The characteristics and variables Accounted by Operators in the Planning and Operation of Airports
Emmy Arsonval Maniriho

Synopsis:
This paper presents airports as crucial components of the aviation industry. Airports play a vital role within the macro environment of transportation in general and in the process of improving the quality of life in regional economies due to their role in wealth creation. Therefore, operators are subject to considerable benchmarking characteristics and variables to plan and run airports effectively. This paper is centered on this discussion and provides a comprehensive review of the operational variables of airports.

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**THE CHARACTERISTICS AND VARIABLES ACCOUNTED BY OPERATORS IN THE PLANNING AND OPERATION OF AIRPORTS**

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Abstract

Aim/Purpose: Today, within the airport and airline industry, characteristics and variables that operators must take into account when planning and running airports are very critical. Therefore, they have to be seriously considered as paramount to ensuring the process of planning and design of airports.

Context: Considering the characteristics and variables that airport operators are required to pay attention to is a significantly improved approach that accounts for the rapid changes in the effective operations of airlines and airports. The present paper is fully focused to reflect the latest characteristics and variables to take into account in the course of planning and running an airport. The study offers a comprehensive coverage of the challenging aviation industry and reviews and discusses factors that affect airport operating and runway capacity, delays, apron layout, gate, taxiway and other aspects of passenger terminal planning ranging from airport access to the number of gates affected by aircraft size and capacity. The paper also shed light on clearances or the procedures where travelers pass through immigration and accustoms before boarding an aircraft, air traffic controls and aids.

Method: The methodological approaches used in this paper are based on best evidence and a narrative review. Selected studies were compared and summarized based on the author's experience and published work. A focus on selected studies is combined with systematic methods of study-selection and analytical exploration.

Contribution: The present paper clearly articulates characteristics and variables that operators must take into account when planning and running airports. It provides thorough knowledge to all direct aviation stakeholders and specifically to operators on how to achieve success in the field of air transport.

Findings: Airport and airline operators should be at the forefront of current consideration of characteristics and variables when planning and running airports.

Recommendations: The author recommends for operators and airport planners to take into account the essential characteristics and variables when planning and running airports. It is important to provide readers with the skills that are research-based from both the fields of airline and airport management in order to meet the demands of dynamic aviation industry. Further research is recommended to carry out a deep research to continue exploring the relationship between aviation safety and security vis-à-vis the characteristics and variables that operators must pay attention to when planning and running airports.

Keywords: Characteristics, variables, operator, planning and airports, airport operating capacity, taxiways and runways
INTRODUCTION

Over the last two decades researchers have diversely approached the study of airports. Previous studies indicated the existence of an imbalance of conditions between different units of major airports (e.g. passenger terminals, airspace planning and airfield). In the meantime, the competition to attract more passengers has led to infrastructure expansion and to the implementation of optimal designs in major airports (Yoon and Jeong, 2015). Airports have long been considered a topic for specialists and designers, admired as a monument celebrating the spectacle of aero mobility. Today, airport decision makers need to deal with a sudden and unexpected situation which can jeopardize operations of airports. Therefore, efficient planning and management practices can be useful to reduce the uncertainty (Yamada et al, 2017). The compatibility and interoperability of the aircraft, operations of airlines, airport infrastructure and facilities are of critical importance to the planning and design process of airports (Laik and Choy, 2018). According to IATA (2018) the number of air travelers is expected to double to 8.2 billion people in 2037. Considering the growing number of passengers, the 900 airlines and more than 25,000 aircrafts, the practice of airport planning and design has become increasingly significant. The 21st century has is an era of colossal technological changes and advancements in air navigation design and systems (Flouris et al, 2016). This is particularly the case when aircraft manufacturers propose the development of new aircraft that might have a heavy impact on airport operations. The technological advancement and computer-based analytical models have resulted in unique challenges and a need to subsequently implement changes in airport and aircraft design subsequently (Curron et al., 2015). Aircraft characteristics have an important role in shaping airport design and planning. For example, the runway and taxiway designs are extensively associated with aircraft characteristics (Putov et al, 2015). The airport airside and landside planning are also based on operating characteristics of the aircraft. On the airside, engineers must determine the runway length and width; the minimum separation between runways and taxiways; the geometric design of taxiways and the pavement strength (Mukabi, 2016). Additionally, environmental issues such as noise and air pollution are also based on the aircraft being used at the airport (Oosterlynck, & Swyngedouw, 2010). On the terminal side, aircraft characteristics influence the number and size of gates needed and consequently they also influence the terminal configuration. Effects of these issues on the transport industry and on airline and airport reputation are often discussed and assumed. Given the importance of airport planning and the factors influencing airport planning, this paper reviews and discusses in a broader perspective, the characteristics and variables that operators must take into account when planning and running airports. It broadens the factors that affect airport operating capacity and delay, apron layout, number of gates, taxiway and runway capacity.

COMPONENT SIZE AND TERMINAL AREA

In order to provide efficient, comfortable and safe terminal areas, building a proper component size especially plays a key role in accomplishing successful airport operation (Kierzkowski and Kisiel, 2017). In recent years, competition in the airline industry and the growth in passenger traffic have created a need to develop new approaches of terminal. The number of gates is the first variable to be considered by operators when planning the passenger terminal. The number of gates required is directly proportional to the gate occupancy time (Merixvell Viñas Tió, 2010). An airport terminal gate is designed to manage the traffic in the airport as well as maximizing the efficiency and the safety for passengers. There are different approaches to design and control the gates. For example, it is crucial to monitor terminal aircraft gates, as it is used by thousands of individuals (Cox & Cox, 2017). It is imperative for an airport operator to consider the following factors that may affect airport operating capacity:

- Size of aircrafts
- Number of gates in airplane areas
- Availability of airspace for establishing arrival and departure routes
• Characteristics and needs of the aircrafts using the airports
• Configuration number of airfield
• Spacing taxiways, layout and spacing gates, and aprons
• Orientation of runway system since the runway marks the heart of airport and may be affected by direction of wind and the location of taxiways
• Existence and nature of navigation aids
• Nature of Air Traffic Control (ATC) facilities
• Noise apartment procedures that effect the type and timing of operations on available runways
• Number and frequency of touch and go operations by general operations of aircraft
• Number of arrivals and departures of aircrafts
• Runway occupancy time for arriving and departing aircrafts
• Techniques adopted by controllers to operate a runway system
• Weather conditions especially visibility aspect.
• Wind conditions which may prohibit use of all available runways by all aircrafts.

In transportation systems, airports are considered as the most resource-constrained elements. Therefore, designing an integrate control system is important to monitor terminal operation (Khadilkar & Balakrishnan, 2016). In addition, forecasting daily traffic, environmental impact assessment and demand analysis should all be conducted and updated constantly to meet the demands for airport. The size of runways and taxiways and the separation between them is determined by the size of the larger aircraft to which the airport is designed. Larger aircrafts require larger runways, taxiways and separations.

APRON LAYOUT
The operator must be aware of the apron layout which is defined by number of stands per aircraft class, gate usage policy, its position with respect to runway system, apron taxiway system and ground handling characteristics (Stamatopoulos et al, 2014). The distance between gates is a function of the aircraft wingspan. In order to minimize the space requirement, airport terminals are usually built with gates of different sizes. As a result, very large aircrafts often have their operations restricted to a few gates. Determination of the number and size of gates must be executed carefully in order to avoid undesired levels of congestion in the future. There are several exciting apron models that calculate apron capacity based on apron layout and the number of weighted average stand occupancy time of aircraft. According to the literature, there are two models frequently used to determine apron layout. Based on the first model of assumption, all aircrafts at the airport are able to use the available stands. These models are suitable for quick and small capacity estimation. However, in the second model, aprons are usually observed, modeled and designed in case-to-case basis. This model deals with apron development along with other elements such as taxiways and curbsides. It usually follows the in-demand changes and keeps the functions efficient. The concept of apron flexibility also needs to be taken into consideration, as it is an indicator of the ability of an apron configuration to respond to structural changes and changes in demand (Mirkovic & Tosic, 2014).

AIRPORT CAPACITY AND DELAY
The term “Airport capacity” is used for aircraft movement that an airport permits within a specified period of time and by allowing an acceptable time of delay to the departure of aircraft. Landing and takeoff are considered the two movements of each aircraft; landing is given priority over take off. Therefore, airport capacity is influenced by a number of factors, some being more significant than others. The most important factor affecting airport capacity is the spacing of successive aircraft
movements. In relation to airport capacity, a delay is defined as the duration between the desired time that an operation occurs and actual time the operation occurs. When aircraft depart and arrive “on time”, according to their respective schedules, the aircraft is said to have experienced no delay (Maniriho, 2016). There have been ongoing attempts and debates within the airport community to revise the regulations and undertake drastic efforts and changes in order to deal with the scarcity of airport capacity. This problem is usually tackled through efficient allocation of airport slots (Madas, & Zoografos, 2008). One of the primary policy concerns lies on the compatibility of alternative slot allocation strategies in order to reduce or avoid ground delays (Pyrgiotis et al, 2013). Previous research works propose different frameworks and strategies for the multi-criteria evaluation and selection of the most compatible slot by optimizing key parameters including file time, end time and distance to avoid ground delay (Ivanov et al, 2017). There are also studies that examine the applicability of policy compatibility results in various airport settings to significantly reduce delay time (Liu et al, 2017).

**Approaches to Reducing Delay**

Unlike the existing literature on this topic, this study explicitly emphasizes end-time and distance models to optimize the ground delay by developing efficient airline equity and air traffic control risks. A study by (Liu et al, 2017) indicates that in comparison with the current “ground delayed program” in operation, the end-time-and-distance solution has a potential to reduce the total delay time by 14.7% and unnecessary ground delays by 50.8% and unnecessary ground delay flights by 48.3%.

Many commercial service airports, particularly those in large metropolitan cities, have experienced significant operating delays on their airfields, in their terminals and on ground access systems around the airports, as well as between the airport and the associated areas. The strategies that may be employed to reduce delays are:

a) **Increasing system capacity:** This includes the addition of infrastructure, such as runways, terminal facilities, and ground access roads. It also includes the provision of technologies and policies to make existing infrastructure operate more efficiently. For example, it reduces the amount of processing time required at any given facility to allow for more operations over a given period of time.

b) **Managing system demand:** Managing time focuses more on changing the behavior of system users that in turn, will lead to better use of existing system capacity.

c) **Creating new airport infrastructure:** Historically, the development of new airports and the construction of new runways and runway extensions at existing airports have offered the greatest potential for increasing aviation system capacity. The modification of runway configurations, in particular converting intersecting runways to parallel configurations, or lengthening shorter runways to accommodate large aircraft have been recent capacity enhancing strategies at airports.

The above mentioned ground delay strategy has the potential to reduce the overall delay effectively while maintaining the traffic control safety risk at accepted levels.

**Runway Capacity**

Runway capacity refers to the ability of a runway system to accommodate aircraft landings and take-offs. It is expressed in operations per unit of time, i.e. operations per hour or operations per year. The ultimate saturation capacity of a runway is the maximum number of aircraft that can be handled during a given period under conditions of continuous demand. Mathematical models or equations are available for computation of saturation capacity, at least for reasonably simple systems for the assumed back log of aircraft waiting to be served. Saturation capacity forms a useful design tool for the comparison of interactive systems. It does not reflect the actual operating characteristics of a runway system under conditions of applied demand. For a practical performance measure, examina-
tion of statistics of demand and delay becomes necessary. Moreover, capacity generally refers to the ability of an airport to handle a given volume of traffic. It is a limit that cannot be exceeded without incurring an operational penalty. As demand for the use of an airport approaches this limit, queues of users awaiting service begin to develop and they experience delay. Generally speaking, the higher the demand in relation to capacity, the longer the queues and the greater the delay. The capacity of a runway has a direct relation to delayed or smooth and quick operations. Insufficient capacity is one of the main problems that many airports are faced with; the situation particularly worsens during peak seasons. Runway characteristics and its occupancy time are among the most influential elements on airport capacity. Not much focus has been given on occupancy time and its impact on landing roll procedures. As an example, the way of braking during landing roll has an essential impact on runway throughput and thus on airport capacity (Skorupski & Wierzbicki, 2017). Their findings indicate the possibility to reduce the runway occupancy time by 50% through optimizing the braking procedure.

Under the runway capacity, there are other crucial aspects to stress such as those discussed below:

**Runway Lengths**
The length of a runway to be provided at an aerodrome is to be determined by the aerodrome operator. It should adequately meet the operational requirements of the critical airplane for which the runway is intended. The operational requirements of airplanes are normally determined by airlines or airplane operators within the airplane mass and performance limitations set by the Civil Aviation Safety Authority (CASA). There is a need to pay particular attention to runway lengths since the number of low-cost carriers is constantly increasing which leads to increase the share of traffic (Barrett, 2004).

**Runway Width**
The appropriate runway width requirement may be determined by cross-reference to use the critical airplane reference code. The runway width standards specified in the table are to be used for the construction of a new runway or for the upgrading of an existing runway (Kazda & Caves, 2010).

**Runway Sight Distances**
Runway sight distance is the distance along a runway, ahead of an observer in an aircraft cockpit, along which there is an unobstructed line of sight to an object on the runway. The observer's eye level is defined as 1.5m, 2.0m and 3.0m above the runway, depending on the runway code letter. The purpose of providing adequate runway sight distance is to provide sufficient runway length to allow for the pilot of an aircraft after sighting an object to react and take appropriate evasive action. For example, braking, exiting the runway or taking-off over the object (Hua-yu et al, 2007).

**Airport Curbside**
Airport curbside is where travelers and baggage enter and exit the terminal, and the designated parking area. In planning and designing airport, curbside demand should be considered and the procedures for adjusting this demand for various service levels and operating conditions.

**Gate Capacity**
The term “gate” refers to an aircraft parking space adjacent to a terminal building that is used by a single aircraft for the loading and unloading of passengers, baggage and freight. Gate capacity defines the ability of a specified number of gates to accommodate aircraft loading and unloading operations under conditions of continuous demand. It is the inverse of the weighted average gate occupancy time for all the aircraft served. The Gate Assignment Problem (GAP) is one of the major issues faced in Air Traffic Control (ATC) operations (Narciso, & Piera, 2015). Optimizing gate assignment at airport terminals aims to assign aircraft to terminal gates to meet operational requirements while
minimizing both inconveniences to passengers and decreasing the operating costs of airports and airlines (Dorndorf et al, 2017).

The number of gates required is directly proportional to the gate occupancy time when passengers pass to board or leave an aircraft and the parking positions used for servicing a single aircraft. Gate occupancy time depends on the following factors:

- The type of aircraft
- Weather and seasons
- The number of deplaning and enplaning passengers
- The amount of baggage and freight
- The efficiency of the apron or ramp personnel
- Whether each gate is available to all users or is allocated for exclusive use of different classes of aircraft.

**Taxiway Capacity**

Studies based on empirical results show that the capacity of a taxiway system generally far exceeds the capacities of runways and gates. There is one notable exception, namely, taxiways that cross active runways. In these situations, the taxiway capacity depends on the runway's operation rate, the aircraft mix and the location of the taxiway relative to the departure end of the runway. Similar to runways, taxiways have been identified as a key source of system-wide congestion. They can also cause delay in an overstrained commercial air traffic system. The mathematical model and solution methodology are embedded in order to evaluate and maximize the resilience of airport taxiway (Faturechi et al, 2014). Other researchers also proposed approaches to optimize airport taxiway scheduling and traversal under uncertain conditions such as harsh weather. Anderson and Milutinović (2013) presented a novel approach for taxiway scheduling and traversal, however this is a dynamic problem which must be updated and revisited every time a new aircraft has been purchased.

**Air Traffic Control and Aids**

The Federal Aviation Administration (FAA) and the pilot-in-command of each aircraft have sole jurisdiction and responsibility for flight paths. Accordingly, only the FAA has enforcement capability over the issues related air traffic control and aids. According to the FAA, helicopters have no minimum altitude requirements when weather, safety, and other air traffic permit as referred to Federal Aviation Regulations (FAR).

The Air Traffic Control System is the second major part of the National Airspace System which offers three basic forms of service:

- Navigation aids including landing aids,
- Flight planning
- In-flight advisory information,
- Air Traffic Control.

**Clearances**

Clearances are the procedures where travelers pass through immigration and customs before boarding an aircraft. The operator should ensure that the clearances are completed to allow for airside transfers.
CONCLUSION

There are various factors related to the characteristics and variables that operators must take into account when planning and running airports. Those factors affect the entire airport design in order to manage the intended volume of traffic that needs to be accommodated by the airport. The capacity of runways, taxiways and terminal planning are also important to ensure the compatibility of aircraft and airport facilities during the process of planning and designing airports. Aircraft manufacturers should carry studies on the development of new aircraft that might impact airlines for smooth operations and safety purpose and airport operations. This paper has been a reflection on the latest characteristics and variables to consider in the sequence of planning and running airports. It has addressed a comprehensive range of challenges of the aircraft industry sector and scrutinized and concretely examined the factors that affect airport operation and runway capacity, flight delays, apron layouts, number of gates and taxiways. Airport and airline operators should be at the threshold of current considerations to identify the characteristics and variables involved in the planning and running airports. Finally, air operators should comply with international air transport policies to ensure the safety and security of passengers and the safe transfer of goods. Future work needs to be directed towards creating flexible runway and taxiway models capable of delivering capacity under more complex situations with inclusion of other parameters that provide for more realistic airports and airlines performance.

To sum, airports must operate adequately as part of the country’s system and policy makers should align their policies with ICAO’s rules and regulations for safe and reliable aviation industry. ICAO Annex 14, as from amendment 4, requires an international airport to be certified for safety purposes. Therefore, airport safety and design should be at the heart of aviation research and development in order to meet the needs of customers profitably without compromising safety and security. The present study provides a brief overview of the existing situation. However, to comply with the ICAO’s requirements, all certified airports are required to implement and operate a Safety Management System since November 2005. Therefore, further research required with directions for safety risk management and allocation of materials and resources to conduct safety training in order to prevent aviation accidents. This study is directly linked to strategic goals of ICAO such as aviation development and aviation safety. It is also related to airport planning since an increased expectation of transparency and engagement impact and drive airport planning and stakeholder engagement processes. The research provides readers with the skills that are research-based from both the field of aviation authorities and airport management.
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Characteristics and Variables for Planning and Running Airports


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APPENDIX

1. Visible Airport and Terminal Areas

2. Aircraft

3. Runway
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