should be restricted to authorized personnel only. For vehicle intrusion prevention, industry guidance sets out a risk-based approach, whereby airports assess suitable setbacks and other measures appropriate to their local risk environment. Some local authorities mandate certain setback distances where no vehicle may be parked or present. Care should be taken when designing facilities that these setback distances are subject to change and vital operational areas near the terminal buildings may need to be repurposed into other uses.

Multi-modal access

2.8.2 Many airports have unique characteristics that allow for access modes beyond the traditional motor vehicles or rail-based transit. Where airports can be made accessible by pedestrians, bicycles or other means, local standards should be used to design these facilities. Consultation with other operators and local groups should be made to determine the appropriate amenities required, such as bicycle parking facilities and the design decisions required to provide them. For airports located on waterfronts, ferry service may provide a useful link between city centres and airport locations.

Pricing

2.8.3 Transit pricing schemes may be used to generate non-aeronautical revenue, achieve certain goals and prompt greater use of more environmentally sustainable modes of transportation. Local custom may allow or disallow certain pricing structures and paid access control to various parts of the airport or certain amenities, potentially in conjunction with an entity external to the airport operator. In some cases, local governing authorities may regulate the types of arrangements that will be allowed. Many large airports, for example, charge taxis and private hire vehicles a fee to enter airport property, potentially through access licensing. One possible measure is to provide short-duration parking in a garage or lot free of charge to encourage drivers to wait and perform pickups via the garage rather than the curb-side.

Logistics vehicles

2.8.4 The curb-side planning process for smaller airports should consider the needs for accommodating logistics and specialty service vehicles such as package delivery services. Dedicated and segregated service roadways and other non-passenger roadways should be planned and considered for medium and larger airports to aid traffic flow and safety.

2.8.5 Delivery vehicles will often use portions of the landside roadway network to access terminals or other locations where deliveries will be made. Terminals must make provisions for loading docks, refuse removal and other facilities to handle large commercial vehicles that will use the terminal environment, but are not directly related to passenger movement.

2.8.6 The centralized nature of the airport and its roadway network allow airport operators a certain amount of control over these large vehicles. This includes access and movement restrictions, time of day requirements and the ability to stage at external locations or create consolidation centres where all deliveries are made to a central location external to the terminals. Deliveries are then broken down into batches on a single vehicle and brought to the terminal, sometimes via airside roadways.

2.8.7 The roads in the cargo terminal complex must also be considered and integrated with the road network. An airside fully customers-bonded, two-lane roadway should be provided between the cargo terminal area and any of the passenger terminals.

2.8.8 Airside access should be granted to vehicles that must go airside to perform their functions. Control posts (controlled access gates) with barrier systems must be provided to allow authorized vehicles to access the airside. These should be kept to a minimum and may be equipped with a key or automatic control, or be manned, illuminated and provided with alarms.

Chapter 3 Landside Development And Airport City

3.1 ABOUT THIS CHAPTER

3.1.1 Airport city concepts can be defined in various ways depending on the context, covering a variety of scales from on-airport, off-airport around the immediate airport site to an extensive level of urban planning.

3.1.2 The master plan should also consider on-airport commercial real estate development opportunities to serve the travelling public, employees working at the airport and communities located within the airport vicinity. This goal can be achieved by strategically locating uses such as commercial development, business parks and free trade zones, if applicable, in areas that not only make the best use of airport property but also allow for the maximization and diversification of airport revenues. These types of developments should take local circumstances into account and be supported by a positive business case.

3.1.3 An airport city is a key component of the on-airport commercial development and is typically a cluster of commercial developments co-located with airport components that include the terminal building. The airport city may include hotels, airport administration and office buildings, retail facilities, conference centres, educational facilities, etc., and can be linked to the terminal by a plaza or mall. It may also be linked to or integrated with the ground transportation centre with its various modes of transport, including cars, buses and trains. Airport city development will provide increased opportunities for the generation and diversification of non-aeronautical revenue for the airport, using land areas that might otherwise be less efficiently utilized (e.g. for long-term parking) or remain underutilized.

3.1.4 Airports generally precipitate significant development of off-airport commercial and support facilities around the airport perimeter. With proper coordination and use of urban design techniques, external developments will form logical extensions of commercial development on the airport. Off-airport developments are often referred to as airport city, airport regional development and aerotropolis. Typically, the terminology is based on the development scale, with airport city developments containing direct and indirect economic activities on or adjacent to the airport precinct. Airport regional developments and aerotropolis mainly refer to large-scale urban development plans with the airport as the central transport node. Broader urban development plans can contain more activities which are catalysed by the airport, including industrial and general business. Caution should be exercised when considering residential development in the vicinity of the airport as residents tend to be the first to oppose future airport expansion.

3.2 GENERAL CONSIDERATIONS

Airport city and airport areas key factors

The success of airport city development will be influenced by the following factors:

a) the level of passenger and cargo traffic activity of the airport, including destinations served;

b) airport accessibility and the quality of the ground transportation facilities which link the airport to the surrounding urban area and regional road and rail network;

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c) the economic dynamism of the region served and the local real estate market in the airport area; and

d) the governance of the airport (e.g. public or profit-oriented private company, concessionaire or owner of the airport), which can have a significant impact on its commercial objectives.

3.3 PLANNING OBJECTIVES

3.3.1 Airport cities should be carefully planned and well-integrated into the airport master plan's phased development strategy. The design and construction of an airport city's individual components must consider the following important physical and environmental requirements and constraints:

a) the relationship to other airport functions, particularly the passenger terminal and ground transportation centre;

b) the layout of the external and internal road networks – ensuring that excellent access is provided without impacting passenger terminal roads and traffic flows, and access to other airport facilities;

c) provisions for future expansion of core airport activities in the master plan. The future expansion of the airport should not be hindered by adjacent commercial development;

d) aeronautical zoning requirements which will determine building height restrictions;

e) ATC tower line-of-sight requirements which will also restrict building height;

f) aircraft noise impact which will typically prohibit the development of residential and other noise sensitive facilities on the airport; and

g) glare impact from building finishes and solar panels.

Urban beautification

3.3.2 Landscape design is a vital requirement for the visual and social experience of all airport users and employees and should be carefully integrated into the design. Robust public areas should be created that encourage outdoor activity, provide natural spaces for people to congregate and create an environment that supports high quality development and the resulting economic opportunities.

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3.4 SPECIFIC CONSIDERATIONS IN THE AIRPORT CITY

Market research

Market research is an essential prerequisite for airport city development and defines the type and scale of development to be considered including the conditions under which the development will be profitable for the parties involved (users, investors, financiers, land developers and landowners). Market research should also assist in identifying essential features such as quality levels, rent levels to be expected, location on the airport and the pace of commercialization to be expected. Findings and recommendations should, however, be regularly updated in the light of the evolution of the real estate market and the success of development that may have already been implemented.

SECTION IV – AIRPORT OPERATIONS AND SUPPORT ELEMENTS

INTRODUCTORY NOTES

A number of special purpose buildings are necessary to support the operation of an airport. The need for all or some of the buildings described will vary from airport to airport, as will the specific space requirements; their locations in the airport or individual master plans should be determined by the functions they are to fulfil and their compatibility with the major features of the plan. When considering the size of buildings, the need for phased expansion along with the general growth of the airport should be considered to preserve the necessary land for future growth.

Specific planning considerations for each facility will be discussed. Consultation with experts knowledgeable in each specific field and the users of the specific facilities is recommended.

Chapter 1 Airport Operations And Support Facilities

1.1 ABOUT THIS CHAPTER

1.1.1 An airport requires a number of support facilities and buildings to support operational effectiveness. An airport master plan must take all of the necessary facilities into account as the airport layout is conceived and updated. Support facilities include, but are not limited to services such as:

a) meteorology;

b) communications;

c) rescue and firefighting;

d) fuel storage and distribution;

e) administration;

f) maintenance;

g) staff support;

h) airline crews;

i) aircraft operations and maintenance;

j) general aviation; and

k) police.

1.1.2 Planners should determine what additional facilities are required to accommodate forecast activity. Although this document provides guidance on the facilities commonly found at many airports of all sizes, planners should work closely with airport clients to ensure they are providing the most appropriate facilities applicable to the specific study airport.

1.1.3 Many of the significant improvements needed at an airport are actually driven by a planning activity level and not a time frame or specific year. Future airport development should be tied to activity such as actual passenger traffic, air cargo weight and aircraft operations. Planners should identify what demand levels will trigger the need for the expansion or improvement of a specific facility. The trigger needs to be set in order to provide sufficient time to plan, develop and prepare new facilities for operational readiness. A balance in capacity between key airport functional areas (terminal, airfield and landside) should be maintained to keep all airport components operationally effective. The master plan should provide for flexibility and expandability to meet changing demand levels based on local and industry changes.

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1.2 ADMINISTRATION AND AIRPORT MAINTENANCE BUILDINGS

1.2.1 A separate building or area for airport administration purposes should be provided. This facility may be located on the perimeter of the airport or incorporated in or adjacent to the terminal building, depending on the size and number of employees. At larger airports that employ large numbers of staff, the airport administration facility should be located as close as possible to primary public transport facilities and should have convenient access to the operational areas and terminal facilities, but not be located as to impede future expansion of key aeronautical facilities.

1.2.2 Functions that may be accommodated in an administration building include office and other accommodations for airport management, aircraft operators, government control authorities (police, customs, immigration, etc.) and communications and IT.

1.2.3 Airport maintenance facilities house functions such as motor vehicle repair, electrical and mechanical repair (buildings, radio, airfield lighting and signage, visual navigation aids, etc.), painting (buildings, roads and runway markings, etc.), landscaping and grass cutting, minor pavement repairs and airfield snow and ice removal. The maintenance facility would typically include offices, locker rooms, workshops, areas for materials storage (such as replacement parts) vehicle repair bays, storage and maintenance of snow and ice control equipment, and a fireproof contained area for flammable materials and other facilities specific to each location.

1.2.4 The location of the airport maintenance building should consider the following:

a) a location on the landside or airside boundary to allow equipment and supply deliveries with no impact on airfield safety;

b) vehicle egress and ingress should not interfere with fire lanes used by RFF equipment or interfere with aircraft taxi ways or lanes; and

c) direct access to the airside service roadway system for quick response to airfield maintenance requirements.

1.2.5 When possible, the maintenance building should be sized to accommodate all maintenance vehicles and airfield snow and de-icing equipment in order to keep these costly pieces of equipment protected from the outside elements. The land area should be sufficient to accommodate future building expansions and employee parking. The building height and location must comply with runway airspace reserves, navigational and surveillance aids reserves and restrictions imposed by the ATC tower line-of-sight.

1.3 MEDICAL CENTRE

Airport operators may decide or be required to provide medical facilities to staff and passengers for treatment of medical emergencies (first aid), for aircrew medical inspection and for emergencies and rescue. Medical facilities are best located on both airside and landside areas. The scale of facilities and their purpose should determine the location, type of services and size of medical facility. Minor injuries can be attended to by first aid stations inside the terminal or concourse buildings, while an ambulance service can respond to the airside areas. First aid stations should be strategically located within the terminal and concourse buildings on both sides of airport security screening and have minimal walking distance to avoid lengthy delays in responding to emergencies. Airside ambulance facilities should be located such that they can respond within a reasonable time to all medical calls. In addition, medical facilities should be located for easy accessibility in case of an aircraft accident and be capable of expansion to serve on short notice as an enlarged aircraft accident first-aid receiving station. The usefulness and efficiency of any medical emergency and rescue organization on an airport may be greatly enhanced if it is in continuous use dealing with day-to-day medical activities during the normal routine working of the airport.

1.4 EMERGENCY OPERATIONS CENTRE

1.4.1 A fixed emergency operations centre should be available to deal with emergency situations at each airport. The location of the emergency operations centre should provide a clear view of the movement area and isolated aircraft parking position, wherever possible.

1.4.2 The main features of this unit are:

a) its fixed location;

b) it acts in support of the on-scene commander in the mobile command post for aircraft accidents and incidents;

c) it is the command, coordination and communication centre for unlawful seizure of aircraft and bomb threats; and

d) it is operationally available 24 hours a day.

1.4.3 A pre-arranged reference point called as rendezvous point, to which personnel and vehicles responding to an emergency situation initially proceed to receive directions to staging areas and/or the accident or incident site, should be established. The function of rendezvous points is to provide a safe area at the airside or landside boundary in which external emergency services can assemble and wait to be escorted to the scene of an incident or accident on the airport. Rendezvous points are normally sited at locations with direct access to the manoeuvring area. However, in order to prevent incursions on the airport manoeuvring area by personnel unfamiliar with the airfield geometry, it is important that external vehicles are appropriately marshalled by airport operations staff prior to escorting them to the scene of an incident or accident on the airport.

1.4.4 Also, in the event of an accident, consideration should be given to providing area for the following functions:

a) survivors reception centre;

b) crew reception centre; and

c) meeters and greeters reception centre.

1.4.5 These areas can be co-located in a secure area that provides a discreet and comfortable environment away from the public eye. It might be appropriate to provide separate facilities for each of these functions.

1.5 GROUND VEHICLE FUEL AND ELECTRICAL RE-CHARGING STATIONS

1.5.1 A fuel station for landside ground vehicles may be necessary where fuelling facilities are not closely available on the main public routes to and from the airport. It should be sited where traffic entering and leaving the airport would not cross or slow down the continuous flow of other traffic on the main vehicle routes. A separate station for airport vehicles may also be justified and be located on the secure airside of the airport.

1.5.2 To further support the on-airport GSE, fuelling and electrical recharging stations should also be located on the airside of the airport. Fuel and electrical recharging stations should be located to minimize travel distances and time for the majority of the GSE fleet from their staging or storage area. These fuelling stations should be capable of providing alternative fuels, including but not limited to petrol, diesel, natural gas, liquefied petroleum gas, compressed natural gas and hydrogen. If possible, it would be desirable to also provide vehicle wash facilities at each fuel station.

1.5.3 In order to manage carbon dioxide (CO2) and other vehicle emissions, many airports have developed strategies for alternatively fuelled vehicles. Electric vehicles have no exhaust emissions and by replacing equipment powered by internal combustion engines with electric equipment, there will be a reduction of non-CO2 emissions. There is conventional charging and fast charging options available. Fast charging gives operators the flexibility to charge a variety of vehicles on the same charger and have them available during longer periods of the day and might require less vehicles due to reduced downtime for recharging.

1.6 GENERATING STATIONS

Generating stations may be required to provide heat, electricity, etc. After considering requirements for future expansion of other airport facilities, generating stations should be sited as close as possible to the areas they serve in order to avoid long service lines which themselves can impose considerable inflexibility on future development. It may be necessary at some airports to provide standby power generators, independent of the main airport power system, as a secondary back-up power supply. Providing standby generators for the main terminal, all radio navigation aids, the control tower and other critical facilities, is highly recommended in order to maintain continuous operation of the airport and its critical functions.

1.7 WATER SUPPLY AND SANITATION

1.7.1 The airport must be supplied with adequate water, that is properly processed and chlorinated and a sewage disposal system for handling and treating waste. A site for a waste management facility must be provided at the airport for the separation of the different types of waste (landfill, recycle, hazardous waste, etc.). This site should be located along the security boundary fence to provide for collection of these materials by outside agencies. Such areas must be carefully planned in order not to create a bird hazard problem and to avoid leaching of materials into the ground water.

1.7.2 Airport waste must be treated either on site or at a nearby treatment system. The primary products which can be found in untreated wastewater discharges include fuel, oil, grease, de-icing fluids and heavy metals. The airport should conduct a review of the site conditions to determine the type of water pollution control programme. All surface run-off from de-icing areas (aircraft and pavement) must be adequately treated before being discharged into storm water drains. Other types of wastewater may be deemed “grey water” and can be recycled for the purpose of landscape irrigation, etc.

1.7.3 EAC139-16 provides more detail on water management within airports.

1.8 ENERGY MANAGEMENT AND POWER PLANT

1.8.1 Energy management includes planning and operation of energy production and energy consumption. Objectives are resource conservation, climate change mitigation and cost savings while the users have permanent access to the energy they need at the airport. The main task of energy management is to reduce energy costs for airport buildings and facilities without compromising work processes. The availability and service life of the equipment and the ease of use should remain the same.

1.8.2 An energy management system (EMS) is a computer system that is designed specifically for the automated control and monitoring of those electromechanical facilities in a building that have significant energy consumption, such as heating, ventilation and lighting installations. The EMS can also facilitate the reading of electricity, gas and water meters.

1.8.3 EMSs can be used to centrally control devices like heating, ventilation and air conditioning (HVAC) units and lighting systems across multiple locations on the airport. An EMS can also provide metering, sub-metering and monitoring functions that allow facility and building managers to gather data and insight that allows them to make informed decisions about energy usage across the airport.

1.8.4 Some larger airports have a central power plant to supply all HVAC, heated water and electricity to their major facilities (terminal, concourses and support facilities). It is important to ensure this facility can be expanded in the future to provide for additional demand as the airport grows. For smaller airports, it might be appropriate to provide stand-alone power in close proximity to each airport facility.

1.8.5 In some areas, renewable power sources such as solar, wind and geothermal might be more cost effective to the airport operator. Some of these sources can be located either on- or off-airport and might be provided by other outside companies.

1.8.6 EAC139-16 provides more detail on energy management within airports.

1.9 FLIGHT CATERING KITCHENS

1.9.1 Airport flight catering kitchens provide meals and services for in-flight catering and ancillary services (airline lounges and staff cafeterias) to airlines operating at the airport. With reference to in-flight catering, meals are prepared in a central kitchen facility and transported by hi-loaders to the departing aircraft. Arriving aircraft require food waste to be unloaded, returned to the catering facility and incinerated according to local and state regulations.

1.9.2 The catering product is very time critical and specific for a particular flight, as the type of food served on the flight depends on several factors such as the destination and any special requests. In some cases, catering satellites are located within the terminal or concourse area to facilitate any last-minute increase meals that might be requested by the airline just prior to departure. It is important that the last-minute increase facility is located within close proximity to the active aircraft stands to minimize travel distance to the stand.

1.9.3 Aircraft operators often require fairly large facilities for preparation and storage of food, drink and other aircraft cabin stores. In order to facilitate the timely delivery of aircraft meals, the main catering facility should be located such that the travel time and distance to the largest number of active aircraft stands is achieved. The main facility should have good access to the aircraft aprons using the airside service road network. The best location depends upon the nature of the airport traffic and ground access roadway network. Customs regulations may require such facilities to be within customs-controlled areas.

1.9.4 Consultation with the individual airlines and existing catering companies is recommended to determine the type and number of meals required for each flight destination, the time of day and number of flights. The size of the catering facility is dependent on the number of meals to be produced during the peak hour or per day, and it is assumed there is a linear relationship between these two numbers. It may be found that there are efficiencies to be gained by producing larger number of meals, hence increasing the number of meals per square metre as a facility increases in size.

1.9.5 In order to calculate the number of meals required during the peak hour or per day, it is necessary to understand the types of flights operated from the airport, as different flight lengths will require different numbers of meals per passenger. Additionally, the type of operator will also affect the numbers of meals required, full-service carriers requiring more provision than new-model carriers.

1.9.6 A benchmark of various size airports provides the following range of catering requirements:

a) 000 10to 36 000 – Meals per day capacity;

b) 114 3to 9 270 – Total facility area (m2); and

c) 0.211to 0.359 – Building area per meal (m2.(

1.9.7 The total size for a catering facility is based on a typical layout providing for a building, truck dock parking, inbound and outbound deliveries, staff car parking and access roads.

Catering airside facilities

1.9.8 The following airside facilities should be considered:

a) designated inbound and outbound catering truck docks;

b) designated catering truck staging areas adjacent to the building;

c) roads providing direct airside access should be equipped with necessary security and access controls; and

d) high mast lighting.

Catering landside facilities

1.9.9 The following landside facilities should be considered:

a) roads for site circulation and access;

b) utility corridors and landscape buffers should be located parallel to designated access roads and site circulation routes;

c) environmental controls designated to treat runoff from impervious surfaces;

d) designated delivery truck loading docks;

e) high mast lighting; and

f) security fence.

1.10 METEOROLOGICAL SERVICES

Meteorological office

1.10.1 Meteorological services contribute towards the safety, regularity and efficiency of international air navigation. Information is provided to:

a) operators;

b) flight crew members;

c) air traffic services units;

d) search and rescue services units; and

e) airport management teams.

1.10.2 An airport meteorological office should be associated with an airport control tower or approach control unit.

1.10.3 Each Contracting State shall determine the meteorological service which it will provide to meet the needs of international air navigation. This determination shall be made in accordance with the provisions in Annex 3 – Meteorological Service for International Air Navigation and in accordance with the regional air navigation agreement. This includes determining the meteorological service to be provided for international air navigation over international waters and other areas which lie outside the territory of the State concerned.

1.10.4 At airports with runways intended for Category I instrument approach and landing operations, automated equipment for measuring and monitoring of surface wind, runway visibility, height of cloud base, air and dew point temperatures and atmospheric pressure are installed to support landing and take-off operations. These devices acquire, process, disseminate and display in real time the meteorological parameters affecting landing and take-off operations. The design of integrated automatic systems should observe human factors' principles and include back-up procedures.

1.10.5 Most forecasts are received from outside sources. Where briefing is carried out by television or other electronic means, the television receivers and monitors should be easily accessible to aircrews, who should also be able to contact the office to deliver post-flight reports, etc.

Aeronautical meteorological stations

1.10.6 Access to aviation weather products has greatly improved with the increase of flight planning services and weather websites. Online aviation weather information is easy to access in today's environment. The ultimate users of aviation weather services are pilots, aircraft dispatchers, airline ground crews, air traffic management and air traffic controllers. Airport maintenance personnel may use the service to stay informed of weather that could create operational disruption and during routine maintenance functions (such as airfield resurfacing.(

1.10.7 Airport operations, airlines, etc. have direct access to the meteorological data via an internet connection from the local station. On-airport equipment records the required information. Many airports rely on outside services for local meteorological information. A single room and computer can be used to collect and disseminate this information. This space can be within the operations centre or airlines crew briefing area.

1.10.8 Today the trend is towards the use of in-pavement sensors on the runways and taxiways to provide surface temperatures and contamination. In addition, the normal above ground weather equipment is installed at the necessary positions with distant reading instruments. In the planning of new airports or improvements to existing airports, consideration should be given to provision of necessary electrical ducts to allow the satisfactory siting of sensors and distant reading equipment such as thermometers and anemometers near the runway, transmissometers near the threshold and ceilometers in the approach area or, where it exists, near the ILS DME or glide path equipment.

1.11 AIRCREW BRIEFING AND REPORTING

1.11.1 Before a flight departs from an airport the aircrew must undertake pre-departure procedures. Aircraft operators may have their own aircrew briefing requirements and facilities they require for crew briefing. These facilities should be provided within the airlines' facilities, or within the terminal buildings. It is important that facilities are appropriately located and efficiently laid out to minimize crew down-time. Aircrew briefing facilities required by government and international regulations should be grouped together at a location suitably related to the aircraft aprons.

1.11.2 Depending on the category of traffic and local regulations, aircrew may be subject to customs inspection of themselves and/or their aircraft. They may also be required to file flight plans or report to the air traffic control authority, and to obtain meteorological and aeronautical information service briefings. On arrival at international airports, aircrew must report to government control authorities to clear themselves, the aircraft and stores.

1.11.3 Facilities for all these purposes should be located as close as possible to the main centre of activity of the aircraft aprons. At large airports with several aprons it may be appropriate to locate facilities in more than one area. The premises where crews report for operational purposes should be readily accessible and next to one another, preferably located at apron level and on the main airside service roads. At large airports where the apron areas for general aviation traffic are located at a considerable distance from the main terminal area, consideration may be given to establishing a satellite facility for air traffic services reporting and aeronautical information service and meteorological briefing in order to facilitate flight preparation and reporting by flight crews. Adequate short-term vehicle parking space for aircrew and aircraft stores vehicles should be associated with these facilities. The objective should be to achieve the quickest and most convenient pre-departure and post-arrival formalities for aircrew.

1.12 AIRCRAFT MAINTENANCE AND APRON AREA

1.12.1 Siting of the aircraft maintenance areas will be influenced by the type of traffic serving the airport and the aircraft operators' route structures. The number of aircraft moving between the maintenance areas and the aprons will depend on whether the airport is used by aircraft operators as a base for major maintenance or only for line maintenance. At a major maintenance base (often an airline home base) there are a considerable number of aircraft movements between the aprons and maintenance areas. At line maintenance bases, maintenance is often carried out during aircraft turnaround mainly on the aircraft stand.

1.12.2 Aircraft maintenance areas are best situated between active runways with taxiway systems to minimize runway crossings. Due consideration should be given to noise during aircraft engine run-up operations, especially during night-time hours. An engine run-up enclosure helps to minimize noise impacts.

1.12.3 Aircraft maintenance programmes are designed to minimize the time the aeroplane is out of service to balance the maintenance workload level and to maximize the use of maintenance facilities. Aircraft maintenance checks are periodic inspections that have to be done on all commercial and civil aircraft after a certain amount of time or usage. Key maintenance activities and maintenance intervals are as follows:

a) 'A' Check – This is performed approximately every 400–600 flight hours or 200–300 cycles (take-off and landing is considered an aircraft "cycle"), depending on aircraft type. It needs about 50–70 person-hours and is usually on the ground in a hangar for a minimum of 10 hours.

b) 'B' Check – This is performed approximately every 6–8 months. It needs about 160–180 person-hours, depending on the aircraft and is usually completed within 1–3 days in a hangar.

c) 'C' Check – This is performed approximately every 20–24 months or a specific amount of actual flight hours as determined by the manufacturer. This maintenance check is much more extensive than a 'B' Check, requiring a large majority of the aircraft's components to be inspected. This check puts the aircraft out of service and it must not leave the maintenance site until it is completed. It also requires more space than 'A' and 'B' Checks and is conducted inside a hangar at the maintenance base. The time needed to complete a 'C' Check is at least 1–2 weeks and might require up to 6 000 person-hours.

d) 'D' Check – This is by far the most comprehensive and demanding check for an aeroplane. It is also known as a "heavy maintenance visit". This check occurs approximately every six years. This check takes the entire aeroplane apart for inspection and overhaul. Even the paint may need to be completely removed for further inspection on the fuselage metal skin. Such a check can take up to 50 000 person-hours and 2 months to complete. It also requires the most space of all maintenance checks and must be performed inside a hangar at the maintenance base.

1.12.4 In order to perform the required aircraft maintenance functions, airports might require the following facilities:

a) aircraft engineering hangars where the various categories of maintenance operations take place;

b) aircraft maintenance apron;

c) aircraft ground run-up enclosure airport;

d) calibration pad;

e) aircraft wash bays; and

f) aircraft paint hangar.

Maintenance hangars

1.12.5 Heavy engineering stores and workshops are normally associated with the maintenance hangar. A typical heavy engineering maintenance hangar for a Code F aircraft (A380) is large (about 90 m by 110 m) which provides space for the associated stores and workshops. At larger airports, a "home based" or tenant airline may establish a maintenance base for the periodic inspection and maintenance of its aircraft. To determine the space requirements and number of maintenance hangars, planners should consult with airline representatives and discuss the types of aircraft being serviced and their facility needs.

Aircraft taxiway, taxilane and apron

1.12.6 An apron area in front of each maintenance hangar for the parking and staging of aircraft with dedicated taxi network to move between different maintenance functional areas without impacting normal airport operations, should be provided, where possible. Taxiways and taxilanes play an important role in determining and maintaining the operational safety at an airport. Faster access from the runway and taxiway system to the aircraft maintenance area will help to maintain safety.

Aircraft ground run-up enclosure

1.12.7 The function of a ground run-up enclosure (GRE) is to ensure the efficient and safe aircraft engine testing in the greatest variety of wind conditions, to deflect blast, and uses acoustical dampening principles to reduce noise impacts during aircraft engine ground run-ups. The GRE may be used as a diagnostic area for engine fault prior to and after repair and can be a 24-hour operation.

1.12.8 The GRE size should be capable of accommodating the largest aircraft at the airport that will be conducting engine thrust testing. The GRE should be located such that it does not interfere with normal aircraft operations, and oriented in the predominant wind direction to avoid any engine stalls or damage during testing. The GRE should not block the air traffic controller's line-of-sight to any airfield "movement areas". Utilities necessary for operation of the GRE will include interior overhead and under-wing flood lighting, exterior obstruction lighting, control room lights, heater and call box.

1.12.9 All aircraft are positioned within the GRE with the nose of the aircraft pointed outward towards the opening. No aircraft engine shall be closer than 18 m to the rear blast deflector and no aircraft tail shall be closer than 10.5 m from the leading edge of the rear blast deflector with the aircraft engine governing the distance. In addition, there should be a minimum of 5 m clearance from the aircraft wing-tip to the side panels.

1.12.10 EAC139-16 provides more guidance on environmental considerations for run-up locations.

Aircraft calibration pad

1.12.11 An aircraft's magnetic compass indicates direction with respect to the earth's magnetic field. A calibration pad provides the space for these instruments to be checked following pertinent aircraft modifications and on frequent routine maintenance schedule. The calibration pad is used to align the aircraft on a known magnetic heading and make adjustments to the compass.

1.12.12 The calibration pad should be sized to accommodate the largest aircraft operating at the airport. The centre of the pad should be at least 183 m from any magnetic object of high voltage power cables, major roads, railways, etc. The centre of the pad should be at least 91 m from any buildings, fuel lines, communications or power cables, light fittings and other aircraft.

Aircraft wash bays

1.12.13 Aircraft are regularly washed both after and between maintenance checks. Dirt and oil can affect the aerodynamics of the aircraft and increase fuel burn during flight. Suitable drainage run-off and separation and contamination facilities will also need to be provided for environment controls. The aircraft washing can be conducted outside or within a hangar depending on weather conditions.

Aircraft paint hangar

1.12.14 Aircraft stripping and painting operations should be done within a dual hangar facility, such that one bay can support a stripping operation while the other bay supports a simultaneous painting operation, or one bay can remain operational while the other is cleaned after a stripping or painting operation. This will prevent cross contamination and provide the cleanest and safest painting operation.

1.12.15 A typical example of a large aircraft maintenance complex is available in Figure IV-1-1.

Aircraft maintenance complex example

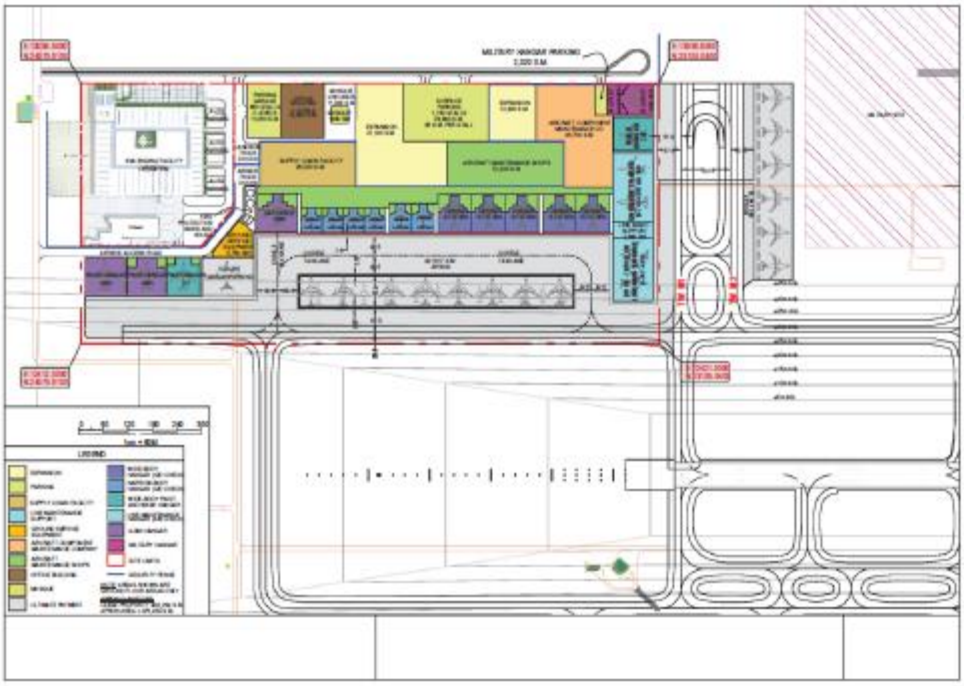

Figure IV-1-1. Aircraft maintenance complex example
)Image reproduced by kind permission of Landrum & Brown, Inc(.

1.13 RESCUE AND FIREFIGHTING SERVICES AND TRAINING FACILITY

1.13.1 The airport fire station(s) should be located so that response times for aircraft accidents and incidents are within the mandatory three-minute requirement and preferably within the recommended two minutes, to any point of each operational runway, in optimum conditions of visibility and surface conditions. The timeline of an airfield emergency fire incident is made up of a number of events, as presented in Figure IV-1-2 below.

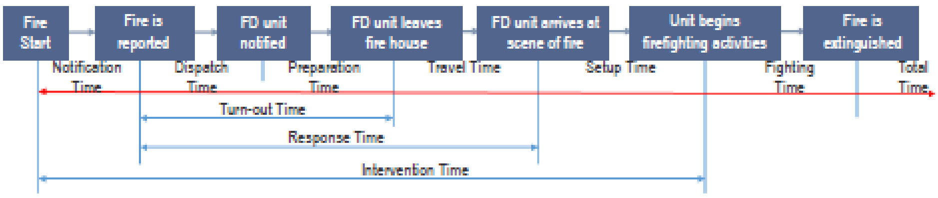

Figure IV-1-2. Typical sequence of events in a firefighting response
Source: Strategic Planning Services, Inc.
(Image reproduced by kind permission of Strategic Planning Services, Inc)

a) Dispatch time: elapsed time between the initial sighting of the fire and when the station is notified.

b) Preparation time: time required for fire fighters to assemble for an emergency response after receiving the dispatching alarm up to the time just before leaving the fire station.

c) Total response time: response time is considered to be the time between the initial call to the rescue and firefighting service and the time when the first responding vehicle(s) is (are) in position to apply foam at a rate of at least 50 per cent of the discharge rate specified in Table 9-2 of ECAR 139 .

Time taken for the fire unit to arrive at the scene of the fire after the fire is reported is the summation of turn-out time (dispatch time + preparation time) + travel time.

1.13.2 Other considerations, such as the need to deal with structural fires and other duties performed by rescue and firefighting personnel, are secondary. At a large airport it may be necessary to provide more than one fire station, each located strategically in relation to the runway system and structural buildings. Analyses of aircraft emergencies have revealed that a large proportion of aircraft accidents and incidents occur on or close to the runway(s). Fire stations must provide the shortest response time to the runway system. In addition, many emergency medical responses related to minor accidents and heart attacks may occur within the terminal or concourse buildings. Therefore, it is recommended that medical facilities also be located on the landside of the terminal.

1.13.3 The airport fire station will provide facilities for housing the rescue and firefighting equipment and personnel, including in some cases, ambulances and their crews. The equipment, amount of extinguishing agents and number of vehicles and personnel will be determined primarily by the length and maximum fuselage width of the aircraft using the airport and their frequency of operations.

1.13.4 Additional emergency access roads should be provided for quick access to the accident or incident area in the quickest manner possible and with minimal interaction with aircraft movements. Crash gates should be provided along the airport perimeter security fence that will provide fire equipment access to the areas off-airport and within the runway approach areas.

1.13.5 Aircraft firefighting personnel are required to train regularly in the application of extinguishing agents to fires that simulate actual conditions. Some large airports provide fire training facilities to maintain airport regulatory requirements with the potential of additional airport revenue by providing fire training services to other airports in the region. The training facility should be located airside and consist of practical (fuselage mock-up) and classroom training facilities. The location of the fire training site must consider the predominant wind direction and the potential for flames or smoke travelling onto the airfield or runway approach areas.

1.13.6 Where airports are located adjacent to large bodies of water (rivers, lakes, the sea, etc.), special provisions are necessary to expedite water rescue. Diving units should be dispatched to the scene with use of helicopters to expedite access to the scene. It might be appropriate to have a rescue boat docked along the water to assist in a potential water rescue operation.

1.14 GENERAL AVIATION AREA AND APRON FACILITIES

1.14.1 General aviation (GA) consists of all operations not considered commercial service or military. GA operations can occur at airports of all sizes and types, including commercial service airports and military joint-use airports. The following various activities are included under GA operations:

a) business operations;

b) recreational operations;

c) training operations;

d) cargo operations;

e) agricultural applications;

f) law enforcement;

g) emergency medical services; and

h) firefighting.

Fixed-base operators

1.14.2 The various types of aircraft comprising the general aviation fleet range from large corporate jets to small single-engine aircraft. This wide variation in aircraft types can make planning efforts for GA services and facilities challenging due to the needs for these diverse types of aircraft operations. Some of these services and facilities are provided by the airport owner; some are provided by private entities, such as fixed-base operators depending on the operational model used by an airport owner. The growth of general aviation activities in many States has greatly exceeded that of the commercial airlines and has become an integral part of the national air transport system. The requirements of locally based and itinerant general aviation activity, both national and international, should be considered an integral element of airport master planning.

1.14.3 One of the primary considerations in the airport planning process is the anticipated volume of general aviation operations the airport will experience, both initially and in the future. The accuracy of forecasts of the demand for general aviation utilization of runways, taxiways, apron and terminal facilities can become a major influence on the capacity of the specific airport and the entire airspace system.

1.14.4 General aviation includes many different types of aircraft with a wide range of operational requirements. An airport that experiences a mix of general aviation and commercial aircraft may cause unacceptable delays in departures and arrivals, particularly during periods of marginal weather conditions. An airport that is to serve both scheduled commercial operations and a substantial volume of general aviation should, when possible, provide a separate runway and taxiway system to serve general aviation type aircraft exclusively. Such airport facilities should be positioned so that general aviation aircraft are not required to taxi, take-off or land across airport facilities primarily provided for commercial aircraft operations. Where possible, separate airspace corridors and procedures should be provided for general aviation activity.

1.14.5 General aviation operations should be located away from the passenger facilities provided for commercial airline services. The site selected for general aviation activities should include sufficient area for hangars, aircraft maintenance facilities, fuelling, aircraft apron parking, storage, aircraft rental, flight services building and surface vehicle parking. Customs and international clearance facilities for international passengers and for aircraft of foreign registry may also be required in the general aviation service area.

1.14.6 At airports where either the scheduled operations or the general aviation operations are very low, separate facilities are not always required and combined facilities may be prudent to support airport concessions.

1.15 CARGO FACILITIES

1.15.1 The availability of current, relevant data and the accuracy of underlying assumptions influence the effective planning of on-airport cargo facilities. The general functional alignments as defined in the master plan and attendant aeronautical infrastructure also define the space allocations for air cargo facilities and operations. The planning and operating parameters for cargo can be further defined by the location of and required interaction with logistics support facilities and access to aeronautical and landside infrastructure.

1.15.2 Air cargo activity is generated by a diverse collection of companies with differing business strategies and market roles, including the following:

a) Integrated carriers: transport freight from door-to-door using their own fleet of trucks and aircraft.

b) Freight forwarders: act as brokers that link shippers with freight carriers; they coordinate the shipment of freight, but do not transport it.

c) All-cargo operators: sell space to freight forwarders or individual companies and only ship the air cargo on their aircraft.

d) Combined carriers: carry both passengers and freight on a single aircraft, typically with a reconfigured cabin.

e) Belly freight carriers: carry cargo in the baggage compartment or belly of a passenger aircraft.

Cargo forecasts

1.15.3 The eventual plan for the cargo facilities and infrastructure should be derived from the forecast, traditional planning axioms and market assessment. These elements need to be integrated with the business goals of the airport, carriers and other regional supporting businesses. The business model helps establish the forecast assumptions. In determining the key assumptions, recognizing that cargo carriers do not typically operate 365 days a year, it is important to utilize the most appropriate number of days on which carriers will operate at the airport annually. For planning purposes and taking into account holidays, weekends and the mix of carriers, the “air cargo year” ranges from 286 to 320 days.

1.15.4 Integrating the analyses of the trends and issues, and after reviewing the primary business considerations, it is important to develop a low, baseline and high growth forecast of projected growth by market segment – OaD versus transfer, belly carriers, freighter operators, combination carriers (those that fly both freighters and passenger aircraft) and integrators. The forecast is typically prepared for 5-, 10- and 20-year planning horizons. Projections of freight tonnage, fleet mix, aircraft operations for the cargo carriers and landed weight should be identified. Additionally, the projections should estimate the anticipated truck movements that could be generated based on the volume of cargo tonnage being processed through the facility for each of the planning year horizons.

1.15.5 Several approaches can be used to develop the forecasts. The most common of these are industry accepted regression-based techniques where existing data provide an adequate basis of historic information. Additional refinement of the cargo forecasts should be based on feedback from the regional shippers, freight forwarders and customs brokers. These varied inputs will influence the market assessment which will be used to develop the low, baseline and high cargo forecast scenarios.

Cargo site elements

1.15.6 A typical air cargo building is considered an inter-modal facility. Accordingly, three physical aspects of a potential air cargo leasehold should be considered as integral to its planning and development:

a) the building as it pertains to the dimensions and operating characteristics of the internal space allocated to warehouse, office and other related uses, and the concentration of truck and airside doors;

b) the aeronautical component including taxiways, taxilanes and apron along with the necessary setbacks; and

c) the landside component including building frontage, queuing capacity and roadway access.

Building component

1.15.7 The dimensions of a building can directly impact throughput, operating efficiencies and leasing costs. Rates for leased cargo facilities are based on the leasehold square footage and the footprint of the building. The tenant's operating efficiencies may also be substantially enhanced by the height of the facility. This is particularly true when the tenant relies on sophisticated material handling systems such as an elevating travelling vehicle system, for which cubic metres are a critical concern. Clear span (the distance between columns) in the facility is also extremely important. The greater the span, the more flexibility the tenant has to process cargo. Height and clear span have become key components of newer cargo facilities. Other critical elements in building design are the number, dimensions and spacing of cargo doors on the airside and landside, the use of floor versus mezzanine office space, equipment storage and security screening footprints.

Aeronautical component

1.15.8 The aeronautical operating area includes the aircraft parking apron that is usually adjacent to the cargo building, the taxiways and taxilanes that provide aircraft access and airside service roads that enable belly cargo tugs to move to between the cargo facility and the passenger terminal stands. Direct aeronautical access to the aircraft apron is not necessary for every tenant. Passenger-only carriers and handling companies that deal with belly cargo need only be connected to the aeronautical operating area via an airside service road. However, most carriers flying freighters or handling companies dealing with freighters must have an apron directly adjacent to the cargo building to minimize operating costs. This is particularly true for integrated carriers.

Landside component

1.15.9 The landside element of an air cargo facility must have sufficient space for truck turning and queuing, acceptable proximate roadway geometry and acceptable overall access to the leasehold. In many airports, older cargo facilities were not designed to accommodate the larger trucks (23 m with tractor and trailer) that are used today for long-haul trucking in many countries. This is true of the areas surrounding the cargo buildings as well as the access roads to the cargo areas in general. Ensuing problems usually result in diminished traffic flows, random off-site truck parking and a negative impact on air quality.

1.15.10 Another aspect of landside planning is the car parking requirements for the facility. Typically, a freight operation does not require extensive parking. However, the need for airport parking accommodation varies based on the regional labour market and the availability of public transport. Employees and customers must both have proximate parking that is physically separated from the trucking operations. When the facility site and thus the availability of areas for car parking is limited, employee parking may be shifted to more remote areas aligned with other airport employee facilities including shuttle bus services.

Categories of cargo layouts

1.15.11 From the airport's perspective, there are essentially four categories of relevant air cargo facility layouts:

a) Category A cargo facility has direct aeronautical access including adjacent aircraft parking apron. This is typically the scarcest and most expensive space on the airport. It also has the highest development cost based on the amount of required aeronautical infrastructure. The tenant base will be carriers who fly freighters, integrated carriers and handling companies. Mezzanine level office space is typically leased to the carriers, federal agencies and customs brokers (see Figure IV-1-3.(

b) Category B cargo facility has indirect aeronautical access via a restricted service road but has no adjacent aircraft apron. The tenant base will be carriers who operate or are handled at the terminal building. This is usually a belly cargo facility. Handling companies that emphasize warehousing will lease space. Office operations are usually on the warehouse floor (see Figure IV-1-4.(

c) Category C cargo facility has no access to the aeronautical areas but is situated proximate to Category A and B facilities and is well positioned on the landside and airside roadway system. This is a cross-dock facility with adequate room on both sides to manoeuvre trucks and maximize the number of truck bays. It competes against off-airport facilities. Note that these facilities are seldom found on-airport because of the amount of land they require. The tenant base will be the trucking component of the cargo industry. Freight forwarders, express mail, customs brokers, container freight stations, consolidators and trucking companies utilize this type of facility (see Figure IV-1-5.(

d) Category D cargo facility has no access to the aeronautical areas, truck access on only one side and is situated to take advantage of available space that might not otherwise have been developed. Historically, airports have not built Category D facilities since the off-airport prices for comparable buildings are much lower. However, this is changing as airports try to capture elements of the market they have not previously pursued to enhance their revenues. The tenant base is focused on freight forwarders and the trucking industry. Customs brokers will also take space if it is available (see Figure IV-1-6.(

1.15.12 Each of these cargo facilities has different physical characteristics that are designed specifically to meet the operating requirements of the building's tenants and users. Category A and B buildings are the primary types of on-airport facilities and have design features not found in the Category C and D facilities that are more typically located off airport. Successful air cargo operations require a broad supporting business infrastructure of small firms with diverse land requirements. Typically, these firms have been located off-airport because of lower leasing rates, limited suitable on-airport facilities and/or an airport policy decision to exclude them. Security requirements resulting in increased screening and slower processing has provided impetus for these businesses to seek an on-airport site and become potential tenants. These properties are usually too small for many "traditional" airport uses but are now considered ideal sites for many of the other ancillary and supporting services and businesses that support air cargo. These businesses also provide new revenue opportunities for airports.

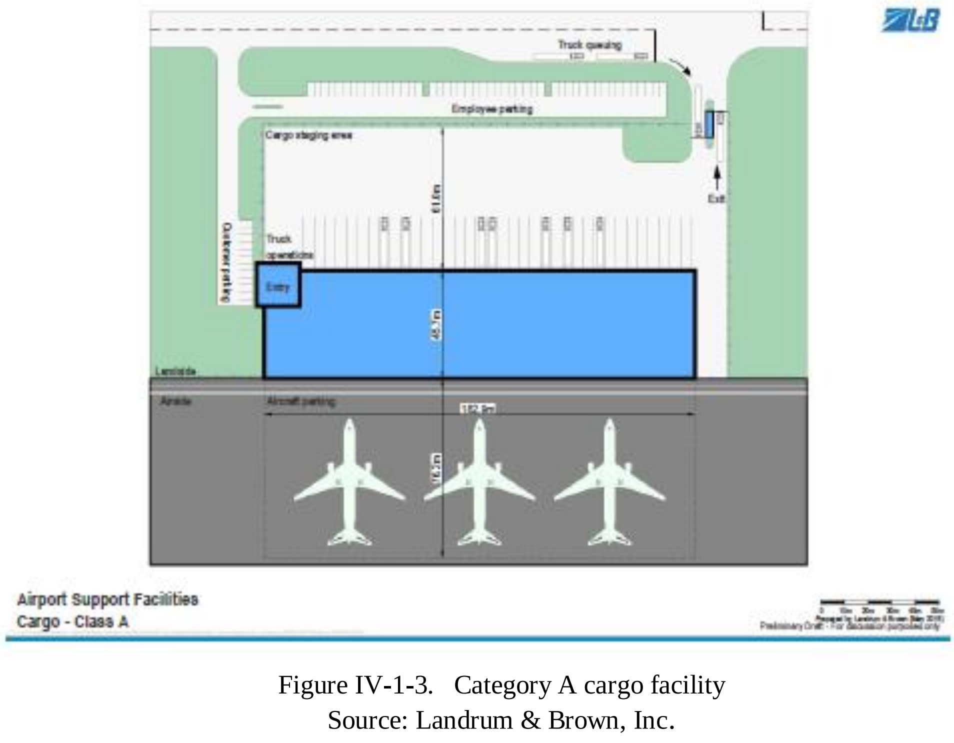

Figure IV-1-3. Category A cargo facility
Source: Landrum & Brown, Inc.
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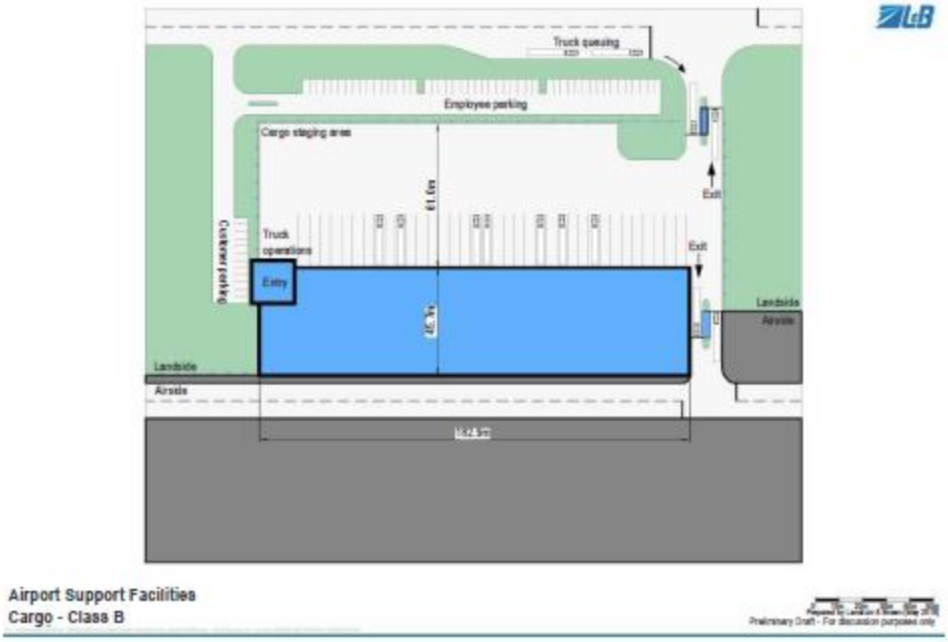

Figure IV-1-4. Category B cargo facility
Source: Landrum & Brown, Inc.
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Figure IV-1-5. Category C cargo facility
Source: Landrum & Brown, Inc.
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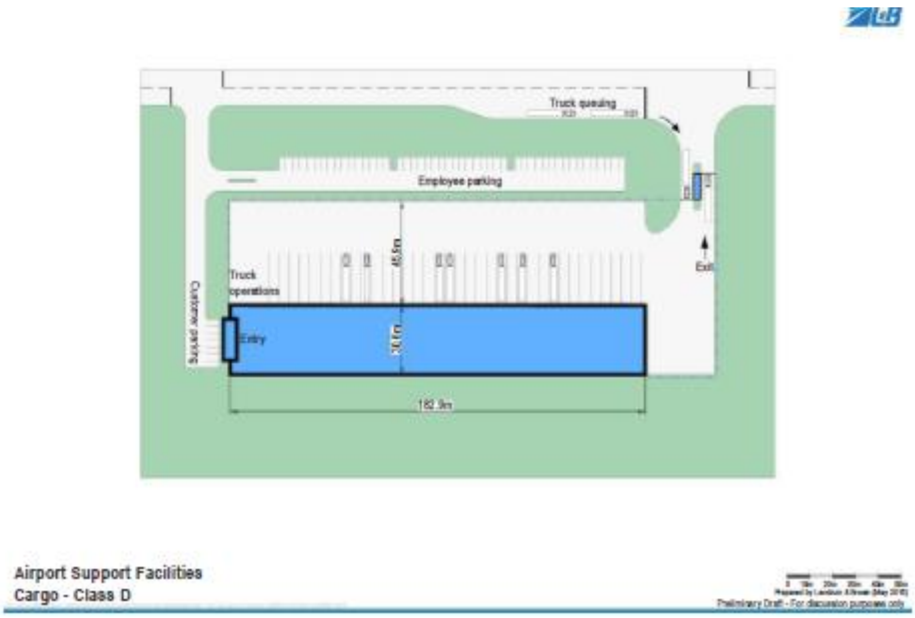

Figure IV-1-6. Category D cargo facility
Source: Landrum & Brown, Inc.
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Express mail facilities

1.15.13 Express air mail operators will typically only require a Category C type layout for their operation. This type of operation will also utilize aircraft being operated by other cargo carriers. Express air mail operators require a sortation building and truck docks for transporting small packages.

Impact of throughput on planning parameters

1.15.14 Tenants whose operations are dependent upon access to the aeronautical area (either adjacent apron or terminal access via the airside service road) typically estimate their space requirements based on the amount of space that they need to process their cargo annually. In the past, industry planning norms stated that cargo warehouses could process ten tons of cargo per square metre per year and many airports have been planned accordingly. This ratio should be considered a generic guideline for physical planning. However, it is not applicable to individual carrier practices which can vary space requirements substantially. Some planning generalities are relevant and are indicated in the following chart.

Carrier groupings and relative utilization

1.15.15 The carrier categories reflect the impact of the factors described below on potential utilization rates. Thus, international passenger carriers, as a group, tend to have the most operating challenges leading to slower cargo processing, and thus, the lowest utilization rates. Domestic passenger carriers would be expected to achieve higher utilization rates. Combination carriers would be expected to move cargo more efficiently than passenger carriers because of the larger volumes involved. Integrators whose business models are built around expedited processing represent the most efficient cargo processors and will achieve the highest utilization rates. Freighter carriers achieve somewhat lower utilization rates than integrators but higher rates than passenger or combination carriers.

1.15.16 General assumptions that impact throughput ratios include but are not limited to:

a) domestic throughput is generally faster than international;

b) freighter cargo allows for more efficient processing because of the economies of scale;

c) certain countries of origins may require more detailed customs inspections slowing throughput;

d) time of arrival for international goods is linked to local retail and commercial distribution networks;

e) delivery of cargo to consignees may include built-in delays based on retailing and/or wholesaling operations;

f) authorized and filled staffing levels of federal agencies affect the processing of international cargo;

g) perishables have a very high throughput due to their time sensitive nature;

h) customs brokers may request that carriers use the airport warehouse to hold cargo for several days for consignees;

i) containerized freight typically moves through a facility faster than palletized freight;

j) the age and configuration of a building may mitigate or enhance throughput mechanization. A newer building with higher ceilings and larger clear spans tends to be more efficient;

k) the use of technically advanced material handling systems accelerates virtually all elements of cargo handling;

l) buildings operated by handling companies with multiple carrier customers, achieve greater operating and cost efficiencies through economies of scale; and

m) security requirements, which may include screening, may impact throughput.

1.15.17 When applying these guidelines, and examining individual carrier operations, the industry evolved a range of applicable throughput ratios illustrated in the following table.

Typical cargo throughput ratios

Low automation (mostly manual)	5 tons per square metre
Automated (average)	10 tons per square metre
Highly automated	17 tons per square metre

Source: IATA Planning Guidelines
(Image reproduced by kind permission of IATA)

1.15.18 The type of operation reflects the primary type of aircraft used to convey the cargo and the throughput range expresses the number of tons that could reasonably be expected to be processed annually through the facility. These ranges also consider the fact that in a typical cargo facility, approximately 10 per cent of the space can be allocated to office and counter use, and another five per cent may be allocated to GSE, supply storage and miscellaneous functions. The result is less useable space for cargo handling. Additionally, leasing costs impact as the anticipated space requirement. Tenants lease only what is required. Other considerations include whether or not the tenant:

a) handles cargo for other carriers;

b) is handled by a third party that also handles other cargo in that space;

c) shares space on an informal basis with adjacent tenants;

d) has entered into a subleasing agreement;

e) has a portion of its cargo handled at another facility; or

f) as a substantial trucking operation.

Physical cargo planning requirements

1.15.19 The business strategies and operating requirements that are reflected in the core operating assumptions must be translated into physical requirements. In certain business and operating models, transfer activity receives substantial emphasis. In such cases, the throughput metric may be two or three times the rates indicated above changing both the size and configuration of the facility.

1.15.20 There are three facility types that typically meet the air cargo objectives of the modern airport. These include:

a) the traditional type of cargo facility designed for carrier OaD cargo as well as routine transfer cargo;

b) a forward transfer area to reduce transit time to the primary cargo facility and handle expedited transfers and interlining; and

c) the traditional integrator facilities.

1.15.21 Each of these categories will have different throughput capabilities that will drive both space allocation and facility configuration. The ratios previously noted should help form the framework for anticipated cargo throughput at the airport. The throughput assumptions should also take into account that some facilities will be phased and future efficiencies will be achieved through increasing levels of customs efficiency, tracking and coding, technological enhancements and experience. Efficiency will be further enhanced through economies of scale. Nevertheless, the cargo plan should always allow for capacity contingency in the event that market conditions change.

Cargo building requirements

1.15.22 There are several important considerations in estimating throughput and sizing the primary facilities:

a) freighter cargo creates greater economies of scale for staff utilization and handling and increases throughput;

b) given a common-use cargo facility, it can be operated by a single handling entity increasing efficiency;

c) new facilities can be sized and configured to handle and screen cargo efficiently and effectively; and

d) increased automation of customs will accelerate throughput. For larger facilities, the cargo handling area can be optimized by the creation of mezzanine office space rather than use of the main floor. Typically, office space is allocated at approximately 10 per cent of the warehouse space.

1.15.23 Note that since integrator operations are focused so heavily on speed and time-defined delivery, their facilities typically achieve substantially higher throughput than regular carrier buildings. In assessing building requirements, the following steps should be considered:

a) calculate gross building requirements for warehouse, office and GSE based on tailored throughput ratios;

b) identify and accommodate specialized facility needs to include perishables, high-risk material, animals, security inspection and clearance, etc;.

c) plan the facilities to accommodate peak traffic requirements. Special attention should be paid to options that impact cost and to the unique challenges that access and egress represent;

d) consider the distances and travel time for cargo to and from the passenger terminal stands, between cargo buildings, to any forward transfer operation, to the regional roadway system, and if appropriate any adjacent logistics complexes;

e) the configuration of the facilities must also enable the carriers and their business partners to address their needs efficiently and cost-effectively. Key considerations include:

(1 the volumes of cargo;

(2 the business model of the operator;

(3 optimizing use of the available property; and

(4 access (as required) on both the airside and landside;

f) ability to provide adequate aircraft apron;

g) if land use must be optimized through vertical development;

h) effective ground circulation for trucks, autos and GSE; and

i) operational connectivity between carriers, government agencies and their business partners.

1.15.24 Cargo facilities and infrastructure must be integrated into an airport master plan. The phasing improvements should be planned based on the forecast, but as with all other airport facilities, the actual development schedule should be tied to market triggers to ensure optimum financial efficiency. Planning for the three primary cargo components – airside, landside and the cargo building, should be carefully linked to other airport development plans. This would include consideration of relevant off-airport efforts to include regional transportation and land-use projects as well as economic development initiatives.

1.15.25 Typically, there are targeted development activity levels in the forecast. A primary concern is that near-term targets are consistent with and facilitate the maximum projected long-term requirements for the cargo operations. To do this effectively, it is important to understand the nature of the cargo handling in general and any specialized requirements and how the cargo will be allocated to OaD or transfer activity.

Customs and government operations

1.15.26 Customs is both a key facilitator of goods movement and a control on shipping processes. As a major component from both an administrative and operating perspective, customs is best served by a large office complex that houses not only their operations but other government agencies as well. The result is a "one-stop shipping centre" which facilitates clearance of cargo and the resolution of other transport issues for carriers, shippers, freight forwarders and customs brokers. For larger international operations, consideration should be given to providing space in each of the cargo buildings for a limited physical inspection of cargo that is pre-determined for inspection through a sampling process or is considered suspect by customs officials.

Perishable cargo (temperature sensitive goods(

1.15.27 A substantial portion of air cargo is dedicated to the movement of goods requiring a climate-controlled environment. Recent global estimates place the volumes at 15 per cent and include such products as flowers, fruits, vegetables, meats and fish. This market segment is particularly attractive to carriers since the products are perishable and timely delivery generates premium rates. Based on the market, there may be a need for a climate-controlled environment for the tenants and users of the cargo facilities. Unless there is extraordinary demand, the climate-controlled facilities should be located within the larger cargo buildings. This makes sense from several perspectives, as it:

a) minimizes transit time between facilities in the heat;

b) reduces the amount of handling of the products and the possibility of damage; and

c) eliminates the need for and costs of a separate facility.

1.15.28 The addition of a small fumigation facility should also be considered.

Living animals and quarantine

1.15.29 Animals frequently require specialized care and handling. Cargo facilities deal with three categories of animals:

a) domestics, which for the most part are dogs and cats kept as house pets. Many airports maintain kennels and boarding operations for these animals both as a service to customers and carriers and as a source of revenue;

b) livestock, which is generally cattle and horses although pigs are often included in shipments. These animals require stalls and in many cases exercise areas during required travel pauses; and

c) exotics, which is usually zoo or circus animals that are sometimes dangerous and often difficult to handle.

1.15.30 It is anticipated that routine animal shipments will be handled in the cargo facilities. If the airport is targeting a large or unique market segment such as horses, a separate facility may be required.

Dangerous goods

1.15.31 Dangerous goods are categorized as such because of the chemicals or combination of ingredients that they contain. The industry groups acids and explosives with aerosol containers and perfumes and a wide range of products – many of them common household products – in between. There are few stand-alone "dangerous goods" facilities at commercial airports. The reason is that the products are so varied, of basically limited scale and for the most part, treated very much as ordinary cargo (with appropriate safeguards), that there is no perceived need or financial justification to pay the handling and storage associated with a separate facility.

Decompression chamber

1.15.32 Cargo which has been screened or which has come from a secure supply chain may additionally be subjected to controls using threat activation methodologies, such as decompression chambers, full-flight simulation systems and cooling periods (e.g. holding cargo for 24 to 48 hours). Decompression chambers may exist at an airport as a component of the hold baggage handling system support or be located at cargo facilities.

Forward transfer concept

1.15.33 One of the most critical elements in planning cargo facilities, particularly at a larger airport, is the time and distance involved in moving cargo between the passenger terminal complex to the main cargo complex. The typical conveyance for the freight is by a tug and cart system. The tugs usually operate at a speed between 10 and 15 kilometres per hour. At an airport targeting rapid cargo transfer as an element of its business plan, the travel time is critical.

1.15.34 If transfer cargo is a primary business target, it may be necessary to consider a “forward transfer facility” designed to reduce the ground transit time for transfer cargo. There are a number of challenges associated with this concept. The first is sizing the facility through a determination of potential throughput volumes (usually much higher than in the main cargo complex), staging requirements and special processing needs. The second is determining the location of where the operation should or can take place, and the third is facilitating access.

1.15.35 In addition to the gross tonnages handled, sizing the forward transfer facilities is based on the operating and service elements that will need to be included, as well as the possible use of any future mechanized transfer. The facility would typically include most of the same kinds of elements as the main cargo complex itself – climate control, dangerous goods, valuable goods, etc., though on a smaller scale. Additionally, the facility should include a large staging area for cargo arriving from the main complex and a sortation area that enables belly cargo to be processed and containers and pallets to be broken down and built up for transfer. A forward transfer facility typically requires little or no landside access for cargo.

Cargo apron

1.15.36 One of the key elements to consider in planning aircraft aprons is the current and intended fleet mix of the cargo carriers. As the use of wide-body aircraft on many long-haul passenger routes proliferates, the utilization of freighters will be affected.

1.15.37 Planning the aeronautical infrastructure requirements includes three primary considerations:

a) minimize the amount of taxi-time and distance for freighter aircraft;

b) ensure that there is sufficient aircraft apron to accommodate peak demand for cargo terminal access and parking considering average aircraft stand occupancy time; and

c) ensure that the aircraft apron has sufficient access and egress for peak operating windows.

1.15.38 The forecast of freighter operations is particularly important; however, it is also essential that the numbers are not taken in isolation. Hours of operations, target markets and the targeted turn times for freighters must be factored into the planning to better assess how the apron will actually be utilized. Many freighters turn very quickly particularly if the airport is on a leg of a multi-stop route. Other aircraft may remain on the ground for extended periods of time. Input from stakeholders is important in understanding the apron dynamic and their needs. Forecasts address the total annual operations. Since an operation is defined as a take-off or a landing, when calculating aircraft parking positions, the numbers of operations are divided in half to determine number of aircraft that must be accommodated.

1.15.39 Aircraft apron space can vary based on the type of aircraft being operated. For purposes of air cargo, most cargo aircraft fall into one of the following categories and are used to estimate individual aircraft apron requirements:

a) Code C aircraft require approximately 2 300 m2 of apron space;

b) Code D aircraft require approximately 3 900 m2of apron space;

c) Code E aircraft require approximately 6 500 m2of apron space; and

d) Code F aircraft require approximately 8 000 m2of apron space.

1.15.40 Access to, from and around the aircraft is important. Cargo apron planning should assess the need for a head-of-stand or tail of stand road for manoeuvring of ground service vehicles. In addition, there should be an area (approximately 15 m) provided between the face of the cargo buildings and the nose of the aircraft for staging and equipment manoeuvring.

Landside requirements

1.15.41 An air cargo operation must be multi-modal so that cargo gets to or from a cargo facility by surface access. As a result, it is essential that landside planning consider trucking operations, as well as the accommodation of automobiles at the cargo buildings in the main cargo complex. Landside planning requirements include truck parking and queuing, roadway geometry, employee parking, customer parking and potential access for employees.

Trucking component

1.15.42 In calculating trucking requirements, the primary consideration is OaD traffic. For many airports, two types of operation should be considered – traditional carriers and the integrators. These types of operations have a different truck fleet mix and the impacts of daily peaking may also be different.

1.15.43 The use of 17-m tractor trailers at many international airports will become more prevalent as roadway systems are improved and regional and airport roadway geometry is modernized. To accommodate trucks of this size, a truck dock depth of approximately 47 m is required. This enables the trucks to back into the bays without impacting the movement of other vehicles on access roads during peak hours. Based on anticipated usage by smaller trucks, the numbers of truck bay doors should be maximized. This requires a minimum separation of 4 m from the centre line to the centre line of each truck.

1.15.44 In reviewing current truck usage requirements, planning should determine the most prevalent sized truck in use. Once this is determined, it should be assumed that the trucks operate with less than a full payload, that the trucks operate on roughly the same number of days in a calendar year as the aircraft, and that there is an approximately equal inbound and outbound traffic flow. These considerations tend to raise the anticipated amount of daily trucking activity and allow for more accurate planning for the required number of truck docks. Ideally, there should be a gated access point and a separate egress to optimize cargo traffic flow and security.

1.15.45 Integrators tend to operate differently with smaller vehicles. Specific discussions with an integrated carrier are recommended if they intend to be a substantial operator at the airport.

1.15.46 To minimize congestion in the truck apron, additional space should be allocated separately for truck staging. Additionally, car parking and access should be physically separated from the trucking access operations. The roadway system should have expansion capability that is compatible with future cargo traffic growth forecasts.

1.15.47 Based on projected tonnages and fleet mix, the annual levels of trucking activity can be calculated and broken down to an estimated daily activity level, which in turn can be converted to peak hour levels.

Cargo facility car parking requirements

1.15.48 There are several operating assumptions that factor into cargo zone car parking requirements:

a) The cars will belong to one of three groups:

(1 employees working in the cargo facilities;

(2 visitors or customers of the carriers; or

(3 government employees and individuals visiting the central government complex.

b) A typical employee car park for an air cargo operation ranges from three to eight spaces per 1 000 m² of warehouse. If employee parking is prohibited due to airport policy, the use of shuttles will result in a lower level per 1 000 m² that can be used.

c) Employee car park requirement is typically two to three spaces per 100 m² of air cargo office space.

d) Integrator operations are labour intensive and require twice the number of parking positions. Typical planning allows for 30 m² per parking space. This may vary based on local planning requirements.

e) Car parking should be separate from truck parking at the cargo facilities.

1.15.49 Special consideration should be given to the sizing of car parking stalls based on the type of vehicles being operated in that particular region. Where an airport has a strict policy that restricts employee parking adjacent to work facilities, cargo employees are usually transported via an airport shuttle. Local situations must be considered when determining the size and demand for car parking requirements. If a shuttle service is provided, there must be adequate space for drop-off, pick-up and vehicle manoeuvring.

1.16 SEARCH AND RESCUE SERVICES

At some airports there may be a need to accommodate a rescue coordination centre collocated with or conveniently close to the area control or flight information centre or a rescue sub-centre collocated with or conveniently close to an appropriate air traffic services unit. For information on the accommodation of rescue coordination centres and rescue sub-centres, see Doc 9731 – International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, Volume I – Organization and Management.

1.17 GROUND SUPPORT EQUIPMENT STORAGE AND MAINTENANCE FACILITY

1.17.1 Providing a dedicated staging and storage areas for GSE vehicles helps in ensuring safe and efficient usage of the aircraft apron area. The GSE staging areas are used to pre-position equipment in advance of an aircraft arrival. These areas are generally located adjacent to each aircraft parking stand, with adequate circulation capability. The GSE staging area should be outside the stand safety line and PBB operating ranges. The area needed will be based on the airlines and/or aircraft operating requirements, GSE provider and type of equipment.

1.17.2 GSE storage areas are also used to park GSE when not in use. These areas are often located on the apron level in close proximity to aircraft stands but separate from the actual stand area. These areas are used to store GSE vehicles which cannot be accommodated on the aircraft stand, during off-peak periods, staff shift changes, and for overflow of excess GSE vehicles. In order to determine the size of the various staging areas required by the operators throughout the airfield, the size of the GSE fleet staging at each area needs to be established. Detailed consultation sessions should take place with the ground service providers to determine this need to support the turnaround of aircraft in an efficient manner. The GSE staging areas should be planned in as an integral component of the aircraft stand planning in the master plan and should not be an afterthought. GSE staging areas should be located adjacent to the relevant staff or driver accommodation and within close proximity to the areas being served.

1.17.3 The storage area should be connected to the airside service road network to provide quick access to the aircraft stands. In some cases, the GSE storage area is located under the concourse buildings or in open areas between the stands and adjacent taxiways or taxilanes (jet blast impacts must be considered). Where a storage area is located near taxiways or taxilanes, a blast fence or other protection should be installed.

1.17.4 The GSE maintenance facility serves as an on-airport maintenance area for scheduled maintenance and repairs of all GSE vehicles in order to minimize the need for vehicles to be taken off-airport. Many GSE vehicles are not licensed to be driven on public roadways and cannot maintain the posted speed limits. The GSE maintenance facility should be located near the aircraft apron areas to minimize travel distances and times. At larger airports, multiple GSE maintenance areas may be desirable to keep GSE vehicle travel distances to a minimum.

1.17.5 The GSE maintenance facility will need to accommodate various size maintenance bays based on the vehicle fleet, parts storage area, office space, locker rooms, etc. Detailed collaboration with the ground handling community is vital to define existing and potential future requirements.

1.18 CONSOLIDATION CENTRE

1.18.1 Larger airports should consider developing a consolidation centre to be used to consolidate all deliveries to concessionaires serving the airport retail, food and beverage (FaB) outlets, as well as airline first and business class lounges. The consolidation centre may also serve as the main delivery point and storage for all maintenance parts, supplies and equipment. The consolidation centre operates in a way similar to a cross docking operation with an X-ray scanner located on the secure line, separating the virtual “airside” and “landside” sections of the building.

1.18.2 Centralizing logistics within the consolidation centre creates a central receiving area which dispatches goods and supplies to smaller localized storage areas, or directly to the shop floor as a redistribution service. A particular service provider will alert the consolidation centre when stocks are depleting so that stored goods can be forwarded in a timely manner.

1.18.3 The consolidation centre must accommodate enhanced security screening of deliveries. Active management by the centralized logistics provider reduces congestion at the loading docks, improves the use of limited in-terminal and concourse concession storage and efficiently manages deliveries and product distribution for numerous functional areas of the airport.

1.18.4 The consolidation centre should be located at the landside and airside security boundary. This placement accommodates landside deliveries, internal screening, storage and distribution via the airside roadway network. Loading docks are required on both the airside and landside with building space provided for product storage (dry and refrigerated) and product sortation.

1.19 DUTY-FREE WAREHOUSE

1.19.1 A duty-free warehouse also supports the retail operation at an airport with a distribution centre where incoming duty-free products are received, stockpiled and bundled for distribution to airside retail centres throughout the terminal and concourse buildings on an as needed basis. Goods from multiple suppliers are accepted at the duty-free warehouse and screened, stored, consolidated and transported to the various outlets operated by the retailers, airlines and stakeholders, either in the terminal, concourses or other on-airport buildings.

1.19.2 The duty-free warehouse should be located on the landside and airside boundary to allow for the delivery of goods and their efficient distribution to the airside. This type of facility will have a high roof structure to support the racking and storage of pallets. The size of the duty-free warehouse is related to the amount and size of retail space within the passenger terminal and concourses as well as the amount of storage needed to ensure adequate, timely supply.

1.20 AIRPORT DATA CENTRE, AIRPORT OPERATION CONTROL CENTRE AND EMERGENCY OPERATIONS CONTROL CENTRE

1.20.1 The main objectives of the airport data centre (ADC) are:

a) Sheltering: For airport critical information and communication technology (ICT) systems;

b) Resiliency: For continuity of operations and recovery of disasters including climate change-related;

c) Scalability and efficiency: To provide flexible, scalable and efficient facilities to accommodate future airport growth and technology enhancements based on best practices;

d) Monitoring: To provide control centres to monitor, manage and support all ICT systems, including support, maintenance, cyber security and configuration management of all airport systems;

e) Storage: To house the data centre environment in support of large-scale data generating systems;

f) Security: To protect, secure and prevent the compromise of airport data physically and over cyber by safeguarding internal networks and systems from unauthorized access and hostile activity; and

g) Testing: To provide secured facility for testing, commissioning and integration of new ICT systems prior to deployment.

1.20.2 The main airport operation control centre (AOCC) serves three key functions of command and control:

a) operations planning centre;

b) operations management and monitoring; and

c) emergency operations centre (EOCC.(

1.20.3 The AOCC is the central monitoring facility responsible for monitoring police, CCTV, airfield operations, medical, APM, BHS and ground transportation roadways. The AOCC provides a collaborative-shared space for all transportation stakeholders that improves communications and situational awareness, response times during security incidents and promotes unity of mission. AOCC enable real-time community domain awareness ensuring multi-agency information sharing and coordinated operations and collaborative decision-making at both the local and national levels.

1.20.4 The main purpose of the EOCC is to provide a secure location with adequate communications for command and control during an incident or emergency. In addition, the EOCC is used in the event of a catastrophic failure of the main AOCC. The EOCC includes space, facilities and protection necessary to manage the airport under temporary conditions. The EOCC need not be the same size as the main AOCC.

1.20.5 The design of the data centre, AOCC and EOCC should be coordinated with the police, airport operations and other stakeholders who operate and maintain these facilities. An integrated ADC, AOCC and EOCC houses a cross-functional team that seamlessly facilitates every aspect of the customer journey through the airport.

1.21 WASTE AND RECYCLING CONSOLIDATION CENTRE

1.21.1 Waste from airports can be divided into nine basic types:

a) municipal solid waste;

b) construction and demolition waste;

c) green waste;

d) food waste;

e) waste from aircraft flight (deplaned waste;(

f) lavatory waste;

g) spill clean-up and remediation waste;

h) hazardous materials; and

i) international catering waste.

1.21.2 The terminal and concourses are the heart of an airport complex and normally have the highest concentration of people. This translates into the highest concentration of waste. Airports develop plans and facilities for recycling, reduction and waste reuse programme to further their waste minimization initiatives. The implementation of a waste and recycling programme at an airport must consider all of the activities and waste streams at the facility.

1.21.3 Starting a sustainability and recycling programme at the airport helps to minimize the amount of refuse and waste that is deposited in landfill, thereby reducing the potential for airport bird hazards.

1.21.4 EAC139-16 provides more guidance on waste management within airports.

1.22 BUS STAGING AND MAINTENANCE FACILITY

1.22.1 Buses can be used for passenger, crew and employee transportation throughout the landside and airside areas of the airport. Various staging areas should be provided depending on the specific bus routes and locations for pick-up and drop-off points. The types of buses used will depend on their specific function. This function is sometimes contracted to an independent third-party for the management and maintenance of the buses.

1.22.2 Proper and timely maintenance of the bus fleet assures a smooth passenger and employee service. The size and location of the bus maintenance facility depends on the fleet type and size. For security purposes, the bus maintenance facility may be located outside the airport security area but in close proximity to the airport to minimize travel distances and possible delays. Direct roadway access routes should be provided between the airport and maintenance facility.

1.23 MOTOR VEHICLE TRANSPORT STORAGE AND MAINTENANCE FACILITY

1.23.1 The motor vehicle transport storage and maintenance facility is required to provide vehicle maintenance for all vehicles owned and operated by the airport operator and/or owner.

1.23.2 This might include vehicles used by:

a) police or security patrols;

b) fire department;

c) medical department;

d) operations department;

e) airport maintenance department; and

f) customs and immigration.

1.23.3 Sizing and location of this facility will need to be coordinated with all relevant stakeholders to determine the fleet size and maintenance requirements. In some cases, maintenance of these vehicles is contracted to a third-party company located off-airport.

1.24 AIRCRAFT AND AIRFIELD DE-ICING AND STORAGE FACILITY

1.24.1 Airports in locations with winter weather conditions that can cause accumulation of frost, snow, slush or ice on aircraft surfaces must have aircraft de-icing facilities. These airports should consider dedicated de-icing pads to maintain departure flow rates and avoid aircraft delays. Many airports provide a centralized de-icing pad in order to minimize equipment and environmental impacts. Aircraft de-icing facilities should have runoff mitigating structures to collect de-icing fluid runoff. Aircraft holdover times must also be considered when locating the aircraft de-icing pads to ensure the aircraft can depart within the specified time period after being de-iced. This depends on the types of de-icing fluid used at the airport by each airline or provider.

1.24.2 Aircraft de-icing is critical to ensuring safe operations during winter weather, including freezing rain, snow and ice crystals. This may sometimes be followed by “anti-icing”, which then prevents the development of further accumulations for a short period of time. Airport de-icing facilities should have a de-icing and anti-icing capacity that approximates the peak hour departure rate that the aerodrome control tower can manage during these weather conditions.

1.24.3 Aircraft de-icing time starts when the wheels stop on the de-icing pad and ends when the wheels start moving again. This includes the time it takes:

a) to allow the engines to run down (as applicable;(

b) to dispense the de-icing application;

c) to notify the pilot that de-icing is complete;

d) to restart the engines (when applicable); and

e) to receive ATC clearance to leave the de-icing pad and proceed to the runway for take-off.

1.24.4 The required number of de-icing positions at the airport is directly related to the average amount of time required to de-ice each aircraft and the number of aircraft that need de-icing. The amount of time spent de-icing each aircraft depends on various factors, including the:

a) amount of snow or ice accumulated on the aircraft;

b) rate at which additional precipitation is falling;

c) time needed to position the aircraft and de-icing equipment;

d) number of de-icing trucks dedicated to each aircraft;

e) type of de-icing trucks operated; and

f) size of the aircraft.

1.24.5 These factors should be considered when determining the minimum, maximum and average aircraft de-icing times.

1.25 UNIT LOADING DEVICE STAGING AND MAINTENANCE FACILITY

1.25.1 Unit loading devices (ULDs) used to transport cargo and baggage require a staging area and maintenance facility. The ULD maintenance facility should be located in close proximity to the passenger aircraft stands and cargo apron area to minimize travel distance and time.

1.25.2 Current and future peak hour demands for cargo and baggage ULDs need to be determined. In addition, the demand for the dolly fleet used to transport ULDs also needs to be determined. In some cases, racking facilities are used to store cargo pallets transported to the aircraft. Consultation with the operators will determine if an area for racking facilities should also be considered.

1.25.3 The ULD storage and maintenance facility must accommodate maintenance bays, parts storage area, office space, locker rooms, etc.

1.26 DETENTION CENTRE

Larger international airports often require a detention centre that can be used by the local police agency. The detention centre should be located on the airside and landside boundary to provide direct access by the police and general public. Depending on their overall responsibilities at the airport, consultation with the local police department will aid in determining the requirements for the detention centre.

1.27 POLICE AND EXPLOSIVE STORAGE AND TRAINING FACILITY

1.27.1 Implementation of aviation security requirements and management of all passengers and their baggage, personnel goods and vehicle entry into the security restricted areas, may be the responsibility of the airport manager through the employment of private security companies, the civil aviation authority (CAA), the appropriate authority for aviation security or law enforcement agencies. Airside support facilities may also be under the aforementioned entities' purview. In addition, there is a wider law enforcement and public security component which generally is dealt with by State, regional and/or local law enforcement agencies.

1.27.2 For the explosive storage and training facilities, consultation with those in charge of implementation of aviation security provisions and the local police department is recommended to determine the actual size and location of these facilities. In addition, the explosive bunkers base requires specific clearance requirements relative to the type and amount of explosives being stored.

1.27.3 Further guidance concerning the provision of aviation security airports can be found in Chapter 3 of this section.

1.28 CONTROL POSTS

1.28.1 A control post is designed to facilitate the screening of vehicles, employees and goods before they are permitted to access the security restricted area (SRA). Some control posts may also serve as an interchange with a landside parking area, rail and bus drop-off (landside), and staff pick-up area (airside) to transport staff to their places of work.

Vehicle screening

1.28.2 All goods, staff and VIP and/or airside vehicles are screened prior to being granted access to the SRA within this facility. This facility also provides screening facilities for drivers and personnel.

1.28.3 Detailed guidance about vehicle screening dispositions can be found in Chapter 11 of Doc 8973.

Staff screening

1.28.4 Many airside staff will access the airside via the control posts. The employees are processed through security lanes. Screening is undertaken using equipment and processes as approved by the State's appropriate authority for aviation security.

1.28.5 Detailed guidance about screening and other security controls pertaining to persons other than passengers and the items they carry can be found in Chapter 11 of Doc 8973.

Airport supplies screening hall

1.28.6 This facility may also to be included at the control posts or may be a separate facility. Airport supplies bound for the airside may be screened before being accepted into SRAs.

1.28.7 Detailed guidance about screening and other security controls pertaining to in-flight and airport supplies can be found in Chapter 14 of Doc 8973.

1.28.8 Control posts need to be sized to accommodate the hourly peak throughput of staff and vehicles accessing the airside facilities at the airport.

1.29 PERIMETER SECURITY FENCING, CRASH GATES AND RENDEZVOUS POINTS

Perimeter security fencing

1.29.1 A security system must be established at an airport to prevent access by unauthorized persons to those parts of the airport not intended for public use. The movement area of the airport should be protected by a fence or other suitable barrier to prevent or deter the inadvertent or premeditated access of unauthorized persons or vehicles. The height of the security fence and materials should be such that it prevents penetration from above or underground and should not result in an obstruction to aircraft and navigational aid signals.

1.29.2 Detailed guidance about perimeter security fencing can be found in Chapter 11 of Doc 8973.

Emergency (crash) gates

1.29.3 Emergency (crash) gates are provided so that emergency services vehicles and other authorized personnel can access areas outside the airport security fence. Access is usually to areas directly off the runway ends in the event of an undershoot or overrun of an aircraft to the runway system. Emergency gates are locked at all times and are opened only during emergency situations by authorized personnel designated by the airport authority. These gates typically are a lock and key system which is controlled by the airport security division.

Rendezvous points

1.29.4 Some airports provide rendezvous points to provide a safe area on the airside and landside boundary where external emergency services can assemble and wait to be escorted to the scene of an incident or accident by the airport's security team airport.

1.29.5 Based on airport emergency orders, specific categories of emergency will require a response from emergency services outside the airport. Such services may include municipal fire, ambulance and police services. Upon arrival at the airport, these services will proceed to the designated rendezvous points.

1.29.6 Rendezvous points may be located adjacent to a control post or crash gate for ease of access. The size and number of rendezvous points will depend on requirements of emergency services at the airport. Direct detailed consultation is recommended.

Chapter 2 Aircraft Fuel Facilities

2.1 ABOUT THIS CHAPTER

2.1.1 The provision and handling of fuel at airports significantly impacts the planning of airport facilities. The Manual on Civil Aviation Jet Fuel Supply (Doc 9977) provides guidance covering all matters related to aviation fuel quality control, operations and training across the entire supply and distribution system, from refinery to aircraft.

2.1.2 Special elements pertaining to aircraft fuel facilities include:

a) safety: due to the potential fire hazard, mainly on aircraft aprons where a number of other activities are taking place simultaneously during aircraft refuelling process;

b) minimizing aircraft gate occupancy times; the fuel flow rates required are a factor in the choice of the refuelling system; and

c) movement of large and heavy vehicles; impacts apron pavement design, remote parking areas and service roads.

2.1.3 There are normally three facility areas associated with aviation fuel provisions:

a) the fuel receipt area where incoming fuel is metered, filtered, tested and combined into a manifold to feed the fuel farm;

b) the fuel farm area where fuel is stored and the hydrant depot is located; and

c) the into-plane services depot which provides staging for hydrant vehicles as well as operational management and welfare facilities.

2.1.4 For any airport fuelling system there are two fundamental quantities that are required in order to determine the type and size of fuel facilities:

a) maximum total uplift of fuel in a given period which dictates the fuel storage capacity and method of supply to the airport; and

b) peak instantaneous rate at which fuel must be delivered into the aircraft which dictates the into-plane method and sizing of the associated facilities, such as the number of dispensers, size of fuel pipes, etc.

2.1.5 A fuel system is designed to receive, store, monitor, filter and transfer fuel in accordance with quality standards.

2.2 FUEL STORAGE CAPACITY

2.2.1 The purpose of the fuel storage facility (fuel farm) at the airport is to:

a) enable appropriate quality control checks to be carried out on the fuel;

b) accommodate normal fluctuations in stock levels;

c) provide a buffer stock to be able to deal with disruption in supply;

d) accommodate future growth; and

e) accommodate different types of new alternative fuels requirements.

2.2.2 A fuel farm will have numerous fuel storage tanks located in a single facility. Each tank may be under separate ownership or management and the fuel in each tank may be owned by more than one entity. However, a fuel farm is part of a larger fuel storage and distribution system that moves fuel from off-airport suppliers through storage tanks and into the aircraft. Ultimately, the purpose of the fuel distribution system is to provide a safe, efficient and cost-effective means to deliver aviation fuel from the refinery to the aircraft. Fuel storage capacity requirements must be estimated based on an air traffic forecast, taking into consideration:

a) types of operating aircraft;

b) frequency of operations;

c) fuel uplift per aircraft; and

d) different types of fuel required.

2.2.3 With regard to different types of fuel required, airport planning should consider the needs for accommodating both “drop-in” alternative fuels such as sustainable aviation fuels and low carbon aviation fuels and “non-drop-in” alternative fuels, such as cryogenic fuels (hydrogen and methane) and electricity.

2.2.4 Typically, a minimum of three days storage capacity is recommended; however, this varies depending on risks to the supply. Also, a usable tank capacity of 95 per cent should be assumed.

2.2.5 The delivery of fuel is made from refineries or other associated main storage facilities. Transportation to airports can be made by ship, barge, railway, truck or pipeline. The delivery system has a significant bearing on the capital cost of an airport, since the construction of special harbours and piers or great extensions of roads extensions, special railway lines or pipelines may become necessary. The following diagram illustrates a typical fuel delivery system from the refinery to the aircraft.

2.2.6 On-site production of new alternative fuels and associated facilities should also be considered for airport long-term planning. As an example, on-site production (and liquefaction) of hydrogen could also be a promising option for airports to meet their individual energy needs, and airport planning should consider the needs to have the infrastructure to convert it to liquid form in addition to its transport and storage requirements if hydrogen is not produced at the airport.

2.2.7 The movement of large and heavy trucks on existing roads is sometimes impossible and topographic conditions may preclude their improvement or construction of new roads or railways. Thus, the fuel delivery system options are largely a question of capital expenditure including cost-benefit analysis. In addition, the number of fuel trucks might also impact air quality and create noise issues around the airport depending on the frequency of deliveries to the fuel farm tanks.

2.2.8 The maximum fuel lift capacity can vary between 24 000 litres for an A321 and 320 000 litres for an A380 aircraft. However, the actual fuel uplift depends on a number of factors:

a) flight sector length;

b) flight load;

c) new technology (could also require fuel related infrastructure retrofit and/or new facilities); and

d) amount of excess or "tankage" fuel with which the aircraft arrives (fuel differential pricing at different airport.(

2.2.9 Optimizing fuel storage at an airport requires:

a) a thorough understanding of the airport's current profile;

b) clarification of the purposes of storage relevant to that specific airport;

c) quantifying the measurable parameters that are applicable to those purposes;

d) calculating optimum storage; and

e) reviewing operational considerations, finance and permissions.

2.2.10 Communication with the stakeholders (fuel suppliers, operators, airline consortia, etc.) during the fuel system design process is strongly recommended.

2.2.11 Figure IV-2-1 is extracted from Doc 9977 – Manual on Civil Aviation Jet Fuel Supply. It illustrates a schematic for the supply and distribution chain from refinery to aircraft.

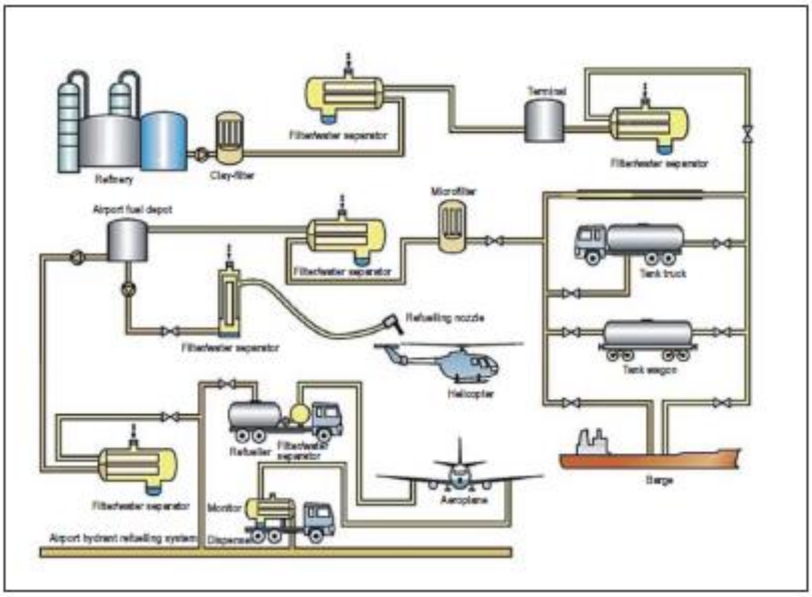

Figure IV-2-1. Schematic for the supply and distribution chain from refinery to aircraft

2.3 LOCATION OF FUEL STORAGE

2.3.1 The fuel storage (fuel tanks) area can be located on- or off-airport property depending on factors related to land availability. These may include environmental and site preparation costs, and efficiency of methods for final delivery to the aircraft (i.e. trucking vs pipeline, etc.). Where dispensing pumps are provided, fuel is loaded into refueller trucks ("bowsers") for final delivery to the aircraft, however where fuel hydrants are used, a hydrant dispenser or hydrant cart is connected to the hydrant pit which then delivers filtered and metered fuel to the aircraft. If possible, the fuel storage areas should be located as close to the aircraft fuelling area as practical, with due recognition given to established safety clearances. Spills, leaks, sample and water drain disposal can have a damaging impact on the environment and must be effectively managed. EAC139-16 –provides more guidance on fuel containment.

2.3.2 In addition, the vapour densities of aviation fuels are such that released vapour, particularly under calm wind conditions, may travel considerable distances along the ground and collect in depressions where they may not readily dissipate. An investigation of inhabited areas around the airport and wind directions is necessary.

2.3.3 In some States, the fuel storage tanks have specific recommended setback distances from the airport property boundary, public roadways and buildings such as the United States National Fire Protection Association (NFPA.(

2.4 FUELLING OF AIRCRAFT

2.4.1 Aircraft are fuelled at their parking positions either at contact stands close to the terminals or at remote stands, by refueller trucks (“bowsers”) or hydrant systems using hydrant dispensers or hydrant carts. The system chosen should be determined by the forecast rate of aircraft movements and required fuel flow rates. Generally, refueller trucks (“bowsers”) are most suitable where plenty of space is available between parked aircraft, the rate of aircraft movements is moderate and the fuel requirements of aircraft are not too great. At busy airports, it is often desirable to install pipelines (fuel hydrant) under the apron from the fuel storage area to the stands. Outlets are provided at stands and only a small fuel hydrant dispenser vehicle is then required to connect the hydrant outlets to the aircraft.

2.4.2 Another method of getting fuel to the aircraft is through a self-contained refueller truck, or “bowser”. The fuel is stored in a chassis-mounted tank with an integral pump, filter and metre system. The vehicle receives a load of fuel from a rack or similar loading area and is driven to each aircraft requiring fuel. The design allows for flexibility, but the size of the vehicle limits the amount of fuel available and the amount of manoeuvring space needed around the aircraft. Capacity of avgas trucks tends to be in the range of 2 000 to 6 000 litres, whereas capacity for jet fuel trucks ranges from 4 000 to 57 000 litres. With gross vehicle weights of 32 tons or more for the largest trucks, terminal aprons and access roadways need to be designed to accommodate heavy truck movements. The design of the truck loading and unloading area requires secondary containment to meet environmental regulations.

2.4.3 Considerable care should be exercised in locating hydrant outlets (such as Pitts valve boxes) at the stands to ensure that they provide optimum flexibility and capacity. Provisions should also be made to increase the capacity (through future provision of more outlets) and to meet possible future aircraft size and parking configurations. Sometimes combinations of hydrants and refueller trucks (“bowsers”) can be used to provide added flexibility.

2.4.4 Caution is required when considering the use of large refuelling trucks. Large jet aircraft require a considerable amount of fuel (nearly 24 000 litres for an A321 and 320 000 litres for an A380 aircraft). A minimum of two refuelling trucks is normally required, one under each wing. For the larger jets, standby units are required when fuel requirements are in excess of two units. Therefore, there are a large number of vehicles manoeuvring on the apron during peak periods, creating a potential safety hazard. When a fuel truck is empty, it returns to the storage area for refuelling before it can be used again. Thus, extra trucks must be provided for use during peak operating periods. When refuelling trucks are not in use, parking space is required for these vehicles at the fuel depot area.

2.4.5 The capacity of fuel servicing tank vehicles varies from 10 000 to 75 000 litres. For the larger fuel servicing rank vehicles, axle loads are sometimes in excess of the bearing limits on highways; the airport designer consequently must provide adequate roadway and apron pavement strengths to support these vehicles.

2.4.6 The trend at large airports is towards providing hydrant refuelling systems. This type of installation is simpler than the refuelling pits while providing similar advantages. Essentially, the hydrant system consists of the same elements as the fuel pits, except that the pit is replaced by a special valve mounted in a box in the pavement and flush with the surface. The hose reel, meter, filter and air eliminator are contained in a mobile self-propelled or towed hydrant dispenser. The most effective practice in hydrant fuel system design is to have a continuous loop, rather than a terminus point. A loop system helps to eliminate stagnant fuel and the potential accumulation of microbial or other contaminants. The placement of isolation valves allows for easy maintenance, inspection and emergency shutoff without affecting other aircraft stands or other fuelling areas of the airport.

2.4.7 A minimum rate throughput rate of fuel delivery systems of 760 litres per minute is required for fuel truck, barge or rail delivery. Higher fuel flow rates may be required based on the aircraft fleet and peak operating period. Transport trucks are often designed to transport 30 300 to 38 000 litres, and it takes anywhere from 40 to 50 minutes to offload a single truck at a rate of 760 litres per minute. With fuel capacities between 24 000 litres for an A321 aircraft and 320 000 litres for an A380 aircraft, hydrant fuelling is preferred over truck filling. Today's jet aircraft are designed to accept flow rates of 2 300 to 3 000 litres per minute through multiple nozzles. Hydrant systems reduce the amount of time required to fuel an aircraft. Hydrant systems also help to reduce aircraft turnaround times on gates and reduced vehicle activity on the apron.

2.4.8 The length of the hose line from the hydrant dispenser or pit to the intakes in the wings be from 6 to 9 m long. If a wide variety of aircraft are to be serviced at an aircraft stand, the precise spacing of the hydrant valves should be established in consultation with the airlines. The number of hydrants required per gate position will depend not only on the type of aircraft but also on the number of grades of fuel required (each grade of fuel requires a separate hydrant.(

2.5 SAFETY AND SPECIAL DESIGN REQUIREMENTS RELATED TO FUELLING SYSTEMS

2.5.1 Jet fuel is a combustible liquid, whereas avgas is a volatile flammable liquid. Contaminated fuel results in underperforming or failed engines. Spilled fuel can contaminate the ground, water and air. Fuel vapour can affect human health. Accessibility by emergency fire equipment is an important consideration when planning aircraft fuel servicing locations and laying out airport fixed fuelling systems. Other important considerations include:

a) Standards are prescribed by the competent authorities or stipulated by specialized institutes and associations. Codes, regulations and specifications are available from several agencies and from different countries. Nevertheless, consultation with key stakeholders such as the airlines and oil companies is advisable when planning fuel supply systems at airports.

b) Fuel piping should not run under buildings, piers or fixed links (excluding movable loading bridges) except when run in buried steel casings enclosing the fuel piping alone.

c) Fuelling hydrants, cabinets and pits should be located at least 15.2 m from any terminal building, hangar, service building or enclosed passenger concourse (other than boarding bridges) (as per NFPA 407, Section 4.4.10.3.(

d) Fuelling hydrants and fuelling pits that are recessed below an apron surface and are subject to vehicle or aircraft traffic, should be fitted with a cover designed to sustain the load of vehicles or aircraft that taxi over all or part of them.

e) Hydrant emergency shutoff buttons that are easily accessible and unobstructed shall be installed to shut down the fuel pumps supplying the fuel hydrant in case of emergency.

f) The apron surfacing material should be graded to form a gradual slope away from the rim or edge of fuelling hydrants or fuelling pits to prevent flooding.

g) At aircraft stands where aircraft are fuelled, to prevent errors in measurement of fuel in the aircraft's tanks caused by parking with one wing low, the slope should not exceed 0.5 per cent in the transverse direction and 1 per cent in the longitudinal direction.

h) The surface must slope away from the face of the terminal building for proper drainage and safety in case of fuel spillage.

i) Fuel-resistant pavements should be used on aprons wherever refuelling operations or engine shut-downs are likely to take place regularly.

j) Surveillance radar equipment in aircraft should not be operated within 90 m of any fuelling, servicing or other operation in which flammable liquids, vapours or mist could be present (as per NFPA 407, Section 4.1.4.1.1.(.

k) Antennas of airport flight traffic surveillance radar equipment should be located so that the beam will not be directed towards any fuel storage or loading racks within 90 m. Aircraft fuelling servicing should not be conducted within this 90-m distance (as per NFPA 407, 4.1.4.2.1.(.

l) The transfer of fuel from an aircraft (defuelling) to a tank vehicle through a hose generally is similar to fuelling, and the same safety requirements shall apply.

m) The development of suitable infrastructure for the supply of new alternative fuels must also guarantee similar safety levels as for conventional jet fuels.

Chapter 3 Security Requirements

3.1 ABOUT THIS CHAPTER

3.1.1 This chapter, as for the rest of this EAC , must be read in conjunction with Doc 8973 to understand and account for all security requirements impacting the design of airports and their planning process. The information provided in this chapter is indicative only and by no means exhaustive.

3.1.2 Distribution of Doc 8973 is restricted and may not be available to all parties preparing an airport master plan. It is available only through State administrations or by special requests to the Aviation Security Policy Section of ICAO. Airport security is an integral part of airport planning and operations but details must be restricted. As a result, the subject is only discussed in general terms in this manual. Attention is directed to the manual cited above for detailed planning data.

3.1.3 At each airport a basic level of security is required under normal operating conditions. In addition, there are measures and procedures which will be required during periods of heightened tension. These requirements will need to be determined at the earliest possible stage in the preparation of plans or designs to assure there are contingency security measures established for these heightened security levels. Consultation with security appropriate authorities for aviation security is essential in order to assure that all security requirements are considered.

3.1.4 In order for security to be effective, a systematic approach is required and this includes the basic plan for the design of the airport. Every measure discussed in this chapter need not necessarily be implemented at every airport but they should be considered against the desired level of security. Security measures should be implemented so as to cause minimum interference with or delay to aircraft operations, passengers, crew, airport staff, baggage, cargo and mail. It should be recognized that the airport design is relatively inflexible once the structures are completed and future increased security requirements may be difficult to implement without significant and sometimes costly changes to the buildings and structures within the same footprint. New and anticipated technologies in airport security should be considered when preparing the master plan and design of all airport facilities.

3.1.5 Concurrently with determining the level of security to be provided, there is a need to define the areas on the airport that require protection. As a minimum, this would include the airside. At some airports however, protection of the entire airport property may need to be considered. In addition, other functions vital to air navigation which may not be located on the airside, such as air traffic services, radio navigation aids, fuel storage areas, water and electrical power supplies are part of the scope of aviation security regulations. These facilities may also need to be protected. It is imperative that all appropriate airport stakeholders be involved in determining the level and sophistication of the airport security systems to be implemented.

3.2 LANDSIDE SECURITY

Passenger buildings – inspection and screening of persons

3.2.1 The key security consideration in the design of passenger buildings is maintaining the integrity of the secure airside. This precaution will equally apply to ducts and cable runs provided for security equipment. It must not be possible for unauthorized persons to pass from the landside to the airside. This means that access from public areas of the access roadway and buildings to operational areas (including hold baggage and cargo areas) must be strictly controlled.

3.2.2 In this context, adequate provisions must be made for the inspection and screening of staff, vehicles, passengers and their baggage. For example, adequate space must be provided to accommodate current modern passenger and cabin baggage X-ray and scanning devices and their conveyor systems, along with passenger queuing space. In addition, it might be necessary to provide full size vehicle scanning devices in remote locations prior to coming within close proximity to the terminal building or public parking structures.

3.2.3 Additional guidance about landside security can be found in Chapter 11 of Doc 8973.

3.2.4 Doc 8973 describes the basic plans for the inspection and screening of passengers at gates, hold areas and terminals, and sets out the advantages and disadvantages of each. A room or other facility should be provided in close proximity to each inspection and screening point where manual or other special search of persons may be carried out in privacy.

3.2.5 Additional guidance about passenger and cabin baggage security can be found in Chapter 11 of Doc 8973.

3.2.6 Regardless of the plan selected, it is essential that the design provide for:

a) the physical separation of persons who have been subjected to inspection and screening from others at the airport; and

b) the prevention of unauthorized access from landside or airside to passenger (security restricted areas) areas in which passengers are waiting after they have been inspected and screened and prior to boarding an aircraft.

3.2.7 Additional guidance about passenger and cabin baggage security, including separation of screened and unscreened passengers, can be found in Chapter 11 of Doc 8973.

3.2.8 Additional guidance about prevention of unauthorized access from landside to airside, including security restricted areas, can be found in Chapter 11 of Doc 8973.

VIP lounges

3.2.9 VIP lounges should be so designed that they do not permit unauthorized landside and airside access. Persons boarding an aircraft from a VIP lounge should be subjected to the passenger and cabin baggage inspection and screening process.

Visitors' observation areas

3.2.10 Due to security concerns, many airports have eliminated observation areas for the public to overlook aprons. If observation areas are to be provided, consideration should be given to enclosing them with glass or providing for surveillance by security guards to avoid objects being thrown onto the apron area. In cases where persons in the observation area would be able to pass material to departing passengers, the observation area should be made sterile (effectively on airside) by subjecting everyone to inspection and screening prior to being permitted access.

3.2.11 In addition, other observation areas outside the airport boundary should not be located within close proximity of the runways and their approach and departure areas. They should also be fully visible from the ATC tower to allow oversight of activity.

Airport emergency operations and security services centre

3.2.12 The airport design must provide for an airport emergency operations centre and a security services centre. These two operations may usefully be located in one complex, either in the PTB or other suitable structure nearby. Use of accommodation in the air traffic services facility, the airport control tower or other remote facility on the airside for these purposes is not recommended.

Public storage lockers and left luggage services

3.2.13 Public storage lockers and left luggage should be located for easy public access and to minimize but away from the main passenger flows. Storage and locker facilities in terminal buildings should be constructed so as divert any explosive incident away from any populated areas, structures or major facilities. Storage and lockers should be fully supervised airport if a potential threat exists.

Hold baggage handling facilities

3.2.14 Some airline operators may have authority to carry unaccompanied hold baggage. Adequate space for additional X-ray or other screening equipment should be considered.

3.2.15 The hold baggage conveyor system must maintain the integrity of the overall security of the terminal facility. Access control between landside and must be maintained.

Storage of mishandled and misrouted hold baggage

3.2.16 A secure storage area in the PTB for mishandled hold baggage prior to the baggage being forwarded, claimed or prior to disposal.

Physical separation of arriving and departing passengers

3.2.17 Arriving passengers and departing passengers in all zones post inspection and screening must be physically separated. There must be no possibility of mixing or contact between passengers who have been inspected and screened and other persons who have not been subjected to that process.

Cargo handling facilities

3.2.18 Special security facilities may be required for cargo. In certain situations, it may be necessary to provide security controls for cargo, including screening. Airport planning should consider special requirements for cargo.

3.3 AIRSIDE SECURITY

Location of operational and security restricted areas

3.3.1 Security of operational areas, where aircraft may be present, from public areas is vital to maintaining a secure airport.

3.3.2 In particular, where runways and taxiways overpass public roads, special measures are needed to restrict access to runways or taxiways at this point and to counteract the possibility of sabotage to the structure of the bridge or tunnel. Other potential areas of focus are the approach and departure paths to runways where aircraft fly at low altitudes. It is expedient to extend the airport boundaries during the initial master design of the airport to include them as part of the airport property.

3.3.3 To adequately protect air operation areas from unauthorized access and interference, physical security measures should include fencing or other barriers, video cameras, lighting, locks, alarms, guards and guard houses airside facilities planning phase.

3.3.4 Additional guidance about restricted areas and airport perimeter protection can be found in Chapter 11 of Doc 8973.

Airport roads

3.3.5 Roads located on the airside should be for the exclusive use of airport personnel. Perimeter roads around the airside area, normally just inside the airport fencing, are required for the use of both maintenance personnel and security patrols.

Fencing

3.3.6 Physical barriers should be provided to deter the access of unauthorized persons onto non-public areas. Fencing is usually provided as the permanent barrier. Fencing should not conflict with the operational requirements of the airport. Control posts and vehicles security checkpoints should be provided to allow the passage of vehicles and persons. The number of access points should be kept to a minimum and equipped so that they can be securely closed should conditions dictate.

3.3.7 Security guards are required at all control posts, and vehicle turnaround and storage areas should be provided in the event an unauthorized vehicle needs to be turned away or for additional inspection processing. Video cameras should be provided to record all activity at the gate areas. The gate area must be illuminated during night use. Discreet communications should be provided between the security post and the airport security services office as well as a discreet and audible alarm by which assistance may be summoned in the event of emergency.

3.3.8 Airport security requires that underground service ducts, sewers and other structures which pass between airside and landside be provided with security mesh or bars. Where access to these facilities is required for maintenance purposes, locked doors, gates or covers should be provided.

3.3.9 Buildings may be used as part of the physical barrier and incorporated in the fence line provided measures are taken to restrict unauthorized passage through the buildings. Building roofs must not provide a possible route for unauthorized access to the airside. Flood-lighting and cameras along the perimeter fencing together with an intruder alarm system should be considered. Often a secondary interior security fence at a reasonable distance from the outer fence provides a prohibited zone and creates a second line of defence from intruders. Fencing should be extended below grade to prohibit intrusion via trenching.

Isolated aircraft parking position

3.3.10 Aircraft suspected of carrying explosive or incendiary devices or where there is a significant onboard security issue, are designated to an isolated parking position. The isolation parking position should be located at the maximum distance possible (at least 100 m) from any other aircraft parking position, buildings or public areas and the airport fence. Taxiways and runways passing within this limit will be closed to normal operations when a “suspect” aircraft is on the isolation pad. The isolated parking position should not be located within a runway approach area or over underground utilities such as gasoline, aviation fuel, water mains or electrical or communications cables.

3.3.11 Facilities for the examination of baggage, cargo, mail and stores removed from an isolated aircraft must be provided as part of the isolated parking position and consideration given to the provision of shelter.

3.3.12 Additional security guidance and considerations on establishing isolated aircraft parking positions can be found in Chapter 17 of Doc 8973.

General aviation parking area

3.3.13 The general aviation aircraft parking apron is usually separated from the commercial aircraft aprons. This safeguards against the possible use of a general aviation aircraft as a means of circumventing security control at the airport.

3.3.14 Taxiways serving general aviation parking areas should be identified and should avoid aprons used by commercial air transport aircraft.

3.3.15 Additional guidance about general aviation and aerial work can be found in Chapter 15 of Doc 8973.

Isolated disposal area

3.3.16 All suspicious articles found on the airport or on an aircraft are placed in a specially designed isolated disposal area. The hold area should be located in a remote area of the airport. A shelter, bunker or building is required to allow bomb disposal experts to deal with possible explosive devices. Explosive device transport vehicles should be able to drive directly into the containment facility. This facility should not be located within close proximity to the runway, taxiway and apron pavement areas or within the runway approach areas.

3.3.17 Additional guidance about handling with suspect explosive general aviation and aerial work can be found in Chapter 17 of Doc 8973.

Appendix A Operational Readiness And Airport Transfer

.1 The opening of new airports is a demanding and intricate logistical project. Implementation of the operational readiness and airport transfer (ORAT) programme is based on five main pillars:

a) the technical readiness assessment;

b) the operational readiness review and evaluation;

c) the training and familiarization planning and monitoring;

d) operational trials; and

e) the airport opening and transfer strategy.

.2 The complexity of an airport ORAT programme depends predominately on the sophistication of the systems employed, the relocation logistics and the physical size of the airport and terminal complex. In order to ensure a successful and “uneventful” opening, sufficient time must be allocated to prepare and implement the ORAT programme.

.3 Planning the ORAT programme should begin at least two years prior to the actual operational opening date of the facility. The training programme needs to take into account the total number of airport employees as well as employees of the many other airport stakeholders including airlines, retailers, contracted service providers, etc. In some cases, a “train the trainer” programme may need to be considered in order to manage the large number of people that need to be familiarized with the new facilities. Recurrent training may also be needed depending on how long it takes before actual ORAT trials can begin.

.4 At least six months is needed for the implementation process including the important series of operational trials. These are significantly and importantly different from the typical systems commissioning phase that completes the contractors’ obligations. ORAT trials involve the comprehensive testing of a sequence of events, for example the passenger departure sequence from curb drop-off through landside processing (check-in and baggage drop, etc.), immigration, security and through to the designated departure gate. A similar sequence applies to both arrivals and transfer passenger processes as well as staff arrivals and departures. ORAT trials allow the ORAT team to access and verify the true “readiness” of the terminal process and equipment to handle the expected volumes of users. The ORAT team is also able to adjust the processes and plan and test contingency operational strategies. The implementation strategies and methodologies need to be adapted to the specifics of each airport, cultural trends, local mentality and contractual obligations, in order to yield the desired results.

.5 The need for an ORAT programme is often overlooked during the initial planning phases of major airport projects including major expansions. However, the absence of a fully comprehensive ORAT programme often results in a less than successful opening, which in turn can cause long-term damage to reputations for the airport, the airlines and often the government and nation itself.

Appendix B Information Technology And Artifical Intelligence

Information technology

.1 Airport managers are under increasing pressure for their airport clients to accommodate more capacity and reduce cost. This will require greater operational efficiency. Management decisions are often affected by operating expenses, limited area for physical expansion and increased environmental restrictions. The solution to many of these challenges is an integrated airport information system for real time operational control, financial management, safety and security oversight and general administrative infrastructure to ensure a continuous and seamless flow of airport information. The system can be adapted to airports of all sizes and can make provisions for individual requirements and future expansion. Different levels of integration need to be evaluated by the airport operator to identify the true needs of the airport. These levels may range from simply co-locating multiple systems in a single, centralized location to the highest level of true interaction where data from one system initiates activity in another system.

.2 The primary functions of an airport information management system are to:

a) act as data storage;

b) provide seamless data flow; and

c) provide data analysis.

.3 The most common airport functions that could benefit from automation and integration can be broken into the following six categories:

a) airside operations;

b) facilities management;

c) passenger, cargo and baggage services;

d) administration (to include finance;(

e) safety and security; and

f) communications.

Artificial intelligence

.4 Artificial intelligence (AI) or intelligent technology can help to boost revenues, pare costs and provide passengers with a more personalized travel experience. New technologies like AI and the use of cross functional big data analyses are essential as passenger activity continues to grow over the next few decades. Many of the benefits will occur behind the scenes in airline and airport operations, but that is expected to trickle down to passengers through improved efficiency and cost savings.

UNMANNED AIRCRAFT SYSTEMS (RESERVED)

AIRPORT SUSTAINABILITY

.1 The objective of comprehensive sustainability planning for airports is to ensure the development and long-term maintenance of sustainable civil infrastructure together with social and corporate governance aspects of airport development. Those elements could be ensured by incorporating sustainability best-practice guidance early in the planning process.

.2 As sustainability can be both globally and locally defined, the strategies included here could be used as a framework to guide airport planning, development and operation and maintenance investments, as needed, to achieve metric targets and thresholds of significance ultimately developed by the airport. Workshops and training sessions should also be conducted to educate relevant airport staff in sustainability best practice strategies. Documents such as the Airports Council International's Sustainability Strategy for Airports Worldwide (2021) and a variety of Airport Cooperative Research Program (ACRP) reports can also provide useful information on how to build airport sustainability strategies.

Sample process

Task 1: Identify and engage stakeholders

At least three categories of stakeholders should be identified and further refined: 1) airport management and operations divisions; 2) tenants; and 3) local community, surrounding cities and business groups.

Task 2: Establish environmental context

a) Review current and prior planning and environmental documents in order to determine a baseline for benchmarking of future initiatives.

b) Identify future planned projects, document the potential size, nature and approximate time frames of each.

Task 3: Conduct sustainability benchmarking and baseline inventory

a) Inventory current practices and efforts underway that would be considered as "sustainable" or "green."

b) Collect and summarize the key points from airport projects and other commercial endeavours that have included a significant sustainability process.

c) Potential baseline categories include:

(1 air quality;

(2 energy management;

(3 water management;

(4 noise management;

(5 landscape management;

(6 solid waste management and recycling; and

(7 biodiversity protection.

d) Indoor environmental quality.

e) Hazardous materials.

f) Surface access.

g) Land-use compatibility (sustainable sites:(

(1 community engagement.

Task 4: Develop sustainability goals

a) Develop measurable goals and objectives that apply to the sustainability categories of airport facilities, environmental resources and/or socioeconomics and community involvement and corporate governance.

(1 Screening criteria to finalize goals and objectives could include:

i) life cycle costs;

ii) return on investment;

iii) benefit-cost analysis;

iv) ability to meet sustainability goals and regional considerations;

v) staffing and maintenance requirements; and

vi) potential funding mechanisms.

Task 5: Identify initiatives to achieve goals and objectives

The following is a sample list of categories of initiatives to achieve an airport's sustainability goals and objectives.

a) Sustainable sites include:

(1 brownfield redevelopment;

(2 alternative transportation;

(3 storm water design;

(4 landscape and exterior design to reduce heat islands; and

(5 light pollution reduction.

b) Water efficiency includes:

(1 water use reduction;

(2 water efficient landscaping; and

(3 innovative wastewater technologies.

c) Energy and atmosphere include:

(1 systems commissioning;

(2 minimum energy performance;

(3 optimize energy efficiency;

(4 on-site renewable energy;

(5 measurement and verification;

(6 green energy; and

(7 noise abatement and mitigation.

d) Materials and resources include:

(1 storage and collection of recyclables;

(2 building and infrastructure reuse;

(3 minimum recycled content;

(4 local and regional sourcing;

(5 rapidly renewable materials;

(6 certified wood;

(7 furniture and equipment; and

(8 equipment salvage and reuse.

e) Indoor environmental quality includes:

(1 minimum indoor air quality;

(2 environmental tobacco smoke control;

(3 outdoor air delivery monitoring;

(4 increased ventilation;

(5 low-emitting materials;

(6 indoor chemical and pollutant source control;

(7 controllability of systems;

(8 thermal comfort;

(9 daylight and views; and

(10 noise transmission reduction.

f) Construction and demolition practices include:

(1 vehicles: clean fuel; low emission;

(2 construction equipment maintenance;

(3 pollution prevention activities;

(4 systems commissioning, enhanced commissioning;

(5 construction waste management;

(6 balanced earthwork;

(7 aggregate reuse, material reuse;

(8 construction indoor air quality management plan;

(9 alternative transportation during construction;

(10 construction material conveyance;

(11 construction noise and acoustical quality; and

(12 temporary construction materials.

Initiatives can be further divided by the type of airport project or facility to which they would apply, such as:

a) civil – airside;

b) civil – landside;

c) occupied buildings; and

d) unoccupied buildings.

Task 6: Develop process to track and report progress

This element of the process includes development of guidelines for the airport to incorporate sustainability actions into such key documents as contracts, lease agreements, procurement and bidding documents, master specifications, design standards, standard operating procedures, license agreements, etc. It is also recommended that template report(s) for benchmarking and communicating progress towards initiatives be developed. An example is an online “dashboard” where progress would be reported; the dashboard can be established for internal use, with an associated version for public release.

Appendix E Spaceport Planning

There has been an increased number of inquiries from both private industry and airport operators to establish commercial space launch sites at or near airports. This section provides a summary-level guidance that the master planning process should consider when evaluating such proposals in a manner consistent with existing statutes, regulations and policy.

a) Standards. Maintaining standards for a broad range of airport facility planning, engineering design, construction, operations and maintenance of airport facilities. Although many launch vehicles have characteristics similar to traditional aircraft (including horizontal take-off), their potential impact to airport design standards (e.g. pavement, signage, marking and lighting) is not fully understood. As the industry evolves and more data becomes available, it will be incumbent upon the master planning process to evaluate whether these vehicles can be accommodated within existing design categories.

b) Safety and operations. There are specific issues that an airport operator will need to address in their airport certification manual and airport emergency plan as well as CAA and government coordination to assure procedures that are established provide the safest operation of these vehicles on the airport.

c) Planning. Approval of these launch vehicles operating at an airport will be predicated on compliance of the most current ICAO design standards and ensuring the safety, efficiency and utility of the airport.

d) Environmental review. All airports must comply with State and local environment laws, regulation and ordinances. Because spaceport operations at airports may have different types of noise sources, it is recommended to conduct noise modelling to determine the potential impact to the surrounding land area.

—END—